AbSciCon 2022

A History of Hypothesis on the Origin of Animals

Dr. Nicole King

1
00:00:07,670 --> 00:00:04,789
welcome to apps icon 2022.

2
00:00:09,350 --> 00:00:07,680
i'm susan lozier president of asu

3
00:00:10,870 --> 00:00:09,360
and the dean of the college of sciences

4
00:00:12,950 --> 00:00:10,880
at georgia tech

5
00:00:14,950 --> 00:00:12,960
i'm delighted to welcome all of you who

6
00:00:16,550 --> 00:00:14,960
are here in atlanta and also i'm

7
00:00:18,310 --> 00:00:16,560
delighted to welcome all of the

8
00:00:21,189 --> 00:00:18,320
participants who are

9
00:00:23,830 --> 00:00:21,199
joining us virtually this morning

10
00:00:26,070 --> 00:00:23,840
as an oceanographer for the past several

11
00:00:29,189 --> 00:00:26,080
decades i've always been inspired by the

12
00:00:31,509 --> 00:00:29,199
romance and mystery of the sea

13
00:00:34,630 --> 00:00:31,519

and motivated by the immensity of what

14
00:00:36,630 --> 00:00:34,640
we don't know about this vast expense

15
00:00:38,310 --> 00:00:36,640
on our planet earth

16
00:00:40,630 --> 00:00:38,320
truth to tell i have always felt a

17
00:00:43,350 --> 00:00:40,640
little sorry for scientists studying

18
00:00:45,270 --> 00:00:43,360
more pedestrian topics

19
00:00:48,150 --> 00:00:45,280
however when considering your work in

20
00:00:50,069 --> 00:00:48,160
astrobiology i stand in awe

21
00:00:52,229 --> 00:00:50,079
hard to compete with your mysteries and

22
00:00:54,229 --> 00:00:52,239
your romances and the sense of vast

23
00:00:56,150 --> 00:00:54,239
possibilities

24
00:00:58,709 --> 00:00:56,160
a thousand years ago near the end of his

25
00:01:00,869 --> 00:00:58,719
life adelard of bath a natural

26
00:01:02,389 --> 00:01:00,879
philosopher who lived during the reign

27
00:01:05,030 --> 00:01:02,399
of henry the first

28
00:01:07,590 --> 00:01:05,040
compiled a list of 76 questions for

29
00:01:10,070 --> 00:01:07,600
which he did not know the answer

30
00:01:12,390 --> 00:01:10,080
among those questions was

31
00:01:16,390 --> 00:01:12,400
are the stars animate

32
00:01:18,469 --> 00:01:16,400
and if so what do they eat

33
00:01:20,550 --> 00:01:18,479
our human existence has been marked by

34
00:01:23,109 --> 00:01:20,560
staring at the night sky in wonder and

35
00:01:25,270 --> 00:01:23,119
considering the possibilities

36
00:01:28,070 --> 00:01:25,280
and our existence on this earth has been

37
00:01:30,630 --> 00:01:28,080
marked by a keen desire to understand

38
00:01:33,350 --> 00:01:30,640

how life began

39
00:01:35,910 --> 00:01:33,360
last week astronomers revealed the first

40
00:01:37,510 --> 00:01:35,920
photo of the black hole at the center of

41
00:01:39,270 --> 00:01:37,520
our galaxy

42
00:01:40,950 --> 00:01:39,280
and this week you're gathered here to

43
00:01:43,350 --> 00:01:40,960
carry on the work of generations of

44
00:01:45,830 --> 00:01:43,360
scientists that have probed the question

45
00:01:48,069 --> 00:01:45,840
of life in this universe

46
00:01:49,109 --> 00:01:48,079
appsicon is the perfect venue for that

47
00:01:52,069 --> 00:01:49,119
work

48
00:01:54,550 --> 00:01:52,079
the first apps icon in 2000 was held at

49
00:01:56,950 --> 00:01:54,560
nasa ames research center

50
00:01:59,429 --> 00:01:56,960
agu with continued support from the nasa

51
00:02:02,069 --> 00:01:59,439
community has been honored to take on

52
00:02:04,870 --> 00:02:02,079
the execution of this small but mighty

53
00:02:07,109 --> 00:02:04,880
meeting since 2018.

