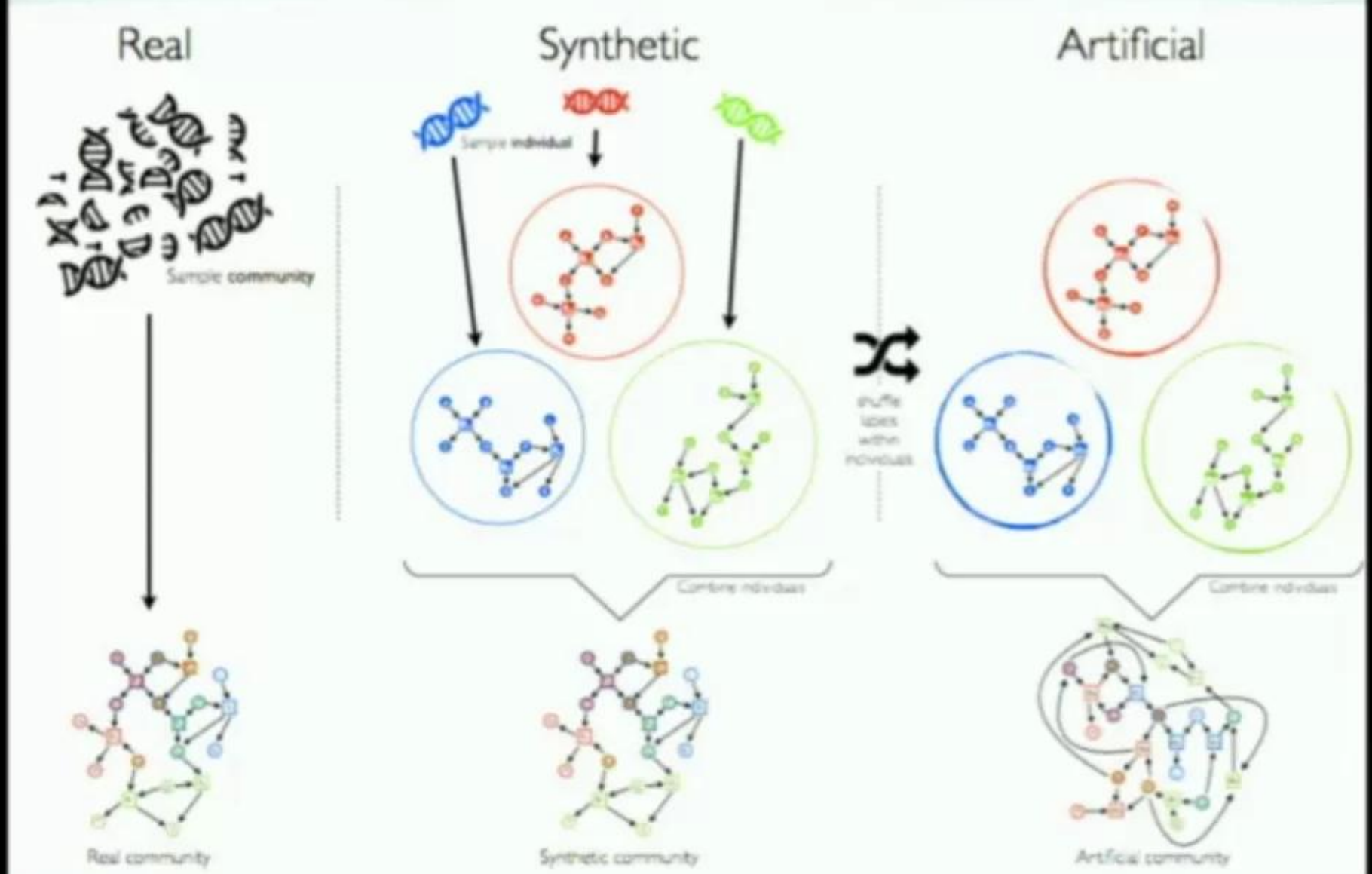
NETWORK CONSTRUCTION



1
00:00:09,799 --> 00:00:06,010
[Music]

