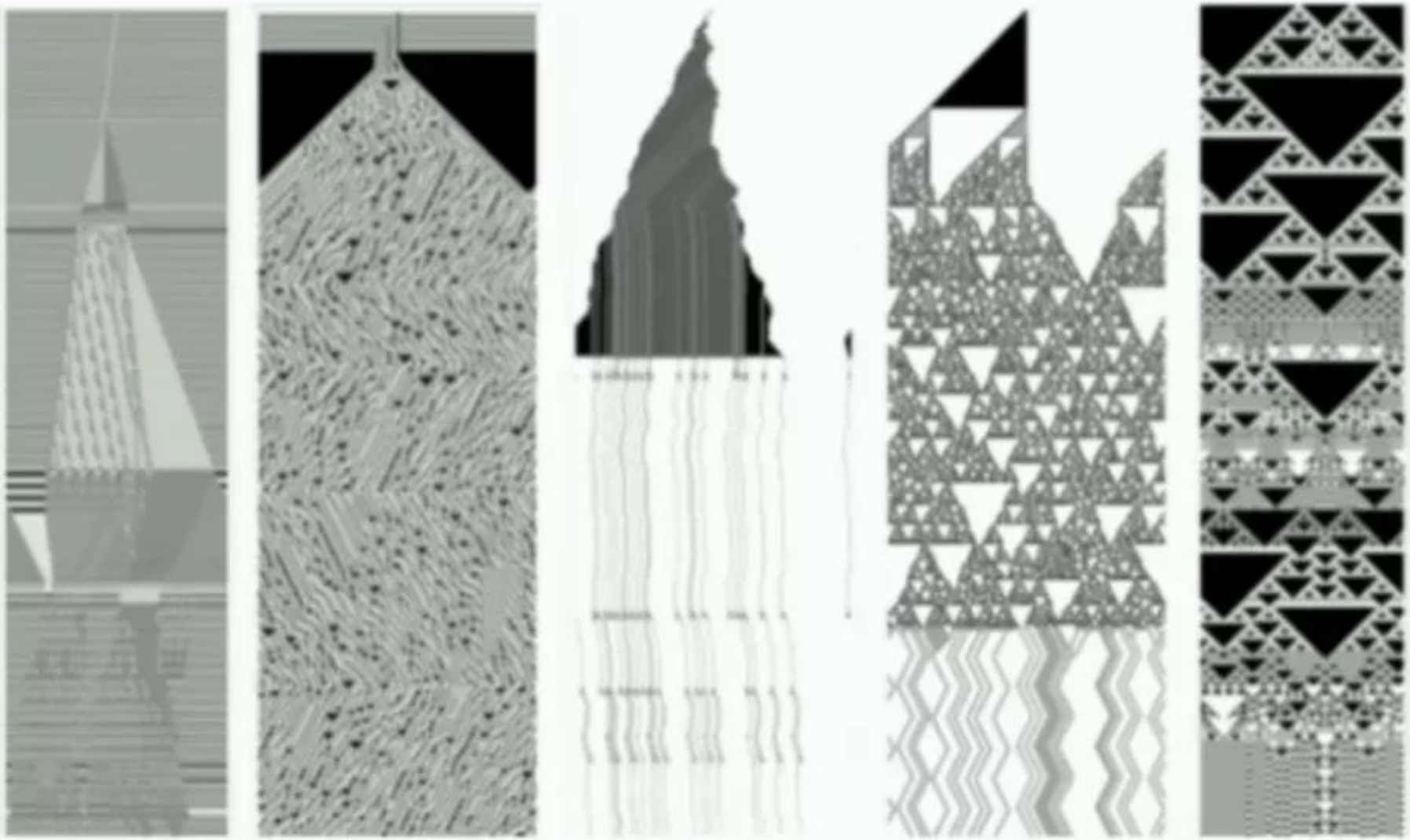

1
00:00:12,110 --> 00:00:09,080
hi everybody my name is Alyssa like he

2
00:00:16,550 --> 00:00:12,120
just said and I'm also a physicist so oh

3
00:00:20,810 --> 00:00:16,560
right but I love biology so that's why

4
00:00:22,670 --> 00:00:20,820
I'm here also i am a amateur computer

5
00:00:25,250 --> 00:00:22,680
theorists so if I say anything wrong

6
00:00:26,599 --> 00:00:25,260
please like correct me because you know

7
00:00:28,339 --> 00:00:26,609
I wasn't trained in any of this

8
00:00:30,410 --> 00:00:28,349
background but I love it so yeah okay

9
00:00:32,389 --> 00:00:30,420
I'm going to talk about it okay from

10
00:00:36,080 --> 00:00:32,399
touring two turtles a theory of

11
00:00:38,600 --> 00:00:36,090
biological computation how exciting okay

12
00:00:41,030 --> 00:00:38,610
so first I'm going to kind of talk about

13
00:00:44,479 --> 00:00:41,040

what do I mean by computation the

14
00:00:46,639 --> 00:00:44,489
dreaded one is live question and then

15
00:00:48,380 --> 00:00:46,649
we're actually just going to look at one

16
00:00:50,630 --> 00:00:48,390
part of life which is open-ended

17
00:00:52,189 --> 00:00:50,640
evolution and then we're going to do

18
00:00:55,240 --> 00:00:52,199
some stuff with a toy model and then

19
00:00:58,250 --> 00:00:55,250
we're going to discuss what we found

20
00:01:02,299 --> 00:00:58,260
okay computation things that we can

21
00:01:04,609 --> 00:01:02,309
compute is life something we can compute

22
00:01:08,090 --> 00:01:04,619
this is the big enchilada question this

23
00:01:10,850 --> 00:01:08,100
is it has a lot of interest in a life

24
00:01:13,399 --> 00:01:10,860
and artificial intelligence but here's

25
00:01:16,940 --> 00:01:13,409
an issue what is life what does it mean

26
00:01:18,620 --> 00:01:16,950
to compute well in order to understand

27
00:01:21,679 --> 00:01:18,630
computers we have to go back to the

28
00:01:24,140 --> 00:01:21,689
1850s where this is Sir Charles Babbage

29
00:01:26,210 --> 00:01:24,150
and he actually invaded invented the

30
00:01:29,330 --> 00:01:26,220
very first computer unfortunately he

31
00:01:31,010 --> 00:01:29,340
never finished it um because he was

32
00:01:32,660 --> 00:01:31,020
notorious for getting really gung-ho

33
00:01:36,190 --> 00:01:32,670
about projects and then not ever

34
00:01:40,130 --> 00:01:36,200
finishing them so he actually was fired

35
00:01:41,510 --> 00:01:40,140
and his machines were never necessarily

36
00:01:44,990 --> 00:01:41,520
completed but they did eventually

37
00:01:48,170 --> 00:01:45,000
compute the complete them like I guess

38
00:01:49,999 --> 00:01:48,180

100 years later but um there was one

39
00:01:52,280 --> 00:01:50,009
person that really understood what

40
00:01:55,670 --> 00:01:52,290
Charles Babbage was doing which was Ada

41
00:01:58,280 --> 00:01:55,680
Lovelace and she actually looked at this

42
00:02:01,249 --> 00:01:58,290
thing and was like oh my gosh this is a

43
00:02:02,899 --> 00:02:01,259
thing you put in input you crank the

44
00:02:06,080 --> 00:02:02,909
handle and then you get an output on the

45
00:02:08,210 --> 00:02:06,090
other side this is computation and what

46
00:02:09,919 --> 00:02:08,220
you can do is you can use the output

47
00:02:11,290 --> 00:02:09,929
from one side and feed it back into the

48
00:02:12,880 --> 00:02:11,300
input again and then

49
00:02:14,770 --> 00:02:12,890
just goes around and around and it runs

50
00:02:17,800 --> 00:02:14,780
and she's like that's a really cool

51
00:02:19,990 --> 00:02:17,810
thing but what she did know is that the

52
00:02:23,050 --> 00:02:20,000
engine has no pretentious to originate

53
00:02:25,660 --> 00:02:23,060
anything and so it can only do whatever

54
00:02:27,160 --> 00:02:25,670
we tell it to do so this is every single

55
00:02:29,200 --> 00:02:27,170
computer in the entire world this is

56
00:02:33,160 --> 00:02:29,210
your smartphone's this is your laptop's

57
00:02:35,560 --> 00:02:33,170