54
00:02:09,510 --> 00:02:07,119
while just over a thousand researchers

55
00:02:12,390 --> 00:02:09,520
gathered at that first abseicon

56
00:02:14,550 --> 00:02:12,400
today more than 800 planetary scientists

57
00:02:16,710 --> 00:02:14,560
biologists chemists astronomers

58
00:02:18,869 --> 00:02:16,720
engineers and even a few ocean

59
00:02:20,470 --> 00:02:18,879
scientists have gathered

60
00:02:22,309 --> 00:02:20,480
and forgot that gathering you have

61
00:02:23,910 --> 00:02:22,319
sessions that reflect many different

62
00:02:26,470 --> 00:02:23,920
disciplines in the earth and space

63
00:02:29,430 --> 00:02:26,480

scientists but mostly they reflect the

64
00:02:31,110 --> 00:02:29,440
melding of those disciplines

65
00:02:32,869 --> 00:02:31,120
i'm impressed by this community's

66
00:02:34,390 --> 00:02:32,879
compassion for interdisciplinary

67
00:02:36,710 --> 00:02:34,400
collaboration

68
00:02:38,550 --> 00:02:36,720
it even more so by its commitment to

69
00:02:40,869 --> 00:02:38,560
inclusivity

70
00:02:42,470 --> 00:02:40,879
as someone who started a science career

71
00:02:45,350 --> 00:02:42,480
when it was rare for someone who looked

72
00:02:48,470 --> 00:02:45,360
like me to be a scientist

73
00:02:50,869 --> 00:02:48,480
it is a delight to live to see

74
00:02:52,790 --> 00:02:50,879
listen to learn from

75
00:02:56,790 --> 00:02:52,800
and be inspired by everyone out there

76
00:02:59,589 --> 00:02:56,800
who looks just like you look a scientist

77
00:03:02,550 --> 00:02:59,599
while abzycon exemplifies agu's goal of

78
00:03:04,550 --> 00:03:02,560
creating inclusive scientific culture we

79
00:03:06,710 --> 00:03:04,560
are still a long way from an environment

80
00:03:09,350 --> 00:03:06,720
where individuals from all social

81
00:03:11,589 --> 00:03:09,360
economic and cultural backgrounds are

82
00:03:14,710 --> 00:03:11,599
equitably included

83
00:03:16,149 --> 00:03:14,720
i encourage everyone to hear to join agu

84
00:03:18,790 --> 00:03:16,159
and its continuing commitment to

85
00:03:22,070 --> 00:03:18,800
diversity equity and inclusion

86
00:03:24,229 --> 00:03:22,080
brilliance creativity and dedication are

87
00:03:25,670 --> 00:03:24,239
surely not the purview of a privileged

88
00:03:27,430 --> 00:03:25,680

view

89
00:03:29,430 --> 00:03:27,440
anyone who knows me know that knows that

90
00:03:30,949 --> 00:03:29,440
i am passionate about supporting and

91
00:03:34,149 --> 00:03:30,959
encouraging our next generation of

92
00:03:36,789 --> 00:03:34,159
scientists as such i encourage you all

93
00:03:39,190 --> 00:03:36,799
to participate in peer-to-peer mentoring

94
00:03:41,589 --> 00:03:39,200
through the brain date platform or sign

95
00:03:43,430 --> 00:03:41,599
up for mentoring 365 where you can

96
00:03:45,430 --> 00:03:43,440
develop one-on-one professional

97
00:03:46,949 --> 00:03:45,440
connections that last throughout the

98
00:03:49,270 --> 00:03:46,959
year

99
00:03:51,670 --> 00:03:49,280
that's all for me other than to consider

100
00:03:53,030 --> 00:03:51,680
what someone a thousand years from now

101
00:03:54,630 --> 00:03:53,040
will wonder when they look up in the

102
00:03:57,190 --> 00:03:54,640
night sky

103
00:03:59,030 --> 00:03:57,200
enjoy the week enjoy atlanta and enjoy

104
00:04:01,030 --> 00:03:59,040
each other's company

105
00:04:03,429 --> 00:04:01,040
and now please join me in welcoming

106
00:04:05,990 --> 00:04:03,439
frank rosenswag the science chair for

107
00:04:18,229 --> 00:04:06,000
absycon and luckily for me my georgia

108
00:04:22,870 --> 00:04:19,909
thank you for those

109
00:04:23,909 --> 00:04:22,880
beautiful and inspiring remarks

110
00:04:26,310 --> 00:04:23,919
um

111
00:04:30,790 --> 00:04:26,320
good morning astrobiologists

112
00:04:33,270 --> 00:04:30,800
uh i'm tickled to kick off our first day

113
00:04:35,189 --> 00:04:33,280

uh at amps icon by introducing our

114
00:04:38,710 --> 00:04:35,199
plenary speaker

115
00:04:40,070 --> 00:04:38,720
uh professor nicole king i first met dr

116
00:04:43,430 --> 00:04:40,080
king

117
00:04:46,070 --> 00:04:43,440
six years ago when she and her son nate

118
00:04:48,070 --> 00:04:46,080
uh traveled to montana to participate in

119
00:04:50,550 --> 00:04:48,080
an nai executive

120
00:04:51,749 --> 00:04:50,560
uh council meeting and workshop that

121
00:04:54,710 --> 00:04:51,759
workshop

122
00:04:56,629 --> 00:04:54,720
was on major evolutionary transitions in

123
00:04:58,790 --> 00:04:56,639
the history of life

124
