



Hong-Yan Shih

*Collective Emergent Evolution Between Marine
Bacteria & Viruses*

1
00:00:16,740 --> 00:00:12,920

[Music]

2
00:00:20,070 --> 00:00:16,750

good afternoon living systems inevitably

3
00:00:22,859 --> 00:00:20,080

form ecosystems therefore in order to

4
00:00:25,260 --> 00:00:22,869

understand the origin of life we need to

5
00:00:29,720 --> 00:00:25,270

understand the origin of ecosystems and

6
00:00:32,490 --> 00:00:29,730

their stability and how ecosystem I

7
00:00:37,250 --> 00:00:32,500

interact which they plan planetary

8
00:00:39,990 --> 00:00:37,260

environments so this is a paragraph from

9
00:00:42,959 --> 00:00:40,000

anthropology roadmap proposed by NASA

10
00:00:45,840 --> 00:00:42,969

what it is says is that astrobiologists

11
00:00:48,389 --> 00:00:45,850

have long recognized that in order to

12
00:00:52,380 --> 00:00:48,399

understand how life can colonize a

13
00:00:55,549 --> 00:00:52,390

planet and how life can have enough

14

00:00:58,290 --> 00:00:55,559

abundance to show is observable I

15

00:01:02,160 --> 00:00:58,300

biosignatures we need to understand the

16

00:01:05,490 --> 00:01:02,170

formation and the maintenance of the the

17

00:01:09,029 --> 00:01:05,500

whole communities especially microbial

18

00:01:11,370 --> 00:01:09,039

communities for example bacteria and a

19

00:01:14,880 --> 00:01:11,380

layer predator versus and a Larry

20

00:01:17,639 --> 00:01:14,890

interaction with the environments so as

21

00:01:21,120 --> 00:01:17,649

we have learned from average shock

22

00:01:23,760 --> 00:01:21,130

yesterday we know life is a planetary

23

00:01:25,830 --> 00:01:23,770

response the planets get trapped in

24

00:01:28,169 --> 00:01:25,840

metastable States and the life helps

25

00:01:33,540 --> 00:01:28,179

them get out of that so in other words

26

00:01:39,540 --> 00:01:33,550

the purpose of life is to help planet to

27

00:01:41,580 --> 00:01:39,550

approach equilibrium and an in principle

28

00:01:44,160 --> 00:01:41,590

a particle process

29

00:01:47,520 --> 00:01:44,170

I also driven by the similar than a

30

00:01:50,729 --> 00:01:47,530

similar dynamic constraints but life can

31

00:01:53,370 --> 00:01:50,739

out-compete about your chemistry by

32

00:01:56,010 --> 00:01:53,380

finding new and faster metabolic

33

00:01:58,949 --> 00:01:56,020

pathways to utilize free energy gradient

34

00:02:01,050 --> 00:01:58,959

and how does life do this life

35

00:02:01,559 --> 00:02:01,060

thursday's by controlling information

36

00:02:05,729 --> 00:02:01,569

flow

37

00:02:08,609 --> 00:02:05,739

so once the one of the things that

38

00:02:10,550 --> 00:02:08,619

distinguish life and non-life is that

39

00:02:15,150 --> 00:02:10,560

life can control information flow and

40

00:02:18,300 --> 00:02:15,160

using information flow I to manipulate

41

00:02:20,960 --> 00:02:18,310

and impact its environments so when we

42

00:02:24,600 --> 00:02:20,970

talk about information flow it can be a

43

00:02:28,320 --> 00:02:24,610

generative gene flows and

44

00:02:32,010 --> 00:02:28,330

people think gene flow from mutations

45

00:02:35,070 --> 00:02:32,020

but later we'll see that there is a more

46

00:02:38,210 --> 00:02:35,080

much more powerful mechanism for during

47

00:02:42,570 --> 00:02:38,220

flow which is horizontal gene transfer

48

00:02:44,700 --> 00:02:42,580

horizontal field is a mechanism where

49

00:02:48,360 --> 00:02:44,710

the genetic functionalities can be

50

00:02:50,280 --> 00:02:48,370

swapped between different organisms so

51
00:02:50,940 --> 00:02:50,290
there are other different ingredients

52
00:02:54,449 --> 00:02:50,950
for life

53
00:02:57,650 --> 00:02:54,459
for example the eleven system is an eco

54
00:03:01,080 --> 00:02:57,660
system and it has two aspects

55
00:03:04,320 --> 00:03:01,090
why is population dynamics and for

56
00:03:06,479 --> 00:03:04,330
example the behavior of predator and

57
00:03:09,420 --> 00:03:06,489
prey in an ecosystem through person

58
00:03:13,229 --> 00:03:09,430
death processes and another aspect is

59
00:03:15,449 --> 00:03:13,239
metabolism query metabolic network

60
00:03:17,699 --> 00:03:15,459
inside organisms will form a global

61
00:03:21,479 --> 00:03:17,709
electronic market that transduces the

62
00:03:24,050 --> 00:03:21,489
energy flow so this to ask aspects has

63
00:03:29,699 --> 00:03:24,060

to be unified but so far we don't have a

64

00:03:32,610 --> 00:03:29,709

framework for that doing this talk we

65

00:03:35,190 --> 00:03:32,620

will focus mostly on the aspects of

66

00:03:38,190 --> 00:03:35,200

population dynamics with a little bit of

67

00:03:41,520 --> 00:03:38,200

energy flow while the next talk will

68

00:03:45,360 --> 00:03:41,530

focus on monopolizing but no population

69

00:03:47,820 --> 00:03:45,370

dynamics and also we will looking at the

70

00:03:50,280 --> 00:03:47,830

personal dynamics of marine microbes and

71

00:03:55,170 --> 00:03:50,290

allowing interaction with viruses and

72

00:04:00,390 --> 00:03:55,180

the energy flow will come from a the

73

00:04:04,320 --> 00:04:00,400

photo ingredients so this is a simple

74

00:04:08,160 --> 00:04:04,330

diagrammatic summary which says that a

75

00:04:09,930 --> 00:04:08,170

life living system can out-compete about

76

00:04:13,890 --> 00:04:09,940

its chemistry

77

00:04:18,599 --> 00:04:13,900

by utilizing gene flow metropolitan and

78

00:04:22,770 --> 00:04:18,609

population dynamics and this is the

79

00:04:25,500 --> 00:04:22,780

outline of my talk so the system were

80

00:04:28,380 --> 00:04:25,510

interesting is the marine Santa bacteria

81

00:04:31,020 --> 00:04:28,390

and that their creator viruses cosine of

82

00:04:33,300 --> 00:04:31,030

age and I will show that how general

83

00:04:36,240 --> 00:04:33,310

trend transfer between Sun and bacteria

84

00:04:38,430 --> 00:04:36,250

and a son of phage will form a

85

00:04:42,690 --> 00:04:38,440

collective Network that

86

00:04:46,080 --> 00:04:42,700

drives that are a whole ecosystem a2i to

87

00:04:48,990 --> 00:04:46,090

evolve and I will show that I build up a

88

00:04:50,970 --> 00:04:49,000

minimal model and the results will

89

00:04:53,640 --> 00:04:50,980

explain the range expansion and niche

90

00:04:57,540 --> 00:04:53,650

stirred stratification that have been

91

00:05:00,170 --> 00:04:57,550

observed in real data surprisely will

92

00:05:04,200 --> 00:05:00,180

see that predation in this case actually

93

00:05:08,790 --> 00:05:04,210

will stabilize a the ecosystem and it's

94

00:05:12,000 --> 00:05:08,800

been and beneficial to bacteria so let

95

00:05:16,380 --> 00:05:12,010

me quickly explain the spirit of

96

00:05:18,090 --> 00:05:16,390

modeling so conventionally I when people

97

00:05:20,160 --> 00:05:18,100

talk about bacteriophage they are

98

00:05:22,980 --> 00:05:20,170

thinking of prey in the predator so they

99

00:05:25,620 --> 00:05:22,990

model the system by using differential

100

00:05:28,320 --> 00:05:25,630

equations for example like a doctor for

101
00:05:30,840 --> 00:05:28,330
her type of models however that we

102
00:05:33,840 --> 00:05:30,850
explained before in a unified way

103
00:05:37,490 --> 00:05:33,850
including energy flow and information

104
00:05:41,040 --> 00:05:37,500
flow the interactions and relationships

105
00:05:44,190 --> 00:05:41,050
between bacteria and viruses are much

106
00:05:47,390 --> 00:05:44,200
more complicated so later I will show

107
00:05:52,620 --> 00:05:47,400
detail how we incorporate Elise

108
00:05:56,400 --> 00:05:52,630
ingredients in a model so the the the

109
00:05:59,250 --> 00:05:56,410
it's an ad hoc reservoir looking at is

110
00:06:02,280 --> 00:05:59,260
called perc attackers it's one of the