2
00:00:11,480 --> 00:00:09,809
okay so I'm Harrison the title my talk

3
00:00:14,120 --> 00:00:11,490
is the network architecture metabolism

4
00:00:15,320 --> 00:00:14,130
on earth Tessa did a good job doing some

5
00:00:16,430 --> 00:00:15,330
introduction and networks and I'm gonna

6
00:00:18,830 --> 00:00:16,440
tell you why they're relevant to

7
00:00:20,870 --> 00:00:18,840
metabolism so basically what I mean by

8
00:00:22,370 --> 00:00:20,880
this is we're studying different types

9
00:00:23,960 --> 00:00:22,380
of metabolism so metabolism of

10
00:00:26,570 --> 00:00:23,970
individuals metabolism of communities

11
00:00:29,089 --> 00:00:26,580
and you can represent metabolism as a

12
00:00:31,009 --> 00:00:29,099
chemical reaction network and when I say

13
00:00:32,330 --> 00:00:31,019

network architecture architecture just

14
00:00:34,040 --> 00:00:32,340
refers to the structure of the network

15
00:00:36,100 --> 00:00:34,050
so just the different properties of the

16
00:00:39,970 --> 00:00:36,110
network itself this is work I do with

17
00:00:41,990 --> 00:00:39,980
the post secondary group and you Jason

18
00:00:43,940 --> 00:00:42,000
Raymond and Sarah Walker who are

19
00:00:45,470 --> 00:00:43,950
professors in the group and then Elife

20
00:00:47,420 --> 00:00:45,480
which is our research group which we'll

21
00:00:49,069 --> 00:00:47,430
have a few talks this afternoon

22
00:00:54,200 --> 00:00:49,079
helps a lot with the input and feedback

23
00:00:57,139 --> 00:00:54,210
and stuff ok so it was really big for

24
00:00:59,540 --> 00:00:57,149
this talk this is basically what I want

25
00:01:01,610 --> 00:00:59,550
to talk about today so all life shares a

26
00:01:03,709 --> 00:01:01,620
common core metabolism what I'm

27
00:01:05,570 --> 00:01:03,719
interested in is is that chance or

28
00:01:07,310 --> 00:01:05,580
necessity is that required if you played

29
00:01:09,440 --> 00:01:07,320
the tape of life again would you always

30
00:01:12,320 --> 00:01:09,450
get only one dominant metabolism on

31
00:01:13,780 --> 00:01:12,330
earth or would you get a couple origins

32
00:01:15,980 --> 00:01:13,790
of life that can coexist with each other

33
00:01:18,440 --> 00:01:15,990
what we also want to do is quantify the

34
00:01:20,030 --> 00:01:18,450
structure of Earth metabolism so again

35
00:01:22,039 --> 00:01:20,040
the metabolism of individuals the

36
00:01:25,219 --> 00:01:22,049
metabolism of communities of all

37
00:01:28,760 --> 00:01:25,229
different types of life what makes a

38
00:01:30,740 --> 00:01:28,770

koval microbial community special so if

39
00:01:33,200 --> 00:01:30,750
you have a group of organisms that

40
00:01:34,969 --> 00:01:33,210
co-evolved together does that community

41
00:01:39,080 --> 00:01:34,979
look different than a group of organisms

42
00:01:42,740 --> 00:01:39,090
that you put in fresh and you just

43
00:01:45,109 --> 00:01:42,750
watching them start to evolve cohabitate

44
00:01:46,550 --> 00:01:45,119
in the same space and then the last

45
00:01:48,469 --> 00:01:46,560
thing I want to address is could we be

46
00:01:51,380 --> 00:01:48,479
living alongside a shadow biosphere and

47
00:01:52,760 --> 00:01:51,390
so by this I mean is could it be that

48
00:01:53,990 --> 00:01:52,770
there is a second origin of life on

49
00:01:55,490 --> 00:01:54,000
Earth that we just don't know about we

50
00:01:57,800 --> 00:01:55,500
have been able attacked either because

51
00:01:59,630 --> 00:01:57,810
we don't have the right techniques or

52
00:02:01,100 --> 00:01:59,640
because it's living somewhere different

53
00:02:02,480 --> 00:02:01,110
than where we are so it's physically

54
00:02:05,600 --> 00:02:02,490
separated and that's what the bottom of

55
00:02:08,389 --> 00:02:05,610
this slide is showing so you can have

56
00:02:09,650 --> 00:02:08,399
ecologically separate biospheres or you

57
00:02:10,850 --> 00:02:09,660
can have ecologically integrated

58
00:02:12,440 --> 00:02:10,860
biospheres or you could have

59
00:02:13,460 --> 00:02:12,450
biochemically integrated and then what I

60
00:02:16,130 --> 00:02:13,470
interpret that to mean