00:05:00,469 --> 00:04:58,800
major transitions occur

125
00:05:03,830 --> 00:05:00,479
when a group of individuals that

126
00:05:07,510 --> 00:05:03,840
previously could replicate independently

127
00:05:10,230 --> 00:05:07,520
come together to form complex autonomous

128
00:05:12,070 --> 00:05:10,240
life forms for example genes coming

129
00:05:15,110 --> 00:05:12,080
together

130
00:05:17,830 --> 00:05:15,120
to form genomes archaea and eubacteria

131
00:05:20,550 --> 00:05:17,840
to form eukaryotes single cells

132
00:05:23,590 --> 00:05:20,560
coming together or staying together

133
00:05:26,550 --> 00:05:23,600
to form multicellular organisms

134
00:05:27,590 --> 00:05:26,560
so dr king regaled the nai with her

135
00:05:28,870 --> 00:05:27,600
unique

136
00:05:32,070 --> 00:05:28,880
insights

137
00:05:35,590 --> 00:05:32,080
into a transition that makes it possible

138
00:05:38,629 --> 00:05:35,600

for us to be here today in atlanta

139
00:05:40,629 --> 00:05:38,639
namely the advent of multicellularity in

140
00:05:43,510 --> 00:05:40,639
the evolutionary clade

141
00:05:45,830 --> 00:05:43,520
that gave rise to animals

142
00:05:47,590 --> 00:05:45,840
dr king's interests

143
00:05:49,749 --> 00:05:47,600
have lain at the intersection of

144
00:05:53,189 --> 00:05:49,759
evolution and development since their

145
00:05:55,110 --> 00:05:53,199
undergraduate days at indiana university

146
00:05:57,670 --> 00:05:55,120
there she worked under the supervision

147
00:06:00,870 --> 00:05:57,680
of tom kaufman studying how homeotic

148
00:06:03,590 --> 00:06:00,880
genes are regulated in drosophila

149
00:06:05,430 --> 00:06:03,600
for her dissertation research nicole

150
00:06:06,629 --> 00:06:05,440
worked with richard losic at harvard

151
00:06:09,430 --> 00:06:06,639
where she helped

152
00:06:12,230 --> 00:06:09,440
she helped to dissect the regulation of

153
00:06:13,510 --> 00:06:12,240
sporulation in the bacterium bacillus

154
00:06:15,749 --> 00:06:13,520
subtlest

155
00:06:17,670 --> 00:06:15,759
and thereafter dr king pursued

156
00:06:20,469 --> 00:06:17,680
postdoctoral studies

157
00:06:22,629 --> 00:06:20,479
with sean carroll at the university

158
00:06:25,749 --> 00:06:22,639
of wisconsin-madison where she helped

159
00:06:28,230 --> 00:06:25,759
pioneer the use of comparative genomics

160
00:06:30,070 --> 00:06:28,240
to eliminate deep branches in the tree

161
00:06:33,189 --> 00:06:30,080
of life

162
00:06:35,909 --> 00:06:33,199
since 2003 nicole has been a professor

163
00:06:38,070 --> 00:06:35,919

at the university of california berkeley

164
00:06:40,309 --> 00:06:38,080
where she's established herself as a

165
00:06:43,189 --> 00:06:40,319
world leader in the field of

166
00:06:44,870 --> 00:06:43,199
evolutionary developmental biology or

167
00:06:47,430 --> 00:06:44,880
evo devo

168
00:06:50,390 --> 00:06:47,440
she has been the recipient of numerous

169
00:06:51,589 --> 00:06:50,400
awards including a macarthur foundation

170
00:06:55,350 --> 00:06:51,599
fellowship

171
00:06:57,430 --> 00:06:55,360
a pew scholarship and she is currently a

172
00:07:00,629 --> 00:06:57,440
faculty investigator of the howard

173
00:07:03,670 --> 00:07:00,639
hughes medical institute

174
00:07:07,270 --> 00:07:03,680
aside from all of these honorifics i can

175
00:07:10,870 --> 00:07:07,280
attest that dr king is a a careful and a

176
00:07:13,909 --> 00:07:10,880
thoughtful mentor to her students

177
00:07:15,510 --> 00:07:13,919
an attentive mother to her son

178
00:07:17,830 --> 00:07:15,520
and a good friend

179
00:07:19,749 --> 00:07:17,840
to those of us lucky enough to claim

180
00:07:22,230 --> 00:07:19,759
that relation

181
00:07:26,070 --> 00:07:22,240
please join me in welcoming

182
00:07:27,909 --> 00:07:26,080
to abs icon 2022 dr nicole king who will

183
00:07:46,629 --> 00:07:27,919
treat us to a history

184
00:07:50,390 --> 00:07:48,950
i'm waiting for my presentation to load

185
00:07:52,469 --> 00:07:50,400
i guess

186
00:07:53,270 --> 00:07:52,479
okay good morning everybody

187
00:07:55,589 --> 00:07:53,280
um

188
00:07:57,670 --> 00:07:55,599

it's a real honor to be here

189
00:08:00,230 --> 00:07:57,680
when i first started my laboratory at

190
00:08:01,270 --> 00:08:00,240
the university of california at berkeley

191
00:08:03,350 --> 00:08:01,280
i was

192
00:08:05,670 --> 00:08:03,360
taken into the

193
00:08:07,670 --> 00:08:05,680
astrobiology community something i

194
00:08:09,189 --> 00:08:07,680
didn't even know about before and it

195