111
00:06:04,710 --> 00:06:02,290
most abundant openings on world and it

112
00:06:07,950 --> 00:06:04,720
has very small genome size is highly

113
00:06:12,090 --> 00:06:07,960

Streamlight but comparison ecoli has

114

00:06:15,540 --> 00:06:12,100

about 4 times larger of estremo sides

115

00:06:20,010 --> 00:06:15,550

and it affects a large amount of carbon

116

00:06:23,610 --> 00:06:20,020

others especially unlike most bacteria

117

00:06:27,870 --> 00:06:23,620

per caucus has no immune mechanism like

118

00:06:32,000 --> 00:06:27,880

CRISPR or profits so how does how does

119

00:06:36,090 --> 00:06:32,010

it avoid extinction under viral attack

120

00:06:40,530 --> 00:06:36,100

and it turns out prayer caucus find is

121

00:06:44,460 --> 00:06:40,540

defense against viruses by changing his

122

00:06:50,550 --> 00:06:44,470

surface protein where viruses would

123

00:06:52,290 --> 00:06:50,560

attach on cells and a and it appears to

124

00:06:56,189 --> 00:06:52,300

be a special signature

125

00:07:00,510 --> 00:06:56,199

this is yes genome coach genomic make

126

00:07:03,409 --> 00:07:00,520

island and we know is from it's probably

127

00:07:07,170 --> 00:07:03,419

from her intention transfer and

128

00:07:11,879 --> 00:07:07,180

therefore it shows a huge pan genome so

129

00:07:16,379 --> 00:07:11,889

a pan genome is a old question of genes

130

00:07:20,490 --> 00:07:16,389

of the same microbial species and and

131

00:07:23,939 --> 00:07:20,500

per caucus has a very large very large

132

00:07:27,360 --> 00:07:23,949

pen genome and is much larger than any

133

00:07:30,510 --> 00:07:27,370

single original world and that means

134

00:07:34,459 --> 00:07:30,520

that any two per kakaka cells would

135

00:07:40,559 --> 00:07:34,469

share only very few genes in common

136

00:07:43,920 --> 00:07:40,569

so on a much larger scope per caucus has

137

00:07:48,270 --> 00:07:43,930

another feature which is a niche

138

00:07:51,330 --> 00:07:48,280

register applications with to emerge

139

00:07:53,520 --> 00:07:51,340

subgroups for example here on a lamp a

140

00:07:57,019 --> 00:07:53,530

know it shows a light intensity as a

141

00:08:01,170 --> 00:07:57,029

function of death that bell in ocean and

142

00:08:04,350 --> 00:08:01,180

the there are two subgroups the to equal

143

00:08:07,469 --> 00:08:04,360

types of per caucus one is highlighted

144

00:08:10,370 --> 00:08:07,479

adapted a colonize near the surface of

145

00:08:14,370 --> 00:08:10,380

ocean another one is low-light adapted

146

00:08:17,790 --> 00:08:14,380

ecotype and our model will try to

147

00:08:20,279 --> 00:08:17,800

explain this phenomenon also Kolkata's

148

00:08:23,700 --> 00:08:20,289

phage calls anaphase carry for the

149

00:08:26,070 --> 00:08:23,710

vintage jeans and it has found that it's

150

00:08:29,879 --> 00:08:26,080

on a phage with polyphenols genes

151
00:08:35,339 --> 00:08:29,889
actually have higher per size when when

152
00:08:38,310 --> 00:08:35,349
they do the lysis and it turns out a

153
00:08:41,100 --> 00:08:38,320
sign of fish god these full of the genes

154
00:08:45,269 --> 00:08:41,110
from horizontal gene transfer so this is

155
00:08:48,180 --> 00:08:45,279
of phenology data I found by a penny

156
00:08:52,470 --> 00:08:48,190
reasons group and this is a published in

157
00:08:55,590 --> 00:08:52,480
the paper by Sullivan at all in 2006 so

158
00:08:58,370 --> 00:08:55,600
here it shows that a in the middle of

159
00:09:02,100 --> 00:08:58,380
bacterial gene for photosynthesis to

160
00:09:04,920 --> 00:09:02,110
adrenal drains and the viruses the genes

161
00:09:05,820 --> 00:09:04,930
appear in the middle of the bacterial

162
00:09:08,430 --> 00:09:05,830
genes

163
00:09:10,710 --> 00:09:08,440

so this is a the evidence of harsh on

164

00:09:16,590 --> 00:09:10,720

gene transfer that viruses cartaginés

165

00:09:19,530 --> 00:09:16,600

from bacteria so I their interpretation

166

00:09:22,560 --> 00:09:19,540

for this data is that bacteria viruses

167

00:09:25,079 --> 00:09:22,570

can form a collective States and create

168

00:09:27,360 --> 00:09:25,089

a global reservoir for photosynthesis

169

00:09:30,449 --> 00:09:27,370

genes that benefits both bacteria and

170

00:09:34,740 --> 00:09:30,459

viruses and in this talk we're going to

171

00:09:40,230 --> 00:09:34,750

a show by a mineral model how this can

172

00:09:42,949 --> 00:09:40,240

actually work so in our model I the

173

00:09:45,120 --> 00:09:42,959

mechanism for hard on gingers fear is

174

00:09:46,880 --> 00:09:45,130

down through the process called

175

00:09:51,360 --> 00:09:46,890

generalized transduction

176

00:09:53,490 --> 00:09:51,370

so in general instruction a virus finds

177

00:09:56,490 --> 00:09:53,500

a bacterial cell and infects it and

178

00:10:00,720 --> 00:09:56,500

insert its genome into the bacterial cell

179

00:10:04,199 --> 00:10:00,730

and it will hijack bacteria's machinery

180

00:10:06,660 --> 00:10:04,209

and so make bacteria to produce many

181

00:10:10,230 --> 00:10:06,670

copies of viruses and the bacteria will

182

00:10:12,780 --> 00:10:10,240

die but occasionally very few of baby

183

00:10:16,470 --> 00:10:12,790

viruses would accidentally

184

00:10:20,940 --> 00:10:16,480

grab some bacteria's genes

185

00:10:23,910 --> 00:10:20,950

so these genes will function like normal

186

00:10:27,870 --> 00:10:23,920

viruses instead they were more like

187

00:10:31,170 --> 00:10:27,880

zombies so when when one of Samba

188

00:10:34,490 --> 00:10:31,180

viruses float and find new bacterial

189

00:10:37,319 --> 00:10:34,500

cell and in fact the new bacterial cell

190

00:10:40,170 --> 00:10:37,329

this new better cell won't die and

191

00:10:44,550 --> 00:10:40,180

instead they can utilize the bacterial

192

00:10:47,819 --> 00:10:44,560

genes from the previous bacteria so this

193

00:10:51,019 --> 00:10:47,829

is how the bacteria can can can

194

00:10:55,110 --> 00:10:51,029

penetrate from a viral pretty predation

195

00:10:58,889 --> 00:10:55,120

so how does that harder in gene transfer

196

00:11:07,819 --> 00:10:58,899

I can work correctly this is how the

197

00:11:10,889 --> 00:11:07,829

story can work yeah this color area

198

00:11:13,949 --> 00:11:10,899

shows BIOS a fear of bacteria and

199

00:11:17,610 --> 00:11:13,959

viruses and the plus sign here for

200

00:11:19,810 --> 00:11:17,620

simplicity stands for the beneficial

201
00:11:22,900 --> 00:11:19,820

genes that

202
00:11:26,290 --> 00:11:22,910

for example provides more efficient

203
00:11:30,540 --> 00:11:26,300

metabolism and the money signs I stands

204
00:11:34,840 --> 00:11:30,550

for jeans that that are less efficient

205
00:11:37,090 --> 00:11:34,850

so first viruses can get a get paid paid

206
00:11:40,600 --> 00:11:37,100

back bacterias genes from hard earned

207
00:11:42,610 --> 00:11:40,610

gene transfer and the key point here is

208
00:11:43,410 --> 00:11:42,620

that the viruses has higher mutation

209
00:11:46,690 --> 00:11:43,420

rate

210
00:11:49,600 --> 00:11:46,700

so therefore the pig the viruses are

211
00:11:53,260 --> 00:11:49,610

like a generator of new genes and they

212
00:11:55,660 --> 00:11:53,270

create either better gene or worse genes

213
00:11:58,780 --> 00:11:55,670

and they don't list genes back to

214

00:12:01,870 --> 00:11:58,790

bacteria and now bacteria got the

215

00:12:05,230 --> 00:12:01,880

nutrients from viruses and then our key

216

00:12:08,740 --> 00:12:05,240

point is that bacteria here the string

217

00:12:10,990 --> 00:12:08,750

Adu streamlining so they behave like a

218

00:12:12,990 --> 00:12:11,000

filter so they filled out of the

219

00:12:16,150 --> 00:12:13,000

belgians and only bacteria with