61
00:02:18,170 --> 00:02:16,140
is uses different sets of chemical

62
00:02:20,030 --> 00:02:18,180
reactions to sustain life but it is

63
00:02:24,290 --> 00:02:20,040

overlapping physically in the same space

64
00:02:27,200 --> 00:02:24,300
as life as we know it so starting at the

65
00:02:31,340 --> 00:02:27,210
organism level we analyze 21,000

66
00:02:33,140 --> 00:02:31,350
bacterial genomes and 730 RKO genomes we

67
00:02:35,120 --> 00:02:33,150
also have 26 metagenomes from

68
00:02:36,860 --> 00:02:35,130
Yellowstone the reason we have meta gems

69
00:02:38,450 --> 00:02:36,870
from Yellowstone is probably a lot of

70
00:02:41,420 --> 00:02:38,460
you know is because it's really diverse

71
00:02:43,430 --> 00:02:41,430
environment so it's really great to look

72
00:02:46,220 --> 00:02:43,440
at the mix of species across different

73
00:02:48,280 --> 00:02:46,230
pH and temperature ranges and then we

74
00:02:50,330 --> 00:02:48,290
also looked at the biosphere level so

75
00:02:55,070 --> 00:02:50,340
three different levels of biological

76
00:02:56,420 --> 00:02:55,080
organization and to get the to make a

77
00:02:59,810 --> 00:02:56,430
network from the biosphere we basically

78
00:03:02,900 --> 00:02:59,820
just use this keg database which has all

79
00:03:04,910 --> 00:03:02,910
the enzymatically catalyzed chemical

80
00:03:07,550 --> 00:03:04,920
reactions and we just treat those as if

81
00:03:09,190 --> 00:03:07,560
they're all part of one physical thing

82
00:03:11,270 --> 00:03:09,200
which they are which is the best for you

83
00:03:12,860 --> 00:03:11,280
so first I want to give you a little

84
00:03:15,890 --> 00:03:12,870
background networks again tested a good

85
00:03:17,810 --> 00:03:15,900
job this is a similar example so I have

86
00:03:19,820 --> 00:03:17,820
a highway network here and I represent

87
00:03:22,280 --> 00:03:19,830
node cities as nodes and then just the

88
00:03:24,949 --> 00:03:22,290

highways between cities are the links or

89
00:03:27,259 --> 00:03:24,959
the edges and this kind of network for a

90
00:03:29,960 --> 00:03:27,269
highway most of your nodes have roughly

91
00:03:32,180 --> 00:03:29,970
the same number of links so you don't

92
00:03:33,650 --> 00:03:32,190
have any cities we have thousands of

93
00:03:35,180 --> 00:03:33,660
highways going out of them and you also

94
00:03:36,800 --> 00:03:35,190
don't have very many cities where

95
00:03:38,330 --> 00:03:36,810
there's only one highway going out of

96
00:03:40,400 --> 00:03:38,340
them and so this is what this

97
00:03:42,110 --> 00:03:40,410
distribution looks like if you plot the

98
00:03:43,400 --> 00:03:42,120
number of nodes with a certain number of

99
00:03:45,590 --> 00:03:43,410
links and then the number of links on

100
00:03:47,810 --> 00:03:45,600
the y axis so most of your nodes have

101
00:03:50,240 --> 00:03:47,820
the same number of links this is as

102
00:03:52,280 --> 00:03:50,250
opposed to like an airport network where

103
00:03:55,580 --> 00:03:52,290
you represent nodes as airports and then

104
00:03:57,860 --> 00:03:55,590
that the traveling between the airports

105
00:04:00,470 --> 00:03:57,870
is the links you do get hubs like

106
00:04:02,360 --> 00:04:00,480
Chicago Boston or LA but you also have

107
00:04:04,070 --> 00:04:02,370
hundreds or thousands of regional

108
00:04:06,380 --> 00:04:04,080
airports that only fly to a few places

109
00:04:08,090 --> 00:04:06,390
and so those are all right here where

110
00:04:10,580 --> 00:04:08,100
you have a lot of nodes with only a few

111
00:04:12,020 --> 00:04:10,590
links and then your big hubs are down at

112
00:04:13,310 --> 00:04:12,030
the tail of the distribution where you

113
00:04:15,080 --> 00:04:13,320

have a few hubs with a large number of

114
00:04:16,400 --> 00:04:15,090
links so you can represent lots of

115
00:04:18,620 --> 00:04:16,410
things as networks this is an example

116
00:04:23,180 --> 00:04:18,630
that's really easy to understand but we

117
00:04:25,090 --> 00:04:23,190
represent communities and individuals as

118
00:04:28,990 --> 00:04:25,100
networks as well

119