it all works like this so we know what

58
00:02:38,160 --> 00:02:35,570
computing is all right but what about

59
00:02:41,110 --> 00:02:38,170
life so because we can't necessarily

60
00:02:43,150 --> 00:02:41,120
describe what life is because we only

61
00:02:46,210 --> 00:02:43,160
have one sample which is here on earth

62
00:02:48,700 --> 00:02:46,220
the only thing we can do is be extremely

63
00:02:50,290 --> 00:02:48,710

general so what I mean by extremely

64
00:02:52,990 --> 00:02:50,300
general I mean like moving away from

65
00:02:56,380 --> 00:02:53,000
chemistry into the abstract sense of

66
00:03:00,520 --> 00:02:56,390
life so we could say that it uses energy

67
00:03:03,070 --> 00:03:00,530
it processes information there are some

68
00:03:06,130 --> 00:03:03,080
replicators in there but one thing that

69
00:03:08,830 --> 00:03:06,140
is agreed on is that life has this thing

70
00:03:11,500 --> 00:03:08,840
called open-ended evolution and what the

71
00:03:13,660 --> 00:03:11,510
heck is that so it means that life

72
00:03:15,850 --> 00:03:13,670
evolves forwards and not backwards and

73
00:03:18,400 --> 00:03:15,860
it also constantly innovates and creates

74
00:03:20,020 --> 00:03:18,410
new things so you'll never well we

75
00:03:22,600 --> 00:03:20,030
haven't seen anything in the biosphere

76
00:03:24,400 --> 00:03:22,610
be like okay now the entire tree of life

77
00:03:25,900 --> 00:03:24,410
is going back to bacteria so it's

78
00:03:29,350 --> 00:03:25,910
open-ended it keeps getting more

79
00:03:33,430 --> 00:03:29,360
complicated and things like that so the

80
00:03:36,280 --> 00:03:33,440
general sense is if we can compute

81
00:03:38,050 --> 00:03:36,290
things like open-ended evolution and we

82
00:03:40,120 --> 00:03:38,060
can compute things that process

83
00:03:45,040 --> 00:03:40,130
information and replicators then maybe

84
00:03:46,270 --> 00:03:45,050
we can compete life after all okay so

85
00:03:48,460 --> 00:03:46,280
let's learn a little bit more about

86
00:03:49,840 --> 00:03:48,470
open-ended evolution because that's the

87
00:03:53,020 --> 00:03:49,850
thing that I want to try to compute

88
00:03:55,690 --> 00:03:53,030

right so in the open-ended evolution

89
00:04:00,820 --> 00:03:55,700
community there is a big consensus on

90
00:04:02,770 --> 00:04:00,830
what it is and this is a summary it's

91
00:04:05,530 --> 00:04:02,780
there's ongoing innovation and

92
00:04:09,640 --> 00:04:05,540
generation of novelty it's unbounded

93
00:04:12,160 --> 00:04:09,650
it's constantly being complex and it's a

94
00:04:14,130 --> 00:04:12,170
defining feature of life but the issue

95
00:04:15,970 --> 00:04:14,140
is that these things aren't necessarily

96
00:04:18,550 --> 00:04:15,980
quantifiable like what does it mean to

97
00:04:21,640 --> 00:04:18,560
be innovative and what does it mean to

98
00:04:23,710 --> 00:04:21,650
be complex all those kinds of things so

99
00:04:24,990 --> 00:04:23,720
what I spent the last two years doing

100
00:04:27,810 --> 00:04:25,000
was trying

101
00:04:30,210 --> 00:04:27,820
to get away to where we can take all

102
00:04:34,200 --> 00:04:30,220
these ideas and put them into something

103
00:04:37,530 --> 00:04:34,210
that you can measure so emerging these

104
00:04:39,120 --> 00:04:37,540
definitions um because I like computers

105
00:04:42,060 --> 00:04:39,130
and I'm interested if we can compute

106
00:04:44,070 --> 00:04:42,070
life I'm going to focus only on finite

107
00:04:46,230 --> 00:04:44,080
and deterministic systems so that's

108
00:04:48,570 --> 00:04:46,240
something that uses ones or zeros or

109
00:04:51,060 --> 00:04:48,580
some sort of alphabet and there's no

110
00:04:54,930 --> 00:04:51,070
stochasticity whatsoever it's completely

111
00:04:57,390 --> 00:04:54,940
deterministic just like our computers so

112
00:04:59,100 --> 00:04:57,400
um one of the first things that you may

113
00:05:01,290 --> 00:04:59,110

or may not learn about with dynamic

114
00:05:03,360 --> 00:05:01,300
systems is the Poincare recurrence down