220

00:12:19,060 --> 00:12:16,160

beneficial genes can survive so by this

221

00:12:22,540 --> 00:12:19,070

way the bacteria will save the

222

00:12:27,579 --> 00:12:22,550

penetrator genes and will transfer these

223

00:12:29,890 --> 00:12:27,589

pathogens to back to viruses and viruses

224

00:12:32,110 --> 00:12:29,900

would get the better chains and that

225

00:12:35,100 --> 00:12:32,120

this processor will repeat again and

226
00:12:41,340 --> 00:12:35,110
again and in the end the whole biosphere

227
00:12:51,160 --> 00:12:46,360
next I'm going to show how show a

228
00:12:55,620 --> 00:12:51,170
sequence of models by adding a step by

229
00:13:00,220 --> 00:12:55,630
step a different evolutionary mechanisms

230
00:13:03,100 --> 00:13:00,230
to explain how the previous cartoon

231
00:13:05,230 --> 00:13:03,110
picture can actually work so first I'll

232
00:13:08,550 --> 00:13:05,240
consider a very simple model where

233
00:13:12,220 --> 00:13:08,560
bacteria and viruses have a type of

234
00:13:16,720 --> 00:13:12,230
infection predation gene and I will show

235
00:13:20,910 --> 00:13:16,730
how how our engines transfer well I will

236
00:13:24,190 --> 00:13:20,920
have is a attacked and AJ I have a

237
00:13:27,160 --> 00:13:24,200
considered different type of model where

238
00:13:30,240 --> 00:13:27,170

bacteria viruses have no type of genes

239

00:13:33,280 --> 00:13:30,250

which stands for photosynthesis

240

00:13:37,150 --> 00:13:33,290

efficiency and we'll see the effect

241

00:13:40,240 --> 00:13:37,160

hurricane transfer as well and for the

242

00:13:44,829 --> 00:13:40,250

next model I'll consider the case where

243

00:13:48,389 --> 00:13:44,839

they the genes have deleterious mutation

244

00:13:54,280 --> 00:13:48,399

and in the end I'll include a the photo

245

00:13:58,059 --> 00:13:54,290

gradient as the energy flow okay so this

246

00:14:00,610 --> 00:13:58,069

is the first model the first model is

247

00:14:02,590 --> 00:14:00,620

very simple we consider a bacteria and

248

00:14:08,129 --> 00:14:02,600

the viruses as prey and the prey here

249

00:14:13,329 --> 00:14:08,139

and here the ecological processes here

250

00:14:17,350 --> 00:14:13,339

like the chemical reactions so here

251
00:14:20,650 --> 00:14:17,360
bacteria we assume bacteria and viruses

252
00:14:29,259 --> 00:14:20,660
have a type of genes whose value stands

253
00:14:32,740 --> 00:14:29,269
for the ability to defense or attack so

254
00:14:36,790 --> 00:14:32,750
here for example a pea with Sabine des i

255
00:14:40,030 --> 00:14:36,800
stands for bacteria individual with some

256
00:14:43,180 --> 00:14:40,040
dream value i and the first process here

257
00:14:46,990 --> 00:14:43,190
is that this bacteria has some

258
00:14:51,939 --> 00:14:47,000
probability be per unit time to produce

259
00:14:54,340 --> 00:14:51,949
another sim copy and an hour process of

260
00:14:57,490 --> 00:14:54,350
partition means that a different

261
00:14:59,949 --> 00:14:57,500
bacteria would compete with the same

262
00:15:02,019 --> 00:14:59,959
food resource so one of bacteria would

263
00:15:06,480 --> 00:15:02,029

die and both bacteria and the viruses

264

00:15:11,230 --> 00:15:06,490

will die and then naturally with some

265

00:15:15,519 --> 00:15:11,240

probability and if in predation one

266

00:15:18,519 --> 00:15:15,529

bacteria in counts viruses if the virus

267

00:15:20,920 --> 00:15:18,529

carries a gene whose value is larger

268

00:15:24,639 --> 00:15:20,930

than the dream value of that bacterial

269

00:15:28,980 --> 00:15:24,649

cell there is a probability that this

270

00:15:32,679 --> 00:15:28,990

Petrea would be killed and a amount of

271

00:15:38,199 --> 00:15:32,689

faith per size of baby viruses will be

272

00:15:41,500 --> 00:15:38,209

produced and the problem of Liz Malo is

273

00:15:46,389 --> 00:15:41,510

largely the phage burst size and here is

274

00:15:47,140 --> 00:15:46,399

large is about ten to hundreds so we

275

00:15:50,250 --> 00:15:47,150

would imagine

276

00:15:52,780 --> 00:15:50,260

that the the viruses so could easily

277

00:15:54,970 --> 00:15:52,790

overwhelm to the hop-hop population and

278

00:15:56,860 --> 00:15:54,980

drive the extinction of bacteria and

279

00:15:59,590 --> 00:15:56,870

this is what are we observing our

280

00:16:02,050 --> 00:15:59,600

simulations this is a population of

281

00:16:06,070 --> 00:16:02,060

bacteria and viruses the Redis virus a

282

00:16:09,130 --> 00:16:06,080

bacteria is in boo and we see that the

283

00:16:12,130 --> 00:16:09,140

the population of viruses would

284

00:16:19,300 --> 00:16:12,140

oscillate a lot and finally we'll drive

285

00:16:23,560 --> 00:16:19,310

the population to extinction however

286

00:16:26,520 --> 00:16:23,570

life finds his own solution in reality

287

00:16:30,220 --> 00:16:26,530

we know that genes can mutate so we

288

00:16:33,430 --> 00:16:30,230

consider a mutation of the genes for

289

00:16:36,220 --> 00:16:33,440

example when a bacteria we dream well I

290

00:16:39,400 --> 00:16:36,230

give the first to another copy

291

00:16:42,280 --> 00:16:39,410

there's additional probability μ B here

292

00:16:44,560 --> 00:16:42,290

for a new copy to mutate into a

293

00:16:48,190 --> 00:16:44,570

different ring values okay

294

00:16:50,770 --> 00:16:48,200

so n stand for the predation so for

295

00:16:53,740 --> 00:16:50,780

predation there's a additional poverty

296

00:16:57,630 --> 00:16:53,750

movie that a lot of baby viruses would

297

00:17:03,070 --> 00:16:57,640

mutate into different gene values from

298

00:17:06,310 --> 00:17:03,080

its mother so in this case we found that

299

00:17:07,000 --> 00:17:06,320

the postpay tree and the viral genes can

300

00:17:10,329 --> 00:17:07,010

Co evolve

301
00:17:12,520 --> 00:17:10,339
so this shows Jun value the averaging

302
00:17:14,770 --> 00:17:12,530
values of bacteria and viruses as a

303
00:17:18,699 --> 00:17:14,780
function of time and we can see they're

304
00:17:21,810 --> 00:17:18,709
both of layering values can evolve and

305
00:17:24,390 --> 00:17:21,820
increase and it turns out in this case

306
00:17:31,150 --> 00:17:24,400
that the post bacteria and the viruses

307
00:17:33,240 --> 00:17:31,160
can come up and avoid the extinction so

308
00:17:39,040 --> 00:17:33,250
however there is a null problem

309
00:17:42,100 --> 00:17:39,050
apartments that usually the bacteria has

310
00:17:45,400 --> 00:17:42,110
slower mutation rate than viruses so in

311
00:17:47,530 --> 00:17:45,410
this case the virus would mutate much

312
00:17:52,390 --> 00:17:47,540
quicker than bacteria so it's gene

313
00:17:54,820 --> 00:17:52,400

values a grows faster in wait time in

314

00:17:56,590 --> 00:17:54,830

the end them means that virus will

315

00:18:01,080 --> 00:17:56,600

become stronger and stronger and

316

00:18:05,770 --> 00:18:01,090

eventually still outcompetes bacteria

317

00:18:08,770 --> 00:18:05,780

again my finds his own solution so if we

318

00:18:10,830 --> 00:18:08,780

consider how to drain gene transfer like

319

00:18:16,530 --> 00:18:10,840

a general instruction process we

320

00:18:20,920 --> 00:18:16,540

explained before so these two processes

321

00:18:23,080 --> 00:18:20,930

well describe the gene flow from

322

00:18:25,510 --> 00:18:23,090

bacteria of Tobias and in virus to

323

00:18:28,590 --> 00:18:25,520

bacteria and viruses with high mutation

324

00:18:32,050 --> 00:18:28,600

rate can keep generator new genes and

325

00:18:34,750 --> 00:18:32,060

they can transfer these genes to

326

00:18:37,360 --> 00:18:34,760

bacteria and eventually form a flow of

327

00:18:41,230 --> 00:18:37,370

beneficial genes and that beneficial

328

00:18:44,320 --> 00:18:41,240