00:08:11,189 --> 00:08:09,199
really helped introduce me to the

196
00:08:12,950 --> 00:08:11,199
opportunities that come from

197
00:08:15,029 --> 00:08:12,960
interdisciplinary research and has

198
00:08:17,909 --> 00:08:15,039
really shaped the way i think about the

199
00:08:18,790 --> 00:08:17,919
problem of animal origins

200
00:08:23,830 --> 00:08:18,800
now

201
00:08:25,670 --> 00:08:23,840
i i actually was asking myself why am i

202
00:08:28,469 --> 00:08:25,680
uh invited to speak here what do i have

203
00:08:30,469 --> 00:08:28,479
to to share that might be of common

204
00:08:32,709 --> 00:08:30,479
interest to this community and i think

205
00:08:34,949 --> 00:08:32,719
one of the big challenges that we face

206
00:08:36,469 --> 00:08:34,959
as evolutionary biologists

207
00:08:39,589 --> 00:08:36,479
is to use

208
00:08:41,269 --> 00:08:39,599
um inference based on the little that

209
00:08:42,630 --> 00:08:41,279
amount of information that's available

210
00:08:45,190 --> 00:08:42,640
to us today

211
00:08:47,350 --> 00:08:45,200
to try to infer what happened

212
00:08:49,509 --> 00:08:47,360
tens or hundreds of millions of years

213
00:08:51,910 --> 00:08:49,519

ago and that will be the focus of my

214
00:08:53,430 --> 00:08:51,920
talk today but i think in similar

215
00:08:55,350 --> 00:08:53,440
challenge faces

216
00:08:56,710 --> 00:08:55,360
the astrobiology community in terms of

217
00:08:59,269 --> 00:08:56,720
thinking about how life might have

218
00:09:01,670 --> 00:08:59,279
evolved elsewhere and where might we

219
00:09:03,670 --> 00:09:01,680
find meaningful evidence so i hope that

220
00:09:05,430 --> 00:09:03,680
the story i'm about to tell you today

221
00:09:09,190 --> 00:09:05,440
will provide inspiration for thinking

222
00:09:11,190 --> 00:09:09,200
about those types of challenges

223
00:09:13,509 --> 00:09:11,200
i want to start by just

224
00:09:14,870 --> 00:09:13,519
reveling in the beauty of animal

225
00:09:16,550 --> 00:09:14,880
morphology

226
00:09:18,630 --> 00:09:16,560
and this i you know the incredible

227
00:09:19,910 --> 00:09:18,640
diversity of animal form that we see

228
00:09:21,350 --> 00:09:19,920
today

229
00:09:23,350 --> 00:09:21,360
and when i first started to learn about

230
00:09:24,230 --> 00:09:23,360
this pretty

231
00:09:27,430 --> 00:09:24,240
um

232
00:09:30,150 --> 00:09:27,440
what excited me and surprised me was to

233
00:09:33,750 --> 00:09:30,160
learn that all animals actually involve

234
00:09:35,190 --> 00:09:33,760
evolve from a single common ancestor

235
00:09:37,590 --> 00:09:35,200
and so

236
00:09:40,070 --> 00:09:37,600
if you look at this phylogenetic tree we

237
00:09:43,110 --> 00:09:40,080
can infer that all animals today have a

238
00:09:46,630 --> 00:09:43,120

common ancestor that's um indicated by

239
00:09:49,190 --> 00:09:46,640
this purple circle here and that

240
00:09:50,949 --> 00:09:49,200
we can study living animals today to try

241
00:09:52,470 --> 00:09:50,959
to reconstruct the biology of that

242
00:09:54,949 --> 00:09:52,480
organism

243
00:09:56,870 --> 00:09:54,959
in addition my particular focus has been

244
00:09:59,110 --> 00:09:56,880
on trying to reconstruct the organisms

245
00:10:01,190 --> 00:09:59,120
from which animals first evolved and in

246
00:10:03,509 --> 00:10:01,200
particular we're trying to figure out

247
00:10:04,470 --> 00:10:03,519
what was the nature of the single-celled

248
00:10:07,030 --> 00:10:04,480
organism

249
00:10:08,870 --> 00:10:07,040
that spawned the animal lineage

250
00:10:11,350 --> 00:10:08,880
how did that organism undergo the

251
00:10:13,750 --> 00:10:11,360
transition to multicellularity

252
00:10:15,829 --> 00:10:13,760
and how did sorry mechanisms that

253
00:10:18,870 --> 00:10:15,839
allowed cells to have different

254
00:10:20,790 --> 00:10:18,880
functions first of all how is it that

255
00:10:23,670 --> 00:10:20,800
cell differentiation arose in this

256
00:10:27,350 --> 00:10:24,790
so

257
00:10:30,630 --> 00:10:27,360
i should back up and say that there's no

258
00:10:32,790 --> 00:10:30,640
fossil record for the first animal or

259
00:10:35,190 --> 00:10:32,800
for for the animals from which or the

260
00:10:37,030 --> 00:10:35,200
organisms from which animals evolved and

261
00:10:39,269 --> 00:10:37,040
so for a long time

262
00:10:40,069 --> 00:10:39,279
um we knew very little

263
00:10:43,030 --> 00:10:40,079

but

264
00:10:45,430 --> 00:10:43,040
starting in the 1990s

265
00:10:47,190 --> 00:10:45,440