115
00:05:04,980 --> 00:05:03,370
basically it just says if you have

116
00:05:07,320 --> 00:05:04,990
finite deterministic system like your

117
00:05:10,020 --> 00:05:07,330
computer it's guaranteed to always come

118
00:05:12,900 --> 00:05:10,030
back to the beginning so what does that

119
00:05:14,550 --> 00:05:12,910
mean um if you have a really simple

120
00:05:16,200 --> 00:05:14,560
computer so pretend you could see your

121
00:05:19,260 --> 00:05:16,210
computer as black and white squares

122
00:05:22,020 --> 00:05:19,270
right if you just ran that thing it's

123
00:05:23,700 --> 00:05:22,030
just always going to repeat so you're

124
00:05:24,870 --> 00:05:23,710
always going to get repeating patterns

125
00:05:26,640 --> 00:05:24,880
because of the Poincare recurrence

126
00:05:29,580 --> 00:05:26,650
theorem there's no way around it

127
00:05:31,200 --> 00:05:29,590
whatsoever um and of course because you

128
00:05:33,030 --> 00:05:31,210
have the same patterns that are

129
00:05:36,480 --> 00:05:33,040
repeating it puts a cap on the

130
00:05:40,200 --> 00:05:36,490
complexity so already we're sad because

131
00:05:44,090 --> 00:05:40,210
we can't type into a code of life and

132
00:05:48,030 --> 00:05:44,100
then really cool things will pop out um

133
00:05:49,500 --> 00:05:48,040
but what we can say is if we want

134
00:05:51,000 --> 00:05:49,510
something that's unbounded evolution

135
00:05:52,680 --> 00:05:51,010
it's going to have to break the point

136
00:05:54,240 --> 00:05:52,690
create recurrence time so that's all

137
00:05:55,680 --> 00:05:54,250
we're saying here so if you have

138
00:05:57,780 --> 00:05:55,690

something that breaks your point career

139
00:06:03,380 --> 00:05:57,790
currents time it's probably unbounded

140
00:06:06,090 --> 00:06:03,390
evolution and so we have to say that

141
00:06:08,190 --> 00:06:06,100
there's input from an external system

142
00:06:09,900 --> 00:06:08,200
because the Poincare recurrence time is

143
00:06:11,640 --> 00:06:09,910
only concerned with things that are

144
00:06:14,010 --> 00:06:11,650
completely internal so if you have

145
00:06:16,350 --> 00:06:14,020
something else that's like kind of

146
00:06:18,930 --> 00:06:16,360
giving it some signals then you're going

147
00:06:22,200 --> 00:06:18,940
to be able to push past that so this is

148
00:06:23,700 --> 00:06:22,210
kind of like a paradigm shift um so now

149
00:06:25,500 --> 00:06:23,710
we have to have a notion of an

150
00:06:27,930 --> 00:06:25,510
environment and we have to have a notion

151
00:06:30,780 --> 00:06:27,940
of like biology or an organism or

152
00:06:32,280 --> 00:06:30,790
something so that can get a little bit

153
00:06:34,500 --> 00:06:32,290
strange because when you look at a

154
00:06:36,719 --> 00:06:34,510
picture like this you kind of say okay

155
00:06:37,679 --> 00:06:36,729
what's the environment well it really

156
00:06:38,549 --> 00:06:37,689
just depends on

157
00:06:40,169 --> 00:06:38,559
what you're talking about you talking

158
00:06:43,529 --> 00:06:40,179
about the trees then the environment

159
00:06:45,959 --> 00:06:43,539
might be other stuff so what about

160
00:06:48,659 --> 00:06:45,969
innovation so innovation what we're

161
00:06:51,509 --> 00:06:48,669
going to say is ok if we have some sort

162
00:06:55,649 --> 00:06:51,519
of biology and it's integrated into

163
00:06:58,559 --> 00:06:55,659

everything on then we say that it could

164
00:07:00,209 --> 00:06:58,569
have an about unbounded evolution but if

165
00:07:02,219 --> 00:07:00,219
we have something that's just all by

166
00:07:03,779 --> 00:07:02,229
itself the exact same size and there's

167
00:07:05,999 --> 00:07:03,789
no external things we're going to call

168
00:07:09,600 --> 00:07:06,009
that the isolated system so that's like

169
00:07:11,399 --> 00:07:09,610
our control right so if we imagine all

170
00:07:13,949 --> 00:07:11,409
the things that are by themselves and we

171
00:07:16,049 --> 00:07:13,959