gene flow will help let bacteria which

329

00:18:47,200 --> 00:18:44,330

have a slow medium rate so in our

330

00:18:50,500 --> 00:18:47,210

simulation we see again a coevolution of

331

00:18:54,670 --> 00:18:50,510

the genes in bacteria and the viruses

332

00:18:56,050 --> 00:18:54,680

and in it turns out that both bacteria

333

00:18:58,420 --> 00:18:56,060

and the viruses can keep later

334

00:19:02,410 --> 00:18:58,430

pollutions and the ecosystem become

335

00:19:05,050 --> 00:19:02,420

stable again so here we consider a

336

00:19:07,750 --> 00:19:05,060

second type of model previously we

337

00:19:10,620 --> 00:19:07,760

consider a packet and the viruses have a

338

00:19:13,840 --> 00:19:10,630

type with chain stands for infection

339

00:19:16,600 --> 00:19:13,850

predation but now here we consider a peg

340

00:19:18,910 --> 00:19:16,610

here and the viruses have a different

341

00:19:23,950 --> 00:19:18,920

type of chains and that gene stands for

342

00:19:27,460 --> 00:19:23,960

metal incidences efficiency policy needs

343

00:19:30,340 --> 00:19:27,470

ability so for example this bacteria P

344

00:19:34,860 --> 00:19:30,350

we submit hinges I stands for bacteria

345

00:19:39,250 --> 00:19:34,870

with some Jing value for managing Val I

346

00:19:43,210 --> 00:19:39,260

so it can and we here we for simplicity

347

00:19:46,060 --> 00:19:43,220

we said that I the the first rate of

348

00:19:49,480 --> 00:19:46,070

bacteria is a function of is

349

00:19:51,370 --> 00:19:49,490

photosynthesis value so different

350

00:19:55,480 --> 00:19:51,380

bacteria would have different birth rate

351
00:19:59,100 --> 00:19:55,490
and to create a new copy and similar for

352
00:20:03,330 --> 00:19:59,110
viruses so viruses to have a

353
00:20:06,970 --> 00:20:03,340
photosynthesis jiating J would have a

354
00:20:10,840 --> 00:20:06,980
different verses that depends on that

355
00:20:14,090 --> 00:20:10,850
dream value so with high dream values

356
00:20:17,860 --> 00:20:14,100
that viruses would have higher

357
00:20:21,049 --> 00:20:17,870
Versailles so in your simulation

358
00:20:24,680 --> 00:20:21,059
similarly in a case that the virus has

359
00:20:27,890 --> 00:20:24,690
higher mutation rate the the viruses

360
00:20:30,919 --> 00:20:27,900
would quickly evolve into very hyper

361
00:20:34,850 --> 00:20:30,929
size and the population will eventually

362
00:20:38,000 --> 00:20:34,860
overwhelm by the bacterial population so

363
00:20:42,970 --> 00:20:38,010

it will drive by the bacteria to

364

00:20:47,600 --> 00:20:42,980

extinction so again if we consider

365

00:20:51,890 --> 00:20:47,610

hard-learned gene transfer then now the

366

00:20:54,100 --> 00:20:51,900

viruses can produce a good genes and and

367

00:20:57,320 --> 00:20:54,110

the transfer of this benefit range of

368

00:21:01,310 --> 00:20:57,330

bacteria then bacteria can also increase

369

00:21:04,549 --> 00:21:01,320

their purse size by utilize viruses

370

00:21:06,409 --> 00:21:04,559

James so in the end the photo sneezed

371

00:21:09,620 --> 00:21:06,419

rings in patreon the virus can call

372

00:21:16,880 --> 00:21:09,630

together again and their population I

373

00:21:20,120 --> 00:21:16,890

can be sustained so next we are going to

374

00:21:25,220 --> 00:21:20,130

consider a different case so in general

375

00:21:28,029 --> 00:21:25,230

for well adapted species I most

376

00:21:31,909 --> 00:21:28,039

mutations are neutral or deleterious

377

00:21:34,730 --> 00:21:31,919

Sudheer engines for mutation accumulates

378

00:21:37,549 --> 00:21:34,740

and they will make individuals die and

379

00:21:40,850 --> 00:21:37,559

the population will shrink in like hey

380

00:21:43,850 --> 00:21:40,860

it's really called mula stretched in

381

00:21:47,360 --> 00:21:43,860

this case when we publish and decrease

382

00:21:50,930 --> 00:21:47,370

the demography stochastic would be more

383

00:21:54,860 --> 00:21:50,940

important and leading population go to

384

00:21:58,820 --> 00:21:54,870

extinction faster and we think that in

385

00:22:02,270 --> 00:21:58,830

range expansion that they in the like

386

00:22:04,580 --> 00:22:02,280

individuals expand is colony at the

387

00:22:06,529 --> 00:22:04,590

front of the demo for the population

388

00:22:09,850 --> 00:22:06,539

small so democrat party asians are

389

00:22:12,890 --> 00:22:09,860

important so this effect would be

390

00:22:15,620 --> 00:22:12,900

significant so we consider release

391

00:22:21,620 --> 00:22:15,630

affecting all model of follow signals

392

00:22:23,720 --> 00:22:21,630

genes so here we plot the fullest aging

393

00:22:26,870 --> 00:22:23,730

of bacteria and viruses function of time

394

00:22:27,950 --> 00:22:26,880

because of deleterious mutation the

395

00:22:32,629 --> 00:22:27,960

virus with high

396

00:22:35,239 --> 00:22:32,639

mutation rate would would decrease lay

397

00:22:38,180 --> 00:22:35,249

jeans very quickly and in the end of

398

00:22:43,269 --> 00:22:38,190

their population would collapse but if

399

00:22:47,359 --> 00:22:43,279

we turn on the halogen transfer then the

400

00:22:50,060 --> 00:22:47,369

the bacteria now can help viruses we can

401
00:22:52,759 --> 00:22:50,070
see that by looking at a distribution of

402
00:22:54,619 --> 00:22:52,769
a full of sneeze genes in bacteria and

403
00:22:58,399 --> 00:22:54,629
distribution of pollination gene in

404
00:23:01,369 --> 00:22:58,409
viruses so this black lines stands for

405
00:23:06,019 --> 00:23:01,379
the genes transferred from viruses to

406
00:23:08,960 --> 00:23:06,029
bacteria and here black pine stands for

407
00:23:11,749 --> 00:23:08,970
genes transferred from patriotic viruses

408
00:23:15,950 --> 00:23:11,759
and we see that the genes transferred

409
00:23:22,249 --> 00:23:15,960
from viruses to bacteria can range with

410
00:23:25,009 --> 00:23:22,259
a can range over a many values however

411
00:23:29,330 --> 00:23:25,019
the bacteria behaves like a filter that

412
00:23:32,690 --> 00:23:29,340
will keep only the genes which are

413
00:23:38,409 --> 00:23:32,700

beneficial and transfer back to viruses

414

00:23:42,580 --> 00:23:38,419

so viruses I now can have more a

415

00:23:47,269 --> 00:23:42,590

frequencies at a the beneficial trains

416

00:23:50,480 --> 00:23:47,279

so so it turns out because of hard rain

417

00:23:53,600 --> 00:23:50,490

transfer now the photos and any genes in

418

00:23:57,320 --> 00:23:53,610

bacteria viruses won't decrease they

419

00:24:01,100 --> 00:23:57,330

won't degenerate and then they can come

420

00:24:06,200 --> 00:24:01,110

off and their population can be stable

421

00:24:09,680 --> 00:24:06,210

in this ecosystem we can start your face

422

00:24:12,499 --> 00:24:09,690

Tigra of this model so here we plot the

423

00:24:16,249 --> 00:24:12,509

ratio of viruses with beneficial genes

424

00:24:18,980 --> 00:24:16,259

as a function of Harvey and transfer in

425

00:24:22,190 --> 00:24:18,990

the units of mutation rates the in

426
00:24:24,259 --> 00:24:22,200
principle we can change or mutate the

427
00:24:26,749 --> 00:24:24,269
horizontal gene transfer rate by

428
00:24:30,379 --> 00:24:26,759
changing the density of the population

429
00:24:32,029 --> 00:24:30,389
early in individuals here in our

430
00:24:35,869 --> 00:24:32,039
simulation we can choose higher interest

431
00:24:39,769 --> 00:24:35,879
rate and we found that only when the

432
00:24:41,030 --> 00:24:39,779
hard interest rate is large enough then

433
00:24:44,750 --> 00:24:41,040
the bacteria

434
00:24:47,450 --> 00:24:44,760
they can form a creative state so there

435
00:24:51,340 --> 00:24:47,460
will be enough beneficial in enough

436
00:24:55,280 --> 00:24:51,350
population of beneficial genes in