00:04:30,670 --> 00:04:29,000
and so what we do is other people go out

120
00:04:33,970 --> 00:04:30,680
and collect samples at Yellowstone and

121
00:04:36,820 --> 00:04:33,980
got these microbial community samples

122
00:04:38,290 --> 00:04:36,830
from hotspring ecosystems and then you

123
00:04:40,570 --> 00:04:38,300
can turn the gene fragments that you

124
00:04:42,700 --> 00:04:40,580
sample into chemical reaction networks

125
00:04:44,290 --> 00:04:42,710
and so for those of you they want all

126
00:04:47,350 --> 00:04:44,300
the details this is a little bit more

127
00:04:49,630 --> 00:04:47,360
detail right here so you match the genes

128
00:04:51,370 --> 00:04:49,640
with the enzymes that they code for you

129
00:04:52,690 --> 00:04:51,380
match the enzymes with the reactions

130
00:04:54,100 --> 00:04:52,700
that you know that they catalyze and

131
00:04:55,900 --> 00:04:54,110
then you put all those reactions

132
00:04:58,060 --> 00:04:55,910
together into one big Network and that's

133
00:05:00,310 --> 00:04:58,070
what we analyze so you do this for

134
00:05:02,590 --> 00:05:00,320
metagenomes and you can also do this for

135
00:05:05,260 --> 00:05:02,600
individual genomes the difference is we

136
00:05:07,120 --> 00:05:05,270
collect the metagenomes out in the field

137
00:05:08,800 --> 00:05:07,130
and the individual genomes we just pull

138
00:05:13,420 --> 00:05:08,810

from Patric which is a database online

139
00:05:15,790 --> 00:05:13,430
of all these genomes ok so here's kind

140
00:05:18,820 --> 00:05:15,800
of the first results this is just some

141
00:05:20,800 --> 00:05:18,830
network stats of real metagenomes and

142
00:05:23,260 --> 00:05:20,810
just real genomes and the biosphere so

143
00:05:25,150 --> 00:05:23,270
here's a little key right here and on

144
00:05:28,570 --> 00:05:25,160
this top plot I'm showing the shortest

145
00:05:30,220 --> 00:05:28,580
path of a network a shortest path is I'm

146
00:05:33,400 --> 00:05:30,230
giving you a little example here so this

147
00:05:35,410 --> 00:05:33,410
is your network the blue numbers are the

148
00:05:37,360 --> 00:05:35,420
shortest paths from F to that node and

149
00:05:38,530 --> 00:05:37,370
then if you do this for every possible

150
00:05:40,270 --> 00:05:38,540
combination of nodes in your network and

151
00:05:42,370 --> 00:05:40,280
you average it you get a single number

152
00:05:45,520 --> 00:05:42,380
and you get one of those numbers for

153
00:05:46,990 --> 00:05:45,530
each of the 21,000 bacterial genomes

154
00:05:48,550 --> 00:05:47,000
that we analyzed each of the 700 are

155
00:05:50,890 --> 00:05:48,560
Keele genomes all the metagenomes the

156
00:05:53,710 --> 00:05:50,900
biosphere and then we plot it right here

157
00:05:55,630 --> 00:05:53,720
and if you notice everything kind of

158
00:05:58,660 --> 00:05:55,640
lumps together there's no clear

159
00:06:01,570 --> 00:05:58,670
distinguish distinguishing shortest

160
00:06:04,090 --> 00:06:01,580
paths for either the individual genomes

161
00:06:06,340 --> 00:06:04,100
or the metagenomes the biosphere is way

162
00:06:07,930 --> 00:06:06,350
over here but that's just because the

163
00:06:09,850 --> 00:06:07,940

size the network if you notice it has a

164
00:06:12,400 --> 00:06:09,860
similar shortest path and this is just a

165
00:06:13,900 --> 00:06:12,410
box plot representation of that data we

166
00:06:15,100 --> 00:06:13,910
also looked at the mean degree we looked

167
00:06:18,640 --> 00:06:15,110
at a bunch of things I'm just showing

168
00:06:20,680 --> 00:06:18,650
you a snapshot of what we looked at the

169
00:06:22,990 --> 00:06:20,690
mean degree is just the number of nodes

170
00:06:24,100 --> 00:06:23,000
that each node is connected to and you

171
00:06:25,960 --> 00:06:24,110
look at that for every node and you

172
00:06:27,670 --> 00:06:25,970
average it and so here's another little

173
00:06:29,380 --> 00:06:27,680
example you do that for each of the

174
00:06:31,960 --> 00:06:29,390
networks and this time it's interesting

175
00:06:34,960 --> 00:06:31,970
because here you notice the real

176
00:06:37,210 --> 00:06:34,970