focus began to increase on a group of

266
00:10:48,949 --> 00:10:47,200
very special organisms called the

267
00:10:51,030 --> 00:10:48,959
choanoflagellates and these

268
00:10:52,949 --> 00:10:51,040
choanoflagellates are interesting and

269
00:10:55,190 --> 00:10:52,959
important for understanding animal

270
00:10:57,110 --> 00:10:55,200
origins because in fact they are our

271
00:10:59,350 --> 00:10:57,120
sister group they are our closest living

272
00:11:01,670 --> 00:10:59,360
relatives and this phylogenetic tree

273
00:11:04,230 --> 00:11:01,680
then shows the diversity of animals all

274
00:11:06,470 --> 00:11:04,240
with a single common ancestor that we

275
00:11:08,389 --> 00:11:06,480
call the ur metazoan

276
00:11:10,949 --> 00:11:08,399
and all coanoflagellates which are

277
00:11:13,670 --> 00:11:10,959
equally diverse to animals

278
00:11:15,190 --> 00:11:13,680
which share their own common ancestor

279
00:11:17,110 --> 00:11:15,200
and if we can compare the quantum

280
00:11:20,310 --> 00:11:17,120
flagellates to animals we can

281
00:11:22,550 --> 00:11:20,320
reconstruct the biology of that ancient

282
00:11:24,949 --> 00:11:22,560
ancestor of these two lineages which

283
00:11:26,310 --> 00:11:24,959
i'll call the urocoanazoin

284
00:11:29,030 --> 00:11:26,320
okay

285
00:11:31,190 --> 00:11:29,040
i've tried to keep terms to a minimum

286
00:11:33,509 --> 00:11:31,200
but uh but i'm going to use the phrase

287
00:11:35,590 --> 00:11:33,519
quantozoa to describe the group that

288
00:11:37,990 --> 00:11:35,600

includes choanoflagellates and animals

289
00:11:40,230 --> 00:11:38,000
and the orc choanozoan to denote their

290
00:11:41,990 --> 00:11:40,240
ancestor

291
00:11:44,310 --> 00:11:42,000
now what is a quantoflagellate maybe you

292
00:11:47,590 --> 00:11:44,320
haven't seen or heard of one before

293
00:11:50,069 --> 00:11:47,600
it's a single celled eukaryote

294
00:11:52,389 --> 00:11:50,079
it has a cell body that you can see here

295
00:11:54,710 --> 00:11:52,399
and a collar of these

296
00:11:56,949 --> 00:11:54,720
what are called microvilli these are

297
00:12:00,069 --> 00:11:56,959
long protrusions and in the center of

298
00:12:02,389 --> 00:12:00,079
this collar is a long flagellum and this

299
00:12:05,590 --> 00:12:02,399
has been described by the author ed

300
00:12:07,430 --> 00:12:05,600
young as sperm with a skirt and so you

301
00:12:09,590 --> 00:12:07,440
can actually imagine it swimming around

302
00:12:12,230 --> 00:12:09,600
with its flagellum but it has the skirt

303
00:12:14,870 --> 00:12:12,240
surrounding it the collar

304
00:12:17,350 --> 00:12:14,880
now the way the cell works is that the

305
00:12:20,069 --> 00:12:17,360
the flagellum beats back and forth

306
00:12:22,069 --> 00:12:20,079
inside that collar and this creates

307
00:12:24,069 --> 00:12:22,079
water currents that pull material out

308
00:12:25,509 --> 00:12:24,079
from the water column up against the

309
00:12:27,509 --> 00:12:25,519
collar and that's actually what the

310
00:12:29,269 --> 00:12:27,519
quantoflagella eats

311
00:12:31,829 --> 00:12:29,279
so the quanoflagel is actually a

312
00:12:33,670 --> 00:12:31,839
specialized feeding cell that swims

313
00:12:35,990 --> 00:12:33,680

around collecting bacteria against the

314
00:12:37,990 --> 00:12:36,000
collar and so you can see for size

315
00:12:40,310 --> 00:12:38,000
example here's a bacterium next to it's

316
00:12:42,629 --> 00:12:40,320
going to flagella that is about to eat

317
00:12:46,470 --> 00:12:44,949
we can zoom in on this color complex a

318
00:12:49,430 --> 00:12:46,480
little bit more carefully so these

319
00:12:51,030 --> 00:12:49,440
images on the right were taken from live

320
00:12:52,310 --> 00:12:51,040
cells and on the right you're going to

321
00:12:54,949 --> 00:12:52,320
see

322
00:12:57,430 --> 00:12:54,959
we can turn this structure so that you

323
00:12:59,430 --> 00:12:57,440
can actually peer into

324
00:13:02,550 --> 00:12:59,440
the collar itself

325
00:13:04,949 --> 00:13:02,560
so this is a fascinating structure

326
00:13:08,150 --> 00:13:04,959
that really is diagnostic for

327
00:13:11,269 --> 00:13:08,160
choanoflagellates if you go out into a

328
00:13:12,790 --> 00:13:11,279
body of water the ocean a pond a lake

329
00:13:14,790 --> 00:13:12,800
and you collect water and you see

330
00:13:16,310 --> 00:13:14,800
something with this structure it's a

331
00:13:18,230 --> 00:13:16,320
choanoflagellate

332
00:13:19,670 --> 00:13:18,240
with one exception

333
00:13:22,230 --> 00:13:19,680