track their behavior we say these are

172
00:07:17,609 --> 00:07:16,059
our control like this is our control but

173
00:07:19,409 --> 00:07:17,619
if we see something different that

174
00:07:22,979 --> 00:07:19,419
hasn't been tracked in the isolated

175
00:07:24,959 --> 00:07:22,989
systems and we say its innovative so if

176
00:07:29,009 --> 00:07:24,969
you don't understand any of that that's

177
00:07:31,829 --> 00:07:29,019
fine because I pictures instead so these

178
00:07:34,379 --> 00:07:31,839
are examples of what innovation means so

179
00:07:37,429 --> 00:07:34,389
these are cellular automata they're just

180
00:07:39,649 --> 00:07:37,439
black and white squares um and they're

181
00:07:42,029 --> 00:07:39,659
notoriously famous for creating patterns

182
00:07:44,399 --> 00:07:42,039
now we've never seen these patterns

183
00:07:46,859 --> 00:07:44,409
before in cellular automata because they

184
00:07:48,779 --> 00:07:46,869
have some sort of additional input and

185
00:07:50,069 --> 00:07:48,789
since they look different than we've

186
00:07:52,619 --> 00:07:50,079
ever seen them before we call them

187
00:07:56,729 --> 00:07:52,629
innovative so hey is it a video we've

188
00:07:58,979 --> 00:07:56,739

never seen it before great so if its

189
00:08:01,619 --> 00:07:58,989
innovative and it's both unbounded that

190
00:08:03,779 --> 00:08:01,629
means it is open and it's it's got

191
00:08:05,699 --> 00:08:03,789
open-ended evolution in it which is

192
00:08:08,609 --> 00:08:05,709
great because that's a one of the

193
00:08:12,989 --> 00:08:08,619
defining features of life okay so more

194
00:08:15,629 --> 00:08:12,999
pictures yay okay for a quick crash

195
00:08:17,399 --> 00:08:15,639
course in cellular automata basically

196
00:08:19,679 --> 00:08:17,409
all it is is you start with a grid of

197
00:08:23,279 --> 00:08:19,689
black and white squares so they could be

198
00:08:25,259 --> 00:08:23,289
12 zeroes and you run this rule on it so

199
00:08:27,059 --> 00:08:25,269
you start with the top state and then

200
00:08:30,389 --> 00:08:27,069
you're like okay well that is going to

201
00:08:32,909 --> 00:08:30,399
update to the next row using this rule

202
00:08:35,850 --> 00:08:32,919
and as you can see four different rules

203
00:08:38,059 --> 00:08:35,860
of CA you get different patterns so

204
00:08:41,369 --> 00:08:38,069
different rules mean different patterns

205
00:08:43,829 --> 00:08:41,379
and just these classic ones the

206
00:08:47,249 --> 00:08:43,839
elementary cellular topic just the ones

207
00:08:49,670 --> 00:08:47,259
that have been studied they have a point

208
00:08:51,800 --> 00:08:49,680
a recurrence time of two

209
00:08:53,210 --> 00:08:51,810
to the system size so the bigger the

210
00:08:55,040 --> 00:08:53,220
system size the longer it's going to

211
00:08:59,389 --> 00:08:55,050
take to repeat but I promise it will

212
00:09:02,180 --> 00:08:59,399
repeat anyway okay but what we did is we

213
00:09:05,019 --> 00:09:02,190

were like hey instead of just having

214
00:09:08,240 --> 00:09:05,029
these guys right here what if we had a

215
00:09:10,940 --> 00:09:08,250
an organism that could change its

216
00:09:14,660 --> 00:09:10,950
updateable so what do I mean by that so

217
00:09:17,889 --> 00:09:14,670
what if we had a organism or a biology

218
00:09:20,240 --> 00:09:17,899
thing and it's over here but it's got an

219
00:09:22,639 --> 00:09:20,250
environment a separate environment and

220
00:09:25,040 --> 00:09:22,649
what if we made them interact in some

221
00:09:27,050 --> 00:09:25,050
sort of way would we get organisms that

222
00:09:29,210 --> 00:09:27,060
are open-ended can we break that point

223
00:09:31,010 --> 00:09:29,220
cry or occurrence time and we're like

224
00:09:32,150 --> 00:09:31,020
that's like an interesting question so

225
00:09:33,860 --> 00:09:32,160
there's different there's so many

226
00:09:36,170 --> 00:09:33,870
different ways these two can interact

227
00:09:39,579 --> 00:09:36,180
but we just picked three of them and the