metagenomes in yellow stand out from all

177
00:06:38,629 --> 00:06:37,220
the individual genomes so this

178
00:06:42,200 --> 00:06:38,639
particular measure

179
00:06:44,629 --> 00:06:42,210
can identify or distinguish communities

180
00:06:46,520 --> 00:06:44,639
from individuals you can see that here

181
00:06:50,689 --> 00:06:46,530
on the box plot and then this is the

182
00:06:52,879 --> 00:06:50,699
biosphere keg on the right side so then

183
00:06:54,950 --> 00:06:52,889
we did another thing and this ties back

184
00:06:57,230 --> 00:06:54,960
to the question the beginning of how do

185
00:06:59,390 --> 00:06:57,240
you co-evolved communities look compared

186
00:07:00,860 --> 00:06:59,400
to communities that are just starting to

187
00:07:02,119 --> 00:07:00,870
evolve together so maybe you've some

188
00:07:04,159 --> 00:07:02,129

kind of big perturbation and

189
00:07:05,809 --> 00:07:04,169
everything's kind of R equal abrading in

190
00:07:07,010 --> 00:07:05,819
a community do those communities look

191
00:07:08,749 --> 00:07:07,020
different than communities that have

192
00:07:10,730 --> 00:07:08,759
been Co evolving for millions of years

193
00:07:12,740 --> 00:07:10,740
and so the way that we decided to

194
00:07:14,899 --> 00:07:12,750
measure that is was something I'm

195
00:07:16,580 --> 00:07:14,909
calling synthetic communities so what we

196
00:07:18,350 --> 00:07:16,590
do is we sample individuals these are

197
00:07:21,110 --> 00:07:18,360
real genomes these are the genomes that

198
00:07:22,820 --> 00:07:21,120
we pull from the databases online and

199
00:07:24,769 --> 00:07:22,830
then you just take random samples of

200
00:07:26,899 --> 00:07:24,779
them and you put them together and you

201
00:07:28,459 --> 00:07:26,909
say ok this is a community even though

202
00:07:31,040 --> 00:07:28,469
they didn't co-evolved in the real world

203
00:07:32,659 --> 00:07:31,050
they were completely separate you just

204
00:07:35,540 --> 00:07:32,669
call them I said then we're calling them

205
00:07:37,369 --> 00:07:35,550
a synthetic community okay so then we

206
00:07:40,309 --> 00:07:37,379
analyze that this is the plots from the

207
00:07:41,600 --> 00:07:40,319
last slide that you just saw so do you

208
00:07:43,490 --> 00:07:41,610
think he'd be able to distinguish

209
00:07:45,680 --> 00:07:43,500
synthetic communities from real

210
00:07:49,640 --> 00:07:45,690
co-evolved communities with networked

211
00:07:50,719 --> 00:07:49,650
measures any inkling absolutely so

212
00:07:53,360 --> 00:07:50,729
that's what we thought too but it's

213
00:07:55,010 --> 00:07:53,370

really weird because you don't and so

214
00:07:56,749 --> 00:07:55,020
this is only for two particular measures

215
00:07:58,790 --> 00:07:56,759
again we did this for lots of different

216
00:08:01,279 --> 00:07:58,800
network measures and you see the same

217
00:08:02,839 --> 00:08:01,289
thing over and over which is these are

218
00:08:05,260 --> 00:08:02,849
the sizes of the synthetic communities

219
00:08:08,029 --> 00:08:05,270
so just random samples of 10 20 30 or 40

220
00:08:08,959 --> 00:08:08,039
individuals and then this is these are

221
00:08:11,119 --> 00:08:08,969
the real metagenomes

222
00:08:13,100 --> 00:08:11,129
and they all fall pretty much within the

223
00:08:15,079 --> 00:08:13,110
same range for these particular measures

224
00:08:16,189 --> 00:08:15,089
the mean degree in the shortest path and

225
00:08:18,559 --> 00:08:16,199
so that's kind of weird

226
00:08:20,089 --> 00:08:18,569
so there are measures where they they

227
00:08:21,619 --> 00:08:20,099
get distinguished a little bit more or

228
00:08:24,320 --> 00:08:21,629
they're a little bit more fuzzy but in

229
00:08:25,969 --> 00:08:24,330
general there's no clear measure that

230
00:08:29,119 --> 00:08:25,979
you can use to distinguish synthetic

231
00:08:31,279 --> 00:08:29,129
communities from real communities so the

232
00:08:33,230 --> 00:08:31,289
last thing we wanted to look at was okay

233
00:08:34,909 --> 00:08:33,240
what if you had individuals that came

234
00:08:36,680 --> 00:08:34,919