and that is that the only other

334
00:13:24,550 --> 00:13:22,240
organisms out there that have a collar

335
00:13:27,990 --> 00:13:24,560
complex are the animals and so here's

336
00:13:29,670 --> 00:13:28,000
one example we're looking into a sponge

337
00:13:33,110 --> 00:13:29,680
and you can see that they have cells

338
00:13:35,030 --> 00:13:33,120

that are nearly identical with this long

339
00:13:37,509 --> 00:13:35,040
collar and then protruding out from the

340
00:13:40,150 --> 00:13:37,519
collar the flagellum

341
00:13:42,230 --> 00:13:40,160
here are 3d reconstructions on the left

342
00:13:44,230 --> 00:13:42,240
of a colonial choanoflagellate to show

343
00:13:45,189 --> 00:13:44,240
you the collar complex on each of these

344
00:13:50,150 --> 00:13:45,199
cells

345
00:13:52,389 --> 00:13:50,160
called choanocyte chamber in which you

346
00:13:54,870 --> 00:13:52,399
can see these collar cells now all

347
00:13:57,030 --> 00:13:54,880
clustered together and it turns out that

348
00:13:59,990 --> 00:13:57,040
even all of you have cells that have a

349
00:14:01,430 --> 00:14:00,000
collar complex these are cells that line

350
00:14:05,430 --> 00:14:01,440
your

351
00:14:07,030 --> 00:14:05,440
see that they all have this collar

352
00:14:10,069 --> 00:14:07,040
complex as well

353
00:14:12,670 --> 00:14:10,079
and in fact if we look across

354
00:14:14,550 --> 00:14:12,680
eukaryotic diversity the animals the

355
00:14:17,110 --> 00:14:14,560
choanoflagellates and many different

356
00:14:19,829 --> 00:14:17,120
diverse outgroups what we see is that

357
00:14:22,550 --> 00:14:19,839
all choanoflagellates and nearly all

358
00:14:25,509 --> 00:14:22,560
animals have the color complex but we

359
00:14:27,509 --> 00:14:25,519
never see them in non-coenozoins

360
00:14:30,150 --> 00:14:27,519
and so from this we infer that the

361
00:14:33,189 --> 00:14:30,160
collar complex was actually present in

362
00:14:35,269 --> 00:14:33,199
the last common ancestor the ercoanizone

363
00:14:37,509 --> 00:14:35,279

and probably evolved along this stem

364
00:14:40,310 --> 00:14:37,519
lineage

365
00:14:43,430 --> 00:14:40,320
so for this reason the community that's

366
00:14:45,670 --> 00:14:43,440
focused on studying animal origins has

367
00:14:47,829 --> 00:14:45,680
largely coalesced around

368
00:14:49,670 --> 00:14:47,839
the hypothesis that the progenitor of

369
00:14:51,430 --> 00:14:49,680
animals was a collared flagellate we

370
00:14:53,750 --> 00:14:51,440
know that there must have been a color

371
00:14:55,829 --> 00:14:53,760
complex in the last common ancestor of

372
00:14:57,750 --> 00:14:55,839
quantum flagellates and animals and so

373
00:14:59,590 --> 00:14:57,760
we infer that that ancestor was a

374
00:15:01,350 --> 00:14:59,600
flagellate with a collar

375
00:15:03,030 --> 00:15:01,360
that then evolved simple

376
00:15:04,629 --> 00:15:03,040
multicellularity

377
00:15:06,870 --> 00:15:04,639
and that the type of cell

378
00:15:09,590 --> 00:15:06,880
differentiation we see in modern animals

379
00:15:12,550 --> 00:15:09,600
must have evolved later

380
00:15:14,470 --> 00:15:12,560
so that's the working hypothesis that

381
00:15:16,710 --> 00:15:14,480
that has really dominated the field

382
00:15:17,430 --> 00:15:16,720
until recently

383
00:15:19,509 --> 00:15:17,440
but

384
00:15:21,590 --> 00:15:19,519
okay i got ahead of myself

385
00:15:23,829 --> 00:15:21,600
in addition

386
00:15:27,030 --> 00:15:23,839
we can reconstruct the biology of the

387
00:15:29,030 --> 00:15:27,040
first animal the or metazoan

388
00:15:30,949 --> 00:15:29,040

by comparing the biology of diverse

389
00:15:33,350 --> 00:15:30,959
animals and what we think is that the

390
00:15:37,030 --> 00:15:33,360
last common ancestor of animals

391
00:15:39,110 --> 00:15:37,040
was a simple multicellular organism with

392
00:15:41,509 --> 00:15:39,120
what's what we call an epithelium these

393
00:15:42,470 --> 00:15:41,519
are cells that stick tightly together

394
00:15:48,150 --> 00:15:42,480
and

395
00:15:50,389 --> 00:15:48,160
impermeable to the outside environment

396
00:15:52,790 --> 00:15:50,399
and that that that simple epithelium

397
00:15:54,389 --> 00:15:52,800
contained these collar cells or cells

398
00:15:57,269 --> 00:15:54,399
with a color complex

399
00:16:00,230 --> 00:15:57,279
and it ate bacteria but most importantly

400
00:16:02,470 --> 00:16:00,240
we also infer that it had simple cell

401
00:16:05,189 --> 00:16:02,480
differentiation including the