228
00:09:42,829 --> 00:09:39,589
first one is a lot like biology so if

229
00:09:45,710 --> 00:09:42,839
I'm a biological organism I'm not just

230
00:09:47,750 --> 00:09:45,720
going to be obeying some sort of fixed

231
00:09:50,000 --> 00:09:47,760
law I'm going to take information about

232
00:09:53,269 --> 00:09:50,010
what I'm doing and information about the

233
00:09:56,000 --> 00:09:53,279
environment to change my behavior so um

234
00:09:58,280 --> 00:09:56,010
probably probably I'm hungry right and

235
00:10:00,769 --> 00:09:58,290
I'm like oh I'm so hungry that's

236
00:10:02,900 --> 00:10:00,779
information about myself but if I see a

237
00:10:04,610 --> 00:10:02,910
food truck over there that's information

238
00:10:06,350 --> 00:10:04,620

about the environment so I take those

239
00:10:09,650 --> 00:10:06,360
two things of information and I change

240
00:10:12,980 --> 00:10:09,660
my behavior to go get myself sandwich so

241
00:10:14,840 --> 00:10:12,990
that's what's happening here you get

242
00:10:17,870 --> 00:10:14,850
your organism it's taking information

243
00:10:19,640 --> 00:10:17,880
about its current state and also taking

244
00:10:22,160 --> 00:10:19,650
information about the environment at the

245
00:10:25,280 --> 00:10:22,170
same time and using that information to

246
00:10:27,230 --> 00:10:25,290
change its update rule so that's the

247
00:10:29,570 --> 00:10:27,240
thing up there so it doesn't just use

248
00:10:33,310 --> 00:10:29,580
one it can pick and choose between all

249
00:10:35,480 --> 00:10:33,320
possible update rules so in terms of

250
00:10:37,490 --> 00:10:35,490
computation bringing this thing back

251
00:10:40,040 --> 00:10:37,500
again it's almost as if the environment

252
00:10:42,230 --> 00:10:40,050
is being dictated by one Turing machine

253
00:10:44,420 --> 00:10:42,240
and it just does its thing right the

254
00:10:47,540 --> 00:10:44,430
organism is also dictated by a Turing

255
00:10:49,910 --> 00:10:47,550
machine but it has a second Turing

256
00:10:51,829 --> 00:10:49,920
machine manipulating the first one so

257
00:10:55,310 --> 00:10:51,839
it's a Turing machine on top of a Turing

258
00:10:58,280 --> 00:10:55,320
machine and this meta Turing machine it

259
00:10:59,120 --> 00:10:58,290
is using information about this Turing

260
00:11:06,260 --> 00:10:59,130
machine

261
00:11:10,160 --> 00:11:06,270
classical computation it's pretty

262
00:11:12,650 --> 00:11:10,170
different ok so we're like well what if

263
00:11:15,230 --> 00:11:12,660

we can get open-ended evolution

264
00:11:18,470 --> 00:11:15,240
organisms but they don't depend on their

265
00:11:22,600 --> 00:11:18,480
own update rule so what I mean by that

266
00:11:25,520 --> 00:11:22,610
instead of like having the organism

267
00:11:27,020 --> 00:11:25,530
affected by its own state like if I'm

268
00:11:28,730 --> 00:11:27,030
hungry I'm only affected by the

269
00:11:30,440 --> 00:11:28,740
environment so the environment in this

270
00:11:34,430 --> 00:11:30,450
case is dictating everything that I do

271
00:11:35,990 --> 00:11:34,440
so no filter at all right so um you know

272
00:11:37,730 --> 00:11:36,000
you're turning machine here and then

273
00:11:39,290 --> 00:11:37,740
you're turning machine here and this

274
00:11:41,060 --> 00:11:39,300
Turing machine is only using information

275
00:11:43,550 --> 00:11:41,070
about that turning machine to change

276
00:11:46,430 --> 00:11:43,560
this Turing machine so it's still a

277
00:11:47,720 --> 00:11:46,440
weird kind of computation and in case

278
00:11:50,570 --> 00:11:47,730
three what if we just did something

279
00:11:54,140 --> 00:11:50,580
random because randomness is fun but it

280
00:11:57,530 --> 00:11:54,150
turns out all it is is just a giant

281
00:11:59,090 --> 00:11:57,540
random randomly turning Turing machine

282
00:12:00,170 --> 00:11:59,100
changing this bottom Turing machine and

283
00:12:01,760 --> 00:12:00,180
as you can see there's no environment

284