together to form a community and all

235
00:08:39,230 --> 00:08:36,690
these individuals relied on different

236
00:08:42,170 --> 00:08:39,240
core metabolisms and so that's kind of a

237
00:08:44,660 --> 00:08:42,180
hard thing to study because we don't

238
00:08:46,430 --> 00:08:44,670

know of any other origins of life so

239
00:08:50,449 --> 00:08:46,440
what we did is we tried to make it a

240
00:08:52,310 --> 00:08:50,459
little toy chemistry's from the real

241
00:08:54,110 --> 00:08:52,320
individuals so what we did is

242
00:08:56,210 --> 00:08:54,120
we took the real individual networks and

243
00:08:59,270 --> 00:08:56,220
all we did was we shuffle the labels of

244
00:09:00,920 --> 00:08:59,280
the compounds of the metabolites and so

245
00:09:02,810 --> 00:09:00,930
effectively what this does is it keeps

246
00:09:05,360 --> 00:09:02,820
the topology of the network the same it

247
00:09:07,640 --> 00:09:05,370
keeps all the links the same but what it

248
00:09:10,940 --> 00:09:07,650
does is it mixes up

249
00:09:13,010 --> 00:09:10,950
just these node labels and what happens

250
00:09:13,940 --> 00:09:13,020
is when you combine networks even though

251
00:09:15,920 --> 00:09:13,950
they look the same when they're

252
00:09:17,150 --> 00:09:15,930
individual with the shuffled labels when

253
00:09:18,320 --> 00:09:17,160
you combine them the network's

254
00:09:19,760 --> 00:09:18,330
completely different because now

255
00:09:22,160 --> 00:09:19,770
different parts of the network are

256
00:09:23,630 --> 00:09:22,170
overlapping and so again this is to

257
00:09:26,600 --> 00:09:23,640
simulate what would happen if you had

258
00:09:28,370 --> 00:09:26,610
different core metabolisms of

259
00:09:32,300 --> 00:09:28,380
individuals forming a community together

260
00:09:34,340 --> 00:09:32,310
what would that network look like okay

261
00:09:37,250 --> 00:09:34,350
and this is work it's kind of weird so

262
00:09:38,750 --> 00:09:37,260
on the left-hand side of these box plots

263
00:09:40,070 --> 00:09:38,760

you can't really read the labels but

264
00:09:42,410 --> 00:09:40,080
again I'm showing you shortest paths I

265
00:09:44,930 --> 00:09:42,420
mean degree on the left side we see all

266
00:09:48,320 --> 00:09:44,940
the real communities all the real

267
00:09:50,180 --> 00:09:48,330
individual genomes and the biosphere and

268
00:09:52,040 --> 00:09:50,190
we see the synthetic networks again they

269
00:09:53,630 --> 00:09:52,050
don't really stand out but starting here

270
00:09:55,940 --> 00:09:53,640
where it says nuts 10 and it goes down

271
00:09:58,100 --> 00:09:55,950
and that's 70 these are these artificial

272
00:10:01,790 --> 00:09:58,110
communities and artificial communities

273
00:10:03,350 --> 00:10:01,800
really diverge from the architecture of

274
00:10:05,570 --> 00:10:03,360
the real communities and the real

275
00:10:07,550 --> 00:10:05,580
individuals and this is kind of

276
00:10:11,420 --> 00:10:07,560
surprising and they diverge in a certain

277
00:10:13,100 --> 00:10:11,430
way this isn't the clearest legend so

278
00:10:14,960 --> 00:10:13,110
I'll just walk you through it here so on

279
00:10:16,790 --> 00:10:14,970
the left again we have the real

280
00:10:18,860 --> 00:10:16,800
individuals the real community the

281
00:10:20,930 --> 00:10:18,870
biosphere and then the synthetic

282
00:10:23,300 --> 00:10:20,940
communities and then all these nuts

283
00:10:25,370 --> 00:10:23,310
labels are these artificial communities

284
00:10:27,530 --> 00:10:25,380
and so with these networks they have a

285
00:10:29,330 --> 00:10:27,540
particular type of distribution which is

286
00:10:31,550 --> 00:10:29,340
similar to a power-law distribution or a

287
00:10:32,960 --> 00:10:31,560
log normal distribution and what that

288
00:10:34,610 --> 00:10:32,970

tells you is how the network is

289
00:10:37,460 --> 00:10:34,620
constructed and also tells you something

290
00:10:40,520 --> 00:10:37,470
about the robustness of the network and

291
00:10:42,290 --> 00:10:40,530
so these networks are known from network

292
00:10:44,600 --> 00:10:42,300