437
00:24:58,250 --> 00:24:55,290
viruses however we also found that a

438
00:25:01,640 --> 00:24:58,260

whole gene transfer rate cannot be too

439

00:25:05,780 --> 00:25:01,650

large if it's too large that means that

440

00:25:08,120 --> 00:25:05,790

all of us would already have very good

441

00:25:13,580 --> 00:25:08,130

genes and more hard gene transfer were

442

00:25:16,460 --> 00:25:13,590

just eye at the last beneficial genes

443

00:25:22,820 --> 00:25:16,470

into a population so that will give the

444

00:25:25,940 --> 00:25:22,830

system a negative effect so here I want

445

00:25:30,650 --> 00:25:25,950

to address again why this is a

446

00:25:34,010 --> 00:25:30,660

collective state so we found that in our

447

00:25:35,930 --> 00:25:34,020

simulation it is very important that we

448

00:25:38,210 --> 00:25:35,940

have the both ways of heard during

449

00:25:41,600 --> 00:25:38,220

transfer from bacteria viruses and from

450

00:25:44,300 --> 00:25:41,610

viruses or bacteria so therefore they

451
00:25:46,460 --> 00:25:44,310
can keep dependable genes in both

452
00:25:50,930 --> 00:25:46,470
bacteria and viruses so in your

453
00:25:53,780 --> 00:25:50,940
simulation if we turn off either a one

454
00:25:56,870 --> 00:25:53,790
side of her gene transfer for example I

455
00:26:01,660 --> 00:25:56,880
at least I'm pwned the system work

456
00:26:04,430 --> 00:26:01,670
quickly just a class so this shows that

457
00:26:07,130 --> 00:26:04,440
this is a truly cracked state that

458
00:26:11,300 --> 00:26:07,140
requires both ways of how our interest

459
00:26:14,330 --> 00:26:11,310
rate between bacteria and viruses so

460
00:26:17,300 --> 00:26:14,340
finally we include the energy flow by

461
00:26:21,800 --> 00:26:17,310
adding a background of home ingredients

462
00:26:24,170 --> 00:26:21,810
for her gradient see this is the data I

463
00:26:26,510 --> 00:26:24,180

show you at the beginning and in our

464

00:26:28,760 --> 00:26:26,520

simulation we also create a background

465

00:26:36,230 --> 00:26:28,770

of photo intensity as function for tab

466

00:26:38,630 --> 00:26:36,240

and here for we include they I the photo

467

00:26:43,340 --> 00:26:38,640

intensity into the first rate of

468

00:26:46,670 --> 00:26:43,350

bacteria and also we the the test rate

469

00:26:49,460 --> 00:26:46,680

of bacteria depend on the photo

470

00:26:51,010 --> 00:26:49,470

intensity because the cells near surface

471

00:26:54,890 --> 00:26:51,020

wouldn't get burned

472

00:26:58,910 --> 00:26:54,900

okay so in your model

473

00:27:03,170 --> 00:26:58,920

we first start with low light adapted

474

00:27:08,000 --> 00:27:03,180

ecotype that evolve first so they

475

00:27:12,590 --> 00:27:08,010

initially occupied at the the parting of

476
00:27:15,890 --> 00:27:12,600
the sea and then they coexist waste of

477
00:27:18,500 --> 00:27:15,900
viruses and they can do horizontal

478
00:27:22,460 --> 00:27:18,510
transfer with the viruses and the wait

479
00:27:25,040 --> 00:27:22,470
turn on the simulations so eventually we

480
00:27:29,180 --> 00:27:25,050
can see that develop of this low light

481
00:27:32,090 --> 00:27:29,190
adaptive bacteria and evolve into a

482
00:27:36,260 --> 00:27:32,100
different eco type which is highlight

483
00:27:38,450 --> 00:27:36,270
adapted bacteria but the key point is

484
00:27:42,260 --> 00:27:38,460
that if we don't have halogen transfer

485
00:27:46,730 --> 00:27:42,270
it takes very very long time for the low

486
00:27:50,500 --> 00:27:46,740
light of bacteria to mutate into halogen

487
00:27:53,960 --> 00:27:50,510
sorry they highlighted ability by

488
00:27:57,770 --> 00:27:53,970

bacteria through just a pure random

489

00:27:59,750 --> 00:27:57,780

mutation so only through our gene

490

00:28:02,440 --> 00:27:59,760

transfer we can see a relative

491

00:28:06,740 --> 00:28:02,450

reasonable time scale that this

492

00:28:10,850 --> 00:28:06,750

evolution of ecosystem development could

493

00:28:13,910 --> 00:28:10,860

occur so I will show you an animation of

494

00:28:15,970 --> 00:28:13,920

our simulation where the yellow stands

495

00:28:19,810 --> 00:28:15,980

for low light a deadly bacteria

496

00:28:22,730 --> 00:28:19,820

advocating coexisting with the red

497

00:28:26,090 --> 00:28:22,740

viruses the eventual evolved form

498

00:28:31,010 --> 00:28:26,100

highlight a tablet bacteria which is in

499

00:28:33,700 --> 00:28:31,020

blue color so here we initially have

500

00:28:37,640 --> 00:28:33,710

localized area coexist with viruses and

501
00:28:42,020 --> 00:28:37,650
they do harder entrance transfer and the

502
00:28:45,650 --> 00:28:42,030
viruses I diffused with bacteria and

503
00:28:47,770 --> 00:28:45,660
help back to the low light at a Debra

504
00:28:51,140 --> 00:28:47,780
tyria develop into a highlight at the

505
00:28:56,650 --> 00:28:51,150
bacteria and we can see the distinct

506
00:29:04,180 --> 00:29:01,150
so our simulation results explain that

507
00:29:08,510 --> 00:29:04,190
bacteria and phage can help each other

508
00:29:10,190 --> 00:29:08,520
bacteria can get help from viruses

509
00:29:12,890 --> 00:29:10,200
because viruses have higher mutation

510
00:29:15,590 --> 00:29:12,900
rates so they behave like a generator of

511
00:29:20,270 --> 00:29:15,600
new genes the bacteria can get benefit

512
00:29:23,419 --> 00:29:20,280
of genes found Rises and viruses can get

513
00:29:25,820 --> 00:29:23,429

help from bacteria in spectra have new

514

00:29:30,020 --> 00:29:25,830

streamlining and have so mutation rate

515

00:29:33,290 --> 00:29:30,030

so big bacteria can help viruses to

516

00:29:35,750 --> 00:29:33,300

filled out that Jing's and keep only

517

00:29:37,610 --> 00:29:35,760

beneficial genes so in these ways they

518

00:29:42,860 --> 00:29:37,620

can help each other and inform

519

00:29:46,640 --> 00:29:42,870

collective States so here I like to

520

00:29:50,270 --> 00:29:46,650

summarize what is our mineral model can

521

00:29:52,340 --> 00:29:50,280

explain so the result of our model are

522

00:29:55,130 --> 00:29:52,350

consistent ways to the facts in perco

523

00:29:58,640 --> 00:29:55,140

caucus for example precocity has high

524

00:30:02,900 --> 00:29:58,650

string my genome and that limits the

525

00:30:04,910 --> 00:30:02,910

metabolic redundancy so the only way to

526

00:30:10,520 --> 00:30:04,920

improve metabolism is to improve the

527

00:30:17,960 --> 00:30:10,530

efficiency and we know and that means

528

00:30:21,140 --> 00:30:17,970

that a so I and we we know there is no

529

00:30:26,810 --> 00:30:21,150

no immune mechanism I CRISPR professors

530

00:30:29,570 --> 00:30:26,820

in purple caucus and and the that

531

00:30:32,600 --> 00:30:29,580

because bacteria don't need that the

532

00:30:35,330 --> 00:30:32,610

sunny bacteria can balance is i between

533

00:30:37,610 --> 00:30:35,340

the risk of predation and the benefit

534

00:30:41,510 --> 00:30:37,620

and the benefit from hard running

535

00:30:44,299 --> 00:30:41,520

transfer and that well reflects in the

536

00:30:47,990 --> 00:30:44,309

hi at a huge pen genome in perco caucus

537

00:30:52,070 --> 00:30:48,000

and the presence of a genomic i islands

538

00:30:55,700 --> 00:30:52,080

and any also they has chose nation

539

00:30:58,370 --> 00:30:55,710

certifications which is a result from

540

00:31:01,940 --> 00:30:58,380

the viral media the utilization of the

541

00:31:04,820 --> 00:31:01,950

energy flow and also our model shows

542

00:31:08,330 --> 00:31:04,830

that a sign of aged which carry full of

543

00:31:10,580 --> 00:31:08,340

these genes can can help improve full

544

00:31:15,520 --> 00:31:10,590

incisions in the bacteria and as

545

00:31:22,370 --> 00:31:15,530