00:12:06,290 --> 00:12:01,770
over here because the environment is

285
00:12:09,080 --> 00:12:06,300
coming from this input at the top ok so

286
00:12:11,900 --> 00:12:09,090
how many open-ended organisms did we get

287
00:12:14,090 --> 00:12:11,910
so if we have just a regular Turing

288
00:12:16,640 --> 00:12:14,100

machine these are our we call it the

289
00:12:18,530 --> 00:12:16,650
control cases of course we don't get any

290
00:12:19,970 --> 00:12:18,540
open-endedness because the point career

291
00:12:22,970 --> 00:12:19,980
occurrence theorem right they're all

292
00:12:26,090 --> 00:12:22,980
subject to it but if I have the first

293
00:12:28,760 --> 00:12:26,100
case then i get a percent of

294
00:12:32,990 --> 00:12:28,770
open-endedness that it doesn't

295
00:12:35,210 --> 00:12:33,000
necessarily increase linearly or

296
00:12:36,980 --> 00:12:35,220
according to some sort of like nice

297
00:12:38,360 --> 00:12:36,990
function that we can write down but

298
00:12:41,620 --> 00:12:38,370
instead it has like this up and down

299
00:12:45,230 --> 00:12:41,630
kind of thing where this axis or this

300
00:12:46,910 --> 00:12:45,240
here is the size of the organism so you

301
00:12:48,770 --> 00:12:46,920
start off with a really small organism

302
00:12:52,310 --> 00:12:48,780
being three bits long it's just got a

303
00:12:53,570 --> 00:12:52,320
few cases but if you have five bits long

304
00:12:55,160 --> 00:12:53,580
then you have three percent of your

305
00:12:58,460 --> 00:12:55,170
cases are open-ended which is pretty

306
00:13:00,830 --> 00:12:58,470
good um but we say this is the only one

307
00:13:03,800 --> 00:13:00,840
that's scalable because if you look over

308
00:13:05,600 --> 00:13:03,810
here like your case to where you're an

309
00:13:08,260 --> 00:13:05,610
organism only being dictated by your

310
00:13:10,610 --> 00:13:08,270
environment your number of

311
00:13:11,260 --> 00:13:10,620
open-endedness cases is going to

312
00:13:12,730 --> 00:13:11,270
decrease

313
00:13:16,330 --> 00:13:12,740

dramatically as the size of your

314
00:13:18,280 --> 00:13:16,340
organism increases and even more

315
00:13:19,720 --> 00:13:18,290
dramatically with just random so this is

316
00:13:21,760 --> 00:13:19,730
a whole monkey than on typewriter thing

317
00:13:24,360 --> 00:13:21,770
you know it's going to take you forever

318
00:13:27,370 --> 00:13:24,370
to find something that's interesting but

319
00:13:29,140 --> 00:13:27,380
you'll find it but it just it takes way

320
00:13:30,640 --> 00:13:29,150
too long so we're we're saying this is

321
00:13:33,390 --> 00:13:30,650
the only one that's scalable so that's

322
00:13:36,820 --> 00:13:33,400
great um real quick I'm just going to

323
00:13:39,760 --> 00:13:36,830
tell you what this means um if we look

324
00:13:43,180 --> 00:13:39,770
at a organism and its environment is

325
00:13:44,500 --> 00:13:43,190
much much greater than the organism then

326
00:13:46,780 --> 00:13:44,510
it's going to have the most amount of

327
00:13:49,840 --> 00:13:46,790
open-ended cases so like twenty eight

328
00:13:51,790 --> 00:13:49,850
percent if your environment is five and

329
00:13:54,520 --> 00:13:51,800
a half times larger than your organism

330
00:13:57,070 --> 00:13:54,530
so bigger the environment and the

331
00:13:59,620 --> 00:13:57,080
smaller the organism the better off

332
00:14:01,300 --> 00:13:59,630
you're going to find open-ended cases so

333
00:14:03,070 --> 00:14:01,310
Turing machines acting on Turing

334
00:14:06,040 --> 00:14:03,080
machines breaks the Poincare recurrence

335
00:14:08,470 --> 00:14:06,050
time and here's what they look like to

336
00:14:10,900 --> 00:14:08,480
sew on each panel you have your

337
00:14:14,200 --> 00:14:10,910
environment and then your organism next

338
00:14:15,670 --> 00:14:14,210

to it and the blue is the point the

339
00:14:18,040 --> 00:14:15,680
expected point create recurrence time

340
00:14:20,080 --> 00:14:18,050
and the red is the actual recurrence

341