science to be robust these power losses

293
00:10:45,500 --> 00:10:44,610
log normal networks but then when you

294
00:10:47,360 --> 00:10:45,510
start looking at the artificial

295
00:10:49,010 --> 00:10:47,370
communities you see that their log

296
00:10:50,450 --> 00:10:49,020
normal which is okay but then as you

297
00:10:51,860 --> 00:10:50,460
grow these networks bigger and bigger

298
00:10:53,960 --> 00:10:51,870
they become exponential and these

299
00:10:57,110 --> 00:10:53,970
exponential distributions are less

300
00:10:59,240 --> 00:10:57,120
robust and by robust in this context

301
00:11:01,610 --> 00:10:59,250
would mean you get some kind of mutation

302
00:11:03,980 --> 00:11:01,620
you get some kind of perturbation to the

303
00:11:04,930 --> 00:11:03,990
community and does the community recover

304
00:11:06,880 --> 00:11:04,940
it does not recover

305
00:11:08,290 --> 00:11:06,890
so you wouldn't see these communities be

306
00:11:10,780 --> 00:11:08,300
you wouldn't see these communities

307
00:11:15,820 --> 00:11:10,790
recovering and so we interpret that to

308
00:11:18,010 --> 00:11:15,830
mean loosely that a shadow biosphere is

309
00:11:19,840 --> 00:11:18,020
unlikely to be ecologically integrated

310
00:11:21,220 --> 00:11:19,850
with our biosphere so maybe you could

311
00:11:24,040 --> 00:11:21,230
have certain types of shadow biospheres

312
00:11:25,870 --> 00:11:24,050
like this ecologically separate one so

313
00:11:27,190 --> 00:11:25,880

maybe like in the deep earth below life

314
00:11:30,750 --> 00:11:27,200
as we know it there's other types of

315
00:11:33,550 --> 00:11:30,760
life living and maybe there's integrated

316
00:11:34,840 --> 00:11:33,560
other biospheres but the integrated

317
00:11:36,100 --> 00:11:34,850
biospheres would have to be using some

318
00:11:37,930 --> 00:11:36,110
different kind of information storage

319
00:11:39,730 --> 00:11:37,940
system than us so instead of DNA they'd

320
00:11:41,230 --> 00:11:39,740
have to be using something different but

321
00:11:43,710 --> 00:11:41,240
what we think we can rule out is that

322
00:11:47,470 --> 00:11:43,720
you'd see other types of life that's

323
00:11:49,210 --> 00:11:47,480
using different core reactions to

324
00:11:51,700 --> 00:11:49,220
sustain themselves living right

325
00:11:53,410 --> 00:11:51,710
alongside life as we know it and that's

326
00:11:54,490 --> 00:11:53,420
what this last point is driven by these

327
00:11:56,140 --> 00:11:54,500
results from these artificial

328
00:11:58,780 --> 00:11:56,150
communities the other results that I

329
00:12:00,850 --> 00:11:58,790
just wanted to recap are you see

330
00:12:03,010 --> 00:12:00,860
Universal topological features four

331
00:12:03,760 --> 00:12:03,020
different levels of the biosphere of

332
00:12:05,800 --> 00:12:03,770
different levels of biological

333
00:12:08,710 --> 00:12:05,810
organization of individuals communities

334
00:12:10,510 --> 00:12:08,720
and the biosphere as a whole and

335
00:12:14,560 --> 00:12:10,520
co-evolved communities are mostly

336
00:12:16,390 --> 00:12:14,570
indistinguishable from non co-evolved

337
00:12:18,390 --> 00:12:16,400
communities and that's what we saw with

338
00:12:20,530 --> 00:12:18,400

the synthetic versus the real networks

339
00:12:22,360 --> 00:12:20,540
but then the artificial communities are

340
00:12:24,100 --> 00:12:22,370
weird and that's where we make this

341
00:12:26,650 --> 00:12:24,110
inference about the shadow biosphere and

342
00:12:28,660 --> 00:12:26,660
then just recapping the points that

343
00:12:30,040 --> 00:12:28,670
brought up at the beginning is this

344
00:12:32,260 --> 00:12:30,050
transfer necessity that all I showed is

345
00:12:34,090 --> 00:12:32,270
common core metabolism this seems a hint

346
00:12:37,510 --> 00:12:34,100
this is necessity you wouldn't see two

347
00:12:40,030 --> 00:12:37,520
types of life living coexisting together

348
00:12:41,530 --> 00:12:40,040
in the same physical space we quantified

349
00:12:43,180 --> 00:12:41,540
the structure of Earth and tabal isms

350
00:12:46,120 --> 00:12:43,190