consistent ways the fact in proto caucus

546

00:31:24,320 --> 00:31:22,380

so here are some take-home messages so

547

00:31:26,720 --> 00:31:24,330

at beginning I show that the planetary

548

00:31:31,310 --> 00:31:26,730

living system theory will require

549

00:31:33,860 --> 00:31:31,320

unified picture of I in ecology which

550

00:31:36,259 --> 00:31:33,870

are there are two aspects one is

551
00:31:38,690 --> 00:31:36,269
population biology and energy flow and

552
00:31:41,629 --> 00:31:38,700
we still need a unified framework for

553
00:31:44,509 --> 00:31:41,639
that and in this talk I use mostly

554
00:31:48,919 --> 00:31:44,519
population dynamics and a little energy

555
00:31:52,909 --> 00:31:48,929
flow and also ecosystems our collective

556
00:31:55,940 --> 00:31:52,919
and our model and simulation shows that

557
00:31:58,399 --> 00:31:55,950
sometimes the eCos instability should be

558
00:32:01,730 --> 00:31:58,409
understood by considering multi state

559
00:32:04,490 --> 00:32:01,740
scale interactions that ranges from the

560
00:32:08,269 --> 00:32:04,500
scale of genes to the scale of the whole

561
00:32:10,970 --> 00:32:08,279
environment another key points that

562
00:32:13,850 --> 00:32:10,980
information flow especially through

563
00:32:17,240 --> 00:32:13,860

halogen gene transfer that provides a

564

00:32:19,639 --> 00:32:17,250

gene flow that allows life to maintain

565

00:32:25,070 --> 00:32:19,649

and expand its range in thermodynamic

566

00:32:27,249 --> 00:32:25,080

radians so with that I stop here and

567

00:32:40,340 --> 00:32:27,259

I'll be happy to take any questions

568

00:32:46,090 --> 00:32:40,350

thank you all right thanks for the great

569

00:32:55,039 --> 00:32:49,490

so the discovery of photosystem 2 genes

570

00:32:58,669 --> 00:32:55,049

in in phage around 15 years ago was very

571

00:33:01,580 --> 00:32:58,679

curious so as I mentioned earlier in a

572

00:33:05,419 --> 00:33:01,590

passing comment about d1 so d1 protein

573

00:33:07,669 --> 00:33:05,429

is the PSB a protein which turns over

574

00:33:11,720 --> 00:33:07,679

very rapidly it also has one of the

575

00:33:15,430 --> 00:33:11,730

fastest promoters of any gene known in a

576

00:33:18,230 --> 00:33:15,440

eukaryotic cell so do you think that the

577

00:33:21,230 --> 00:33:18,240

virus has co-opted these genes in order

578

00:33:23,720 --> 00:33:21,240

to promote their own rapid reproductive

579

00:33:25,519 --> 00:33:23,730

capability within their host cell or is

580

00:33:27,769 --> 00:33:25,529

there some other reason that you can

581

00:33:29,570 --> 00:33:27,779

imagine that these genes very

582

00:33:37,039 --> 00:33:29,580

specifically were incorporated into

583

00:33:44,940 --> 00:33:41,909

so the questions is about the details of

584

00:33:47,430 --> 00:33:44,950

evolution of photosynthesis system genes

585

00:33:52,219 --> 00:33:47,440

but their incorporation of those genes

586

00:33:55,229 --> 00:33:52,229

into viruses into marine viruses rather

587

00:33:56,399 --> 00:33:55,239

was never you know when it was

588

00:34:02,700 --> 00:33:56,409

discovered it was thought it was an

589

00:34:04,259 --> 00:34:02,710

artifact and itself obviously not an

590

00:34:05,969 --> 00:34:04,269

artifact I just wondered if you have any

591

00:34:14,510 --> 00:34:05,979

thoughts as to why those genes would be

592

00:34:16,919 --> 00:34:14,520

in a virus they're very abundant right

593

00:34:27,419 --> 00:34:16,929

so then we try to understand the

594

00:34:35,190 --> 00:34:27,429

question a are you asking that a why

595

00:34:39,240 --> 00:34:35,200

those genes have to appear in viruses so

596

00:34:42,779 --> 00:34:39,250

in photosystem ii there are a series of

597

00:34:47,190 --> 00:34:42,789

genes in cyanobacteria and every alga

598

00:34:49,319 --> 00:34:47,200

and every plant that splits water that

599

00:34:51,750 --> 00:34:49,329

encodes for this one protein called the

600

00:34:57,450 --> 00:34:51,760

d1 protein that if you span one protein

601
00:35:01,170 --> 00:34:57,460
and the gene is photosystem PS be

602
00:35:06,089 --> 00:35:01,180
photosystem 2 subunit a right so it's PS

603
00:35:09,750 --> 00:35:06,099
PA all right now yes B yeah okay so now

604
00:35:12,630 --> 00:35:09,760
when we get to this gene it turns out

605
00:35:15,990 --> 00:35:12,640
this protein product of the of the gene

606
00:35:18,240 --> 00:35:16,000
turns over very rapidly about every 25

607
00:35:20,579 --> 00:35:18,250
to 30 minutes from the end of day when

608
00:35:24,660 --> 00:35:20,589
the light is shining so in order to keep

609
00:35:27,029 --> 00:35:24,670
that repair mechanism going the cell

610
00:35:30,779 --> 00:35:27,039
makes a lot of extra d1 so it has a

611
00:35:33,870 --> 00:35:30,789
promoter that is very very very highly

612
00:35:38,819 --> 00:35:33,880
demanding of RNA so it's a very rapid

613
00:35:40,980 --> 00:35:38,829

the turning over system so it's we use

614

00:35:43,559 --> 00:35:40,990

that promoter a lot in in in molecular

615

00:35:46,200 --> 00:35:43,569

biology to promote other genes I mean we

616

00:35:47,940 --> 00:35:46,210

just cut the the business end of the

617

00:35:48,630 --> 00:35:47,950

gene off and use the promoter so I'm

618

00:35:50,819 --> 00:35:48,640

just wondering

619

00:35:52,589 --> 00:35:50,829

if the gene if you don't have a positive

620

00:35:55,829 --> 00:35:52,599

feedback in the system here that the

621

00:35:58,079 --> 00:35:55,839

virus is actually selected or uses that

622

00:36:00,720 --> 00:35:58,089

gene from a selection point of view in

623

00:36:03,150 --> 00:36:00,730

order to promote its own birth size its

624

00:36:05,180 --> 00:36:03,160

own facilitation of its own growth

625

00:36:09,000 --> 00:36:05,190

within a host cell once it's invaded

626

00:36:10,410 --> 00:36:09,010

you're following my logic here so I'm

627

00:36:12,450 --> 00:36:10,420

just wondering if there's some feedback

628

00:36:14,370 --> 00:36:12,460

here that you could think of I mean is

629

00:36:15,720 --> 00:36:14,380

that you I don't I'm trying to

630

00:36:21,180 --> 00:36:15,730

understand why horizontal gene transfer

631

00:36:23,400 --> 00:36:21,190

of ps/2 genes is occurring so much those

632

00:36:26,490 --> 00:36:23,410

genes it's not Rubisco genes it's not

633

00:36:34,859 --> 00:36:26,500

you know it's not just any random gene

634

00:36:37,200 --> 00:36:34,869

yeah so I think the feedback I picture

635

00:36:41,339 --> 00:36:37,210

you are talking about we can kind of see

636

00:36:48,539 --> 00:36:41,349

that in this contributor right so let me

637

00:36:52,620 --> 00:36:48,549

quickly I repeat again so so the once

638

00:36:56,249 --> 00:36:52,630

the bacteria got some beneficial genes

639

00:37:01,319 --> 00:36:56,259

or more efficient felicitous genes from

640

00:37:03,240 --> 00:37:01,329

viruses the bacteria do streamlining so

641

00:37:07,109 --> 00:37:03,250

that means they keep only small size of

642

00:37:10,680 --> 00:37:07,119

genes small size of genomes so bacteria

643

00:37:13,890 --> 00:37:10,690

who is less efficient chains would just

644

00:37:17,339 --> 00:37:13,900

die out so therefore only bacterial

645

00:37:21,539 --> 00:37:17,349

cells with more efficient genes can

646

00:37:24,779 --> 00:37:21,549

stand out during selection so that will

647

00:37:26,839 --> 00:37:24,789

give who innate to horan transfer and

648

00:37:30,390 --> 00:37:26,849

dump will stream back to you virus

649

00:37:35,099 --> 00:37:30,400

viruses this world give a feedback

650

00:37:39,359 --> 00:37:35,109

effect that increase the change in the

651
00:37:48,390 --> 00:37:39,369
power feel of viruses I think tasks like

652
00:37:48,400 --> 00:37:54,870
[Music]