00:14:22,990 --> 00:14:20,090
time so as you can see the red is longer

342
00:14:25,990 --> 00:14:23,000
than the blue so that's great and also

343
00:14:28,900 --> 00:14:26,000
you have um if you just looked at this

344
00:14:31,210 --> 00:14:28,910
red part here it's not repeating within

345
00:14:33,190 --> 00:14:31,220
that red part so it's also innovative so

346
00:14:35,140 --> 00:14:33,200
since it's breaking the Poincare

347
00:14:38,710 --> 00:14:35,150
recurrence time and innovative it's an

348
00:14:41,140 --> 00:14:38,720
open-ended organism yay so if more

349
00:14:46,030 --> 00:14:41,150
informational not please visit this it's

350
00:14:48,640 --> 00:14:46,040
on archive yes okay so i told you about

351
00:14:51,580 --> 00:14:48,650
computation we talked about how we can't

352
00:14:53,860 --> 00:14:51,590
define life we also picked one part of

353
00:14:55,450 --> 00:14:53,870
biology which is open-endedness we

354
00:14:57,550 --> 00:14:55,460
tested with a toy model and found out we

355
00:15:04,090 --> 00:14:57,560
can compute it so what does this all

356
00:15:07,450 --> 00:15:04,100
mean discussion lies all of them lies

357
00:15:09,760 --> 00:15:07,460
I'm just kidding not all of them but if

358
00:15:11,650 --> 00:15:09,770
there's this really great paper that

359
00:15:13,960 --> 00:15:11,660
came out on which is the limits of

360
00:15:16,540 --> 00:15:13,970
decidable States on open-ended evolution

361
00:15:18,550 --> 00:15:16,550
and emergence and what this is about is

362
00:15:21,700 --> 00:15:18,560
any Turing computable system that is

363
00:15:24,040 --> 00:15:21,710

truly open-ended is undecidable and what

364
00:15:24,770 --> 00:15:24,050
that means in terms of cherry of

365
00:15:28,130 --> 00:15:24,780
computation

366
00:15:32,120 --> 00:15:28,140
is for something to be truly open ended

367
00:15:36,110 --> 00:15:32,130
you can't compute it according to the

368
00:15:38,570 --> 00:15:36,120
Turing definition of computation okay

369
00:15:41,630 --> 00:15:38,580
but wait um I thought you I just showed

370
00:15:44,150 --> 00:15:41,640
that you can do that but actually we're

371
00:15:45,980 --> 00:15:44,160
not using a Turing computable system

372
00:15:47,270 --> 00:15:45,990
even though it's using Turing machines

373
00:15:49,340 --> 00:15:47,280
it's using turning machines in a

374
00:15:52,490 --> 00:15:49,350
different way that allows you to get

375
00:15:54,530 --> 00:15:52,500
open-endedness and we're saying that the

376
00:15:57,140 --> 00:15:54,540
only way you can do it is you have to

377
00:15:59,780 --> 00:15:57,150
define open-endedness with respect to

378
00:16:02,330 --> 00:15:59,790
something else so it's open-endedness on

379
00:16:04,670 --> 00:16:02,340
the scale of the organism but not

380
00:16:07,780 --> 00:16:04,680
open-ended on the scale of the entire

381
00:16:12,200 --> 00:16:07,790
ecosystem so time scales are important

382
00:16:16,100 --> 00:16:12,210
ok so now about to the question can we

383
00:16:18,440 --> 00:16:16,110
compute life well we would have to move

384
00:16:20,840 --> 00:16:18,450
beyond Turing in order to do so we have

385
00:16:22,540 --> 00:16:20,850
to move past the idea of you have one

386
00:16:24,920 --> 00:16:22,550
Turing machine and it does its thing

387
00:16:28,700 --> 00:16:24,930
instead we need to do something that

388
00:16:31,670 --> 00:16:28,710

involves self-reference it needs to

389
00:16:33,770 --> 00:16:31,680
involve subsystems and separating your

390
00:16:36,800 --> 00:16:33,780
organism from your environment it needs

391
00:16:38,960 --> 00:16:36,810
to be subjective and i'm going to say

392
00:16:41,240 --> 00:16:38,970
down with random and also up with random

393
00:16:43,310 --> 00:16:41,250
because randomness doesn't exist in

394
00:16:44,840 --> 00:16:43,320
terms of computational theory and is

395
00:16:47,660 --> 00:16:44,850
really really bad for creating

396
00:16:49,550 --> 00:16:47,670
open-endedness but it's also really

397
00:16:53,360 --> 00:16:49,560