what makes it co-evolved microbial

351
00:12:47,560 --> 00:12:46,130
community special not much there are

352
00:12:49,600 --> 00:12:47,570
some measures that they're distinguished

353
00:12:52,030 --> 00:12:49,610
a little bit but not but most of the

354
00:12:53,170 --> 00:12:52,040
measures they look pretty similar who

355
00:12:55,810 --> 00:12:53,180
would be living alongside a she had a

356
00:12:57,760 --> 00:12:55,820
biosphere well yes but not this

357
00:13:00,370 --> 00:12:57,770
particular type where your biochemically

358
00:13:04,949 --> 00:13:00,380
integrated so with that thank you and

359
00:13:13,690 --> 00:13:11,320
we have time for a few questions thanks

360
00:13:14,920 --> 00:13:13,700
that was really cool with regard to the

361
00:13:16,600 --> 00:13:14,930
not being able to distinguish the

362
00:13:18,550 --> 00:13:16,610
co-evolved communities from ones you

363
00:13:20,410 --> 00:13:18,560

just start again isn't that definitely a

364
00:13:22,840 --> 00:13:20,420
signal to noise problem like if you

365
00:13:26,590 --> 00:13:22,850
start removing core consistent things

366
00:13:28,090 --> 00:13:26,600
that that signal will come up I'm not

367
00:13:29,740 --> 00:13:28,100
sure what you mean exactly so if you

368
00:13:31,329 --> 00:13:29,750
take away all core metabolism that's

369
00:13:32,769 --> 00:13:31,339
shared across everything sure and then

370
00:13:35,139 --> 00:13:32,779
look at them I mean I feel like your

371
00:13:35,980 --> 00:13:35,149
artificial part kind of shows right it's

372
00:13:38,230 --> 00:13:35,990
going yeah

373
00:13:39,850 --> 00:13:38,240
and that's I guess that's in hindsight

374
00:13:41,170 --> 00:13:39,860
that kind of makes sense right because

375
00:13:43,360 --> 00:13:41,180
if you take a bunch of things that

376
00:13:45,130 --> 00:13:43,370
already shared this common core then

377
00:13:47,079 --> 00:13:45,140
they're gonna look similar to things

378
00:13:49,980 --> 00:13:47,089
that are COBOL but the same core anyways

379
00:13:52,210 --> 00:13:49,990
right is that kind of what you're saying

380
00:13:56,380 --> 00:13:52,220
okay maybe not

381
00:14:01,389 --> 00:13:56,390
we can talk after if you are any other

382
00:14:03,250 --> 00:14:01,399
questions while really naive your

383
00:14:04,540 --> 00:14:03,260
question on how I deal with the graph so

384
00:14:07,000 --> 00:14:04,550
there are two kinds of notes you have

385
00:14:08,889 --> 00:14:07,010
reactions because I have species I'm

386
00:14:11,680 --> 00:14:08,899
sorry you also have like the genetic

387
00:14:13,480 --> 00:14:11,690
sequences I guess so do you distinguish

388
00:14:14,769 --> 00:14:13,490

those two kinds of nodes or do Shrunk

389
00:14:17,650 --> 00:14:14,779
the reactions when you account the

390
00:14:18,699 --> 00:14:17,660
distance so the we construct two

391
00:14:20,050 --> 00:14:18,709
different types of networks for the

392
00:14:21,730 --> 00:14:20,060
analysis depending on the measures were

393
00:14:24,490 --> 00:14:21,740
looking at so what type of the network

394
00:14:26,019 --> 00:14:24,500
has nodes for reactions and nodes for

395
00:14:27,880 --> 00:14:26,029
metabolites and then metabolites are

396
00:14:29,410 --> 00:14:27,890
connected to the reactions if they're

397
00:14:31,090 --> 00:14:29,420
shared as part of the same reaction the

398
00:14:32,199 --> 00:14:31,100
other one we just do metabolites and you

399
00:14:34,000 --> 00:14:32,209
connect those that those are part of the

400
00:14:35,829 --> 00:14:34,010
same reaction and so depending on what

401
00:14:37,650 --> 00:14:35,839
measure we're looking at we do analysis

402
00:14:40,120 --> 00:14:37,660
I'm one of those two types of networks

403
00:14:42,760 --> 00:14:40,130
so for like the distance like the

404
00:14:44,829 --> 00:14:42,770
shortest path what we do is we do it for

405
00:14:50,920 --> 00:14:44,839
the substrate substrate networks so just

406
00:14:52,600 --> 00:14:50,930
the metabolite sorry no we don't do any

407
00:14:56,519 --> 00:14:52,610
way that edges here these are all simple

408
00:15:01,519 --> 00:14:56,529
graphs any other questions