653
00:37:59,049 --> 00:37:57,279
other cyanobacteria have multiple copies

654
00:38:02,440 --> 00:37:59,059
of the photosystem two genes so I think

655
00:38:04,289 --> 00:38:02,450
it's Seneca sister says three copies to

656
00:38:06,069 --> 00:38:04,299
or two are different from each other and

657
00:38:09,490 --> 00:38:06,079
they're expressed differentially

658
00:38:11,710 --> 00:38:09,500
depending on the stresses I don't know

659
00:38:15,460 --> 00:38:11,720
here I mean - is there more than one

660
00:38:19,000 --> 00:38:15,470
copy in prochlorococcus when they do

661
00:38:20,859 --> 00:38:19,010
these harder in transferred if through

662
00:38:23,410 --> 00:38:20,869
the generalize transaction they would

663
00:38:26,950 --> 00:38:23,420

dump a lot of genes not just full of

664

00:38:30,000 --> 00:38:26,960

energy but also the genes that can coat

665

00:38:34,210 --> 00:38:30,010

the service protein that will help

666

00:38:45,609 --> 00:38:34,220

defense the viruses and that will have

667

00:38:51,490 --> 00:38:45,619

its benefits in the diversity it's not

668

00:38:53,799 --> 00:38:51,500

just wondering yeah beautiful work

669

00:38:55,510 --> 00:38:53,809

I have a question that perhaps bridges a

670

00:38:58,299 --> 00:38:55,520

little bit what Paul is talking about

671

00:39:01,120 --> 00:38:58,309

and extensions of these ideas that I was

672

00:39:04,180 --> 00:39:01,130

wondering about which is have you

673

00:39:07,660 --> 00:39:04,190

thought about for example you know

674

00:39:10,059 --> 00:39:07,670

having other types of organisms around

675

00:39:12,640 --> 00:39:10,069

other phytoplankton or other bacteria

676

00:39:14,260 --> 00:39:12,650

where but possibly in sort of rare

677

00:39:16,260 --> 00:39:14,270

circumstances you could have cross

678

00:39:18,730 --> 00:39:16,270

infections between the phage

679

00:39:20,980 --> 00:39:18,740

transferring genes across species being

680

00:39:24,099 --> 00:39:20,990

a font of innovation and the reason I

681

00:39:25,480 --> 00:39:24,109

ask that is that in the so in the

682

00:39:27,099 --> 00:39:25,490

evolution of prochlorococcus actually

683

00:39:29,370 --> 00:39:27,109

not just photosynthesis genes that are

684

00:39:31,599 --> 00:39:29,380

being transferred but all the major

685

00:39:32,980 --> 00:39:31,609

divergences within the lineage at the

686

00:39:34,450 --> 00:39:32,990

sort of macro from each nighttime skill

687

00:39:38,079 --> 00:39:34,460

look like they're horizontal genes

688

00:39:39,700 --> 00:39:38,089

coming from different groups so so you

689

00:39:40,779 --> 00:39:39,710

know in connection to what Paul is

690

00:39:42,250 --> 00:39:40,789

saying it's actually not just

691

00:39:43,750 --> 00:39:42,260

photosynthesis genes for which this sort

692

00:39:45,309 --> 00:39:43,760

of thing seems to happen and I just

693

00:39:48,789 --> 00:39:45,319

wondering about the role of phages in

694

00:39:51,849 --> 00:39:48,799

those kinds of transfers yes I believe

695

00:39:55,089 --> 00:39:51,859

well there are different examples that

696

00:39:57,700 --> 00:39:55,099

show similar mechanisms right so for

697

00:40:01,120 --> 00:39:57,710

example I there are different type of

698

00:40:04,029 --> 00:40:01,130

sound bacteria that now live in ocean

699

00:40:04,750 --> 00:40:04,039

but they've rocks so they will form

700

00:40:08,470 --> 00:40:04,760

different there

701
00:40:11,770 --> 00:40:08,480
rocks and they were utilize a different

702
00:40:15,280 --> 00:40:11,780
intensity and frequency of light depends

703
00:40:19,060 --> 00:40:15,290
on the depth of the rock layers yeah

704
00:40:23,050 --> 00:40:19,070
yeah and we also believe might be

705
00:40:24,400 --> 00:40:23,060
similar mechanism here right so there's

706
00:40:25,840 --> 00:40:24,410
a particular gene you might find

707
00:40:27,970 --> 00:40:25,850
interesting to look at which sits in the

708
00:40:30,580 --> 00:40:27,980
electron transfer chain called the

709
00:40:31,720 --> 00:40:30,590
plastic window terminal oxidase and that

710
00:40:34,180 --> 00:40:31,730
looks like it's being transferred

711
00:40:36,460 --> 00:40:34,190
between viruses of different different

712
00:40:39,930 --> 00:40:36,470
phytoplankton groups yes full bacteria

713
00:40:44,490 --> 00:40:39,940

suites of reefs muttering sighs and

714

00:40:47,260 --> 00:40:44,500

gasps we could say similar in fact that

715

00:40:51,790 --> 00:40:47,270

for example there might be evidence that

716

00:40:54,610 --> 00:40:51,800

you can find some genes in bacteria that

717

00:40:59,370 --> 00:40:54,620

come from viruses and that that would be

718

00:41:02,200 --> 00:40:59,380

a example that these mechanism can work

719

00:41:04,710 --> 00:41:02,210

so to just go back answer your question

720

00:41:07,060 --> 00:41:04,720

and poles and 4G Paul was just leaving

721

00:41:09,100 --> 00:41:07,070

but but if special here about

722

00:41:12,010 --> 00:41:09,110

photosynthesis genes these are both the

723

00:41:14,440 --> 00:41:12,020

bacteria and the phage can utilize them

724

00:41:16,840 --> 00:41:14,450

in their life cycle whereas other genes

725

00:41:18,880 --> 00:41:16,850

that are that are horizontally

726

00:41:21,970 --> 00:41:18,890

transferred from bacteria to bacteria

727

00:41:24,670 --> 00:41:21,980

the fade is just the bus that takes them

728

00:41:26,650 --> 00:41:24,680

from one place to the other but what's

729

00:41:28,930 --> 00:41:26,660

special and what is the feedback that

730

00:41:31,660 --> 00:41:28,940

Paul was asking about is the fact that

731

00:41:33,910 --> 00:41:31,670

both the bacteria and the phage are able

732

00:41:37,150 --> 00:41:33,920

to directly utilize the photosynthesis

733

00:41:39,160 --> 00:41:37,160

the PSB genes in their in their life

734

00:41:41,650 --> 00:41:39,170

cycle so that that's that's what gives

735

00:41:49,870 --> 00:41:41,660