important for processing information in

398
00:16:55,280 --> 00:16:53,370
terms of information theory so also if

399
00:16:58,600 --> 00:16:55,290
you guys have any other ideas of how to

400
00:17:00,650 --> 00:16:58,610
compute life using a new kind of

401
00:17:03,740 --> 00:17:00,660
computational method then let me know

402
00:17:06,460 --> 00:17:03,750
because it's super interesting ok

403
00:17:09,560 --> 00:17:06,470
special thanks to everybody our

404
00:17:13,190 --> 00:17:09,570
incredible fantastic lab and my advisor

405
00:17:14,780 --> 00:17:13,200
Sarah and Hector and also Paul and then

406
00:17:24,259 --> 00:17:14,790
of course all of you guys because

407
00:17:35,100 --> 00:17:30,810
turtles well there's tert there's

408
00:17:40,950 --> 00:17:35,110
Turtles all the way down you'll find

409
00:17:42,870 --> 00:17:40,960
them so I guess using its physical

410
00:17:45,210 --> 00:17:42,880
example of a guest case one does that

411
00:17:46,799 --> 00:17:45,220
mean nor for life to actually evolve

412
00:17:50,070 --> 00:17:46,809
does that mean then you need to have a

413
00:17:52,110 --> 00:17:50,080

system that's actually organism that

414
00:17:54,119 --> 00:17:52,120
actually has like I see a feedback loop

415
00:17:55,830 --> 00:17:54,129
and be able to actually be able to move

416
00:17:57,840 --> 00:17:55,840
and actually be able to interact with

417
00:18:00,240 --> 00:17:57,850
the environment and vice versa is that

418
00:18:02,789 --> 00:18:00,250
what's being said yeah yeah yeah and

419
00:18:06,149 --> 00:18:02,799
actually we didn't explicitly have a

420
00:18:08,340 --> 00:18:06,159
case where we had the organism change

421
00:18:10,710 --> 00:18:08,350
the update rule of the environment like

422
00:18:12,149 --> 00:18:10,720
where it's double feedback system we

423
00:18:13,649 --> 00:18:12,159
haven't done that yet but that's

424
00:18:15,450 --> 00:18:13,659
definitely something that we would like

425
00:18:16,950 --> 00:18:15,460
to do in the future so I guess it would

426
00:18:18,690 --> 00:18:16,960
be almost getting too close to what we

427
00:18:20,909 --> 00:18:18,700
humans do and just basically alter the

428
00:18:22,259 --> 00:18:20,919
environment as building buildings and

429
00:18:35,580 --> 00:18:22,269
carbon emissions and stuff like that

430
00:18:39,940 --> 00:18:38,080
so if you're as you just mentioned

431
00:18:42,400 --> 00:18:39,950
changing the update rule of the

432
00:18:45,880 --> 00:18:42,410
environment and the environment has its

433
00:18:48,400 --> 00:18:45,890
own little Turing machine in terms of

434
00:18:51,060 --> 00:18:48,410
this open evolution open-ended evolution

435
00:18:54,400 --> 00:18:51,070
sense could you have the environment

436
00:18:56,530 --> 00:18:54,410
exhibit open into devolution that's a

437
00:18:58,270 --> 00:18:56,540
really great question um and I love that

438
00:19:00,910 --> 00:18:58,280

questions so much because it really like

439
00:19:03,250 --> 00:19:00,920
challenges what's an environment you

440
00:19:06,190 --> 00:19:03,260
know because at least providers live

441
00:19:09,790 --> 00:19:06,200
yeah exactly and I think of an

442
00:19:13,600 --> 00:19:09,800
environment in like when you partition

443
00:19:17,410 --> 00:19:13,610
up a system into subsystems it's almost

444
00:19:20,050 --> 00:19:17,420
like where do you call the environment

445
00:19:22,780 --> 00:19:20,060
and I think the answer is like you you

446
00:19:25,900 --> 00:19:22,790
can't necessarily call the environment

447
00:19:29,140 --> 00:19:25,910
in very many places like this this room

448
00:19:30,520 --> 00:19:29,150
isn't like its biology like we made this

449
00:19:32,020 --> 00:19:30,530
this is these are things that we have

450
00:19:35,830 --> 00:19:32,030
done this is things that biology is

451
00:19:37,570 --> 00:19:35,840
computed but on yeah I definitely think

452
00:19:38,890 --> 00:19:37,580
the environment should be open-ended to

453
00:19:44,440 --> 00:19:38,900
I think that's a really great thing to