402
00:16:07,829 --> 00:16:05,199
differentiation between these

403
00:16:09,430 --> 00:16:07,839
columnar epithelial cells and another

404
00:16:11,430 --> 00:16:09,440
cell type that i'm going to talk about

405
00:16:13,990 --> 00:16:11,440
which are amoeboid cells or crawling

406
00:16:18,790 --> 00:16:16,550
okay crawling cells are central to

407
00:16:19,990 --> 00:16:18,800
animal biology in fact all of you are

408
00:16:21,829 --> 00:16:20,000
here

409
00:16:23,829 --> 00:16:21,839
because of an important group of

410
00:16:25,990 --> 00:16:23,839
crawling cells which are in your immune

411
00:16:26,870 --> 00:16:26,000
system and so this is one example right

412
00:16:29,590 --> 00:16:26,880
here

413
00:16:30,949 --> 00:16:29,600

and um and crawling cells actually exist

414
00:16:33,269 --> 00:16:30,959
throughout

415
00:16:35,110 --> 00:16:33,279
animal diversity and this picture down

416
00:16:36,629 --> 00:16:35,120
here is of crawling cells that are found

417
00:16:38,710 --> 00:16:36,639
in sponges

418
00:16:41,350 --> 00:16:38,720
now crawling cells are also found

419
00:16:43,030 --> 00:16:41,360
throughout uh eukaryotic diversity this

420
00:16:45,110 --> 00:16:43,040
single-celled amoeba there's not there's

421
00:16:47,189 --> 00:16:45,120
gonna be any volume on that sorry

422
00:16:49,430 --> 00:16:47,199
um

423
00:16:50,389 --> 00:16:49,440
there we go

424
00:16:53,430 --> 00:16:50,399
um

425
00:16:56,230 --> 00:16:53,440
so so crawling cells are found across

426
00:16:58,629 --> 00:16:56,240
eukaryotic diversity this is an example

427
00:17:01,189 --> 00:16:58,639
of an amoeba cell this is actually a

428
00:17:03,749 --> 00:17:01,199
relatively close animal or relative of

429
00:17:06,150 --> 00:17:03,759
the choanazola and ichthyospurian and

430
00:17:08,150 --> 00:17:06,160
even these early branching fungi that

431
00:17:09,829 --> 00:17:08,160
you can see here

432
00:17:11,510 --> 00:17:09,839
are able to crawl

433
00:17:13,829 --> 00:17:11,520
and so it looks like

434
00:17:15,990 --> 00:17:13,839
this crawling behavior is widespread and

435
00:17:18,150 --> 00:17:16,000
yet we don't know how it first evolved

436
00:17:19,590 --> 00:17:18,160
in animals

437
00:17:21,350 --> 00:17:19,600
okay hold on we're having a little bit

438
00:17:24,069 --> 00:17:21,360

of a lag here okay

439
00:17:26,870 --> 00:17:24,079
so to talk about this mystery i first

440
00:17:30,710 --> 00:17:26,880
need to uh reintroduce some of you to

441
00:17:33,190 --> 00:17:30,720
earns techel so ernst heckle is

442
00:17:35,110 --> 00:17:33,200
actually one of his major contributions

443
00:17:37,430 --> 00:17:35,120
to biology has been the invention of a

444
00:17:40,310 --> 00:17:37,440
lot of important terminology including

445
00:17:42,310 --> 00:17:40,320
the word phylogeny so he's the one who

446
00:17:44,470 --> 00:17:42,320
first

447
00:17:47,029 --> 00:17:44,480
started drawing these kinds of trees

448
00:17:48,870 --> 00:17:47,039
showing his inferred

449
00:17:50,630 --> 00:17:48,880
what he inferred to be the relationship

450
00:17:52,789 --> 00:17:50,640
between different groups of organisms so

451
00:17:55,909 --> 00:17:52,799
on the left here we have his depiction

452
00:17:58,230 --> 00:17:55,919
of phylogeny but one of the hypotheses

453
00:18:00,950 --> 00:17:58,240
for which he's best known is this idea

454
00:18:03,909 --> 00:18:00,960
that ontogeny or development

455
00:18:06,710 --> 00:18:03,919
recapitulates phylogeny and so the idea

456
00:18:09,990 --> 00:18:06,720
here is that as an organism particularly

457
00:18:12,830 --> 00:18:10,000
an animal goes through development it

458
00:18:13,990 --> 00:18:12,840
essentially reflects

459
00:18:16,710 --> 00:18:14,000
evolutionary um

460
00:18:19,270 --> 00:18:16,720
the the biology of the ancestors from

461
00:18:21,510 --> 00:18:19,280
which it evolved and this has been this

462
00:18:23,190 --> 00:18:21,520
hypothesis has been highly controversial

463
00:18:25,510 --> 00:18:23,200

and it's not the main focus of what i'm

464
00:18:27,029 --> 00:18:25,520
going to talk about today um but i

465
00:18:29,510 --> 00:18:27,039
wanted you to have the sense that when

466
00:18:34,150 --> 00:18:29,520
he looked at developmental processes

467
00:18:35,750 --> 00:18:34,160
what he saw was evolution unfolding

468
00:18:37,909 --> 00:18:35,760
and so heckle

469
00:18:40,310 --> 00:18:37,919
actually hypothesized that the first

470
00:18:41,750 --> 00:18:40,320
animal was not a flagellate but instead

471