you the non nonlinear feedback to

736

00:41:51,490 --> 00:41:49,880

stabilize the system hungin said these

737

00:41:57,990 --> 00:41:51,500

are the systems where we know there's

738

00:42:12,100 --> 00:41:58,000

other genes I can do other questions a

739

00:42:14,080 --> 00:42:12,110

couple more minutes so it's not a fair

740

00:42:18,060 --> 00:42:14,090

question because it's not well thought

741

00:42:20,190 --> 00:42:18,070

out but as I listened to the talk

742

00:42:22,830 --> 00:42:20,200

I have a question that's much like when

743

00:42:24,180 --> 00:42:22,840

we listen to chemistry talks when we

744

00:42:25,740 --> 00:42:24,190

listen to the chemistry talks at the

745

00:42:27,450 --> 00:42:25,750

beginning of the meeting we have a

746

00:42:29,790 --> 00:42:27,460

problem of getting from some starting

747

00:42:31,500 --> 00:42:29,800

point to some molecule and most things

748

00:42:34,800 --> 00:42:31,510

we try don't work and eventually we find

749

00:42:36,870 --> 00:42:34,810

a solution that gets there in population

750

00:42:38,520 --> 00:42:36,880

processes if you take the properties

751
00:42:39,960 --> 00:42:38,530
that you think are native properties of

752
00:42:42,300 --> 00:42:39,970
bacteria and you think our native

753
00:42:44,370 --> 00:42:42,310
properties of viruses and you plug them

754
00:42:46,320 --> 00:42:44,380
into a model the model goes unstable and

755
00:42:47,760 --> 00:42:46,330
everyone dies and you change some

756
00:42:50,160 --> 00:42:47,770
details and it goes unstable and

757
00:42:51,780 --> 00:42:50,170
everyone dies and eventually you work

758
00:42:56,180 --> 00:42:51,790
and you work and you find a model that

759
00:42:59,550 --> 00:42:56,190
can produce stable population processes

760
00:43:01,320 --> 00:42:59,560
at the end you tell a story where

761
00:43:03,240 --> 00:43:01,330
there's a kind of a general set of

762
00:43:06,390 --> 00:43:03,250
principles that you think are at work

763
00:43:08,760 --> 00:43:06,400

that viruses handle some jobs bacteria

764

00:43:11,450 --> 00:43:08,770

handle other jobs and it's a collective

765

00:43:15,090 --> 00:43:11,460

state that produces stable populations

766

00:43:17,670 --> 00:43:15,100

how much can you show that even if a

767

00:43:19,890 --> 00:43:17,680

particular model is wrong those

768

00:43:22,590 --> 00:43:19,900

principles are likely to be the real

769

00:43:25,410 --> 00:43:22,600

reason you have stable populations in

770

00:43:26,490 --> 00:43:25,420

the world and maybe some other model

771

00:43:28,590 --> 00:43:26,500

that's different than the one you

772

00:43:30,210 --> 00:43:28,600

thought of but that's organized by the

773

00:43:36,900 --> 00:43:30,220

same principles is still the correct

774

00:43:37,890 --> 00:43:36,910

explanation okay let me try to

775

00:43:42,900 --> 00:43:37,900

understand your question

776

00:43:48,260 --> 00:43:42,910

I guess you're asking that if this

777

00:43:51,510 --> 00:43:48,270

mechanism is robust enough or is just

778

00:43:54,150 --> 00:43:51,520

requires many different conditions to

779

00:43:59,750 --> 00:43:54,160

make it work okay so we single-edged

780

00:44:02,000 --> 00:43:59,760

mechanisms wrote robust first we can I

781

00:44:04,980 --> 00:44:02,010

predict the phase diagram and that

782

00:44:08,340 --> 00:44:04,990

Peregrine's is consistent with a little

783

00:44:15,330 --> 00:44:08,350

data and we can show a phenomena in real

784

00:44:17,730 --> 00:44:15,340

data and and it's not it doesn't require

785

00:44:20,220 --> 00:44:17,740

fine tuning of parameter in our

786

00:44:27,390 --> 00:44:20,230

simulations right so which means the

787

00:44:29,880 --> 00:44:27,400

result is stable so and we might be able

788

00:44:32,039 --> 00:44:29,890

to think of different kind of models

789

00:44:35,819 --> 00:44:32,049

that maybe if

790

00:44:38,760 --> 00:44:35,829

type of bacteria weighs Patriot was

791

00:44:42,779 --> 00:44:38,770

different mutation rate but that way in

792

00:44:48,150 --> 00:44:42,789

order to see this in fact some fun

793

00:44:52,109 --> 00:44:48,160

phenomena in real like what we I show

794

00:44:55,079 --> 00:44:52,119

here the niche stratification and the

795

00:44:59,779 --> 00:44:55,089

collective effects we also need some

796

00:45:03,569 --> 00:44:59,789

other conditions like which would be to

797

00:45:09,660 --> 00:45:03,579

manipulating my if it's not bacteria and

798

00:45:14,549 --> 00:45:09,670

viruses like in this Rio ecosystems we

799

00:45:26,370 --> 00:45:14,559

thing is I it could be I I wish I thing

800

00:45:28,620 --> 00:45:26,380

is a robust mechanism it has

801
00:45:30,720 --> 00:45:28,630
automatically homeostasis for the

802
00:45:33,000 --> 00:45:30,730
ecosystem built in whereas other

803
00:45:36,990 --> 00:45:33,010
proposed mechanisms for the stability of

804
00:45:39,180 --> 00:45:37,000
phage systems like low dimensionality or

805
00:45:43,500 --> 00:45:39,190
things like this that those really don't

806
00:45:44,789 --> 00:45:43,510
have homeostasis emerging naturally you

807
00:45:47,700 --> 00:45:44,799
have to do some fine-tuning of

808
00:45:50,250 --> 00:45:47,710
parameters as high and said here without

809
00:45:52,470 --> 00:45:50,260
if generically stable is a stage it's

810
00:45:54,420 --> 00:45:52,480
not the it's not the only mechanism that

811
00:45:57,180 --> 00:45:54,430
that can do this but in this particular

812
00:46:00,380 --> 00:45:57,190
system it seems to be the one that is

813
00:46:05,160 --> 00:46:00,390

appropriate because of the utilization

814

00:46:10,829 --> 00:46:05,170

by both biosphere and bacteria sphere of

815

00:46:12,359 --> 00:46:10,839

the funding systems all right it's this

816

00:46:13,330 --> 00:46:12,369

rate at time so let's thank the speaker

817

00:46:16,630 --> 00:46:13,340

again

818

00:46:35,630 --> 00:46:16,640

[Applause]