00:18:44,230 --> 00:18:41,760
an amoeba

472
00:18:46,230 --> 00:18:44,240
and so the reason that he did this was

473
00:18:48,630 --> 00:18:46,240
that when he looked at the biology of

474
00:18:50,870 --> 00:18:48,640
sponges which he was one of the first to

475
00:18:52,549 --> 00:18:50,880
propose that sponges were actually

476
00:18:54,789 --> 00:18:52,559
animals

477
00:18:58,470 --> 00:18:54,799
he recognized that some sponges or mini

478
00:19:00,870 --> 00:18:58,480
sponges actually had an amoeboid zygote

479
00:19:03,430 --> 00:19:00,880
so not a flagellate but an amoeba and so

480
00:19:04,789 --> 00:19:03,440
based on that he actually proposed that

481
00:19:06,950 --> 00:19:04,799
there might have been an amoeboid

482
00:19:08,870 --> 00:19:06,960
ancestry for animals and you can see

483
00:19:11,110 --> 00:19:08,880
further stages in his

484
00:19:13,029 --> 00:19:11,120
hypotheses about the intersection

485
00:19:15,430 --> 00:19:13,039
between development and evolution

486
00:19:17,350 --> 00:19:15,440
because as animals evolved they form

487
00:19:19,270 --> 00:19:17,360
these simple balls of cells called a

488
00:19:21,909 --> 00:19:19,280

morula

489
00:19:24,549 --> 00:19:21,919
followed by this blastula stage a hollow

490
00:19:26,870 --> 00:19:24,559
ball of cells but now with flagella

491
00:19:28,950 --> 00:19:26,880
and then this gastrulation stage and so

492
00:19:30,630 --> 00:19:28,960
based on this heckle huckel really held

493
00:19:33,190 --> 00:19:30,640
strongly to this idea that the first

494
00:19:35,350 --> 00:19:33,200
animal was amiiboit of course he didn't

495
00:19:37,510 --> 00:19:35,360
have access to the type of data that i

496
00:19:39,510 --> 00:19:37,520
just showed you about the universality

497
00:19:41,830 --> 00:19:39,520
of the cholera complex

498
00:19:42,870 --> 00:19:41,840
now a deep rival at the time they

499
00:19:44,630 --> 00:19:42,880
actually

500
00:19:46,150 --> 00:19:44,640
hated each other

501
00:19:51,110 --> 00:19:46,160
um

502
00:19:53,350 --> 00:19:51,120
was william savile kent and samuel kent

503
00:19:55,510 --> 00:19:53,360
actually first of all did not agree with

504
00:19:58,230 --> 00:19:55,520
the idea that sponges were animals but

505
00:19:59,110 --> 00:19:58,240
in addition felt that heckle's idea

506
00:20:01,990 --> 00:19:59,120
about

507
00:20:04,230 --> 00:20:02,000
amoeba and amoeba being the ancestral

508
00:20:05,830 --> 00:20:04,240
state for animals was incorrect

509
00:20:08,390 --> 00:20:05,840
and part of his argument was his

510
00:20:11,350 --> 00:20:08,400
discovery of this organism that he named

511
00:20:14,230 --> 00:20:11,360
after heckle as sort of a a dig

512
00:20:15,909 --> 00:20:14,240
um which he called protospongia hecleyi

513
00:20:17,510 --> 00:20:15,919

and this was an interesting organism

514
00:20:19,990 --> 00:20:17,520
because they had these collar cells on

515
00:20:21,270 --> 00:20:20,000
the periphery but it had amoeboid cells

516
00:20:23,750 --> 00:20:21,280
in the middle

517
00:20:25,669 --> 00:20:23,760
interestingly enough nobody has ever

518
00:20:28,950 --> 00:20:25,679
seen this organism again and there's

519
00:20:31,510 --> 00:20:28,960
been quite a bit of uh speculation that

520
00:20:34,390 --> 00:20:31,520
savile kent who who had many moral

521
00:20:36,870 --> 00:20:34,400
failings might have just made it up and

522
00:20:40,149 --> 00:20:36,880
i'll leave you to decide what you think

523
00:20:41,029 --> 00:20:40,159
based on what i'm about to show you

524
00:20:42,950 --> 00:20:41,039
so

525
00:20:45,110 --> 00:20:42,960
what can we learn from choanoflagellates

526
00:20:47,830 --> 00:20:45,120
about this mystery we're crawling cells

527
00:20:49,430 --> 00:20:47,840
in the first animals or

528
00:20:52,870 --> 00:20:49,440
or

529
00:20:55,510 --> 00:20:52,880
animal lineage

530
00:20:57,669 --> 00:20:55,520
now coinoflagellates are actually named

531
00:20:58,950 --> 00:20:57,679
for the flagellum they are iconic

532
00:21:00,549 --> 00:20:58,960
flagellates

533
00:21:02,230 --> 00:21:00,559
they have only been observed in a

534
00:21:03,909 --> 00:21:02,240
flagellated state every single

535
00:21:05,990 --> 00:21:03,919
choanoflagellate that's been identified

536
00:21:09,990 --> 00:21:06,000
has a flagellum and i'm showing you some

537
00:21:13,830 --> 00:21:11,510
nonetheless

538
00:21:15,750 --> 00:21:13,840

this very brave postdoc tebow brunei

539
00:21:17,430 --> 00:21:15,760
who's in the middle of this picture here

540
00:21:18,549 --> 00:21:17,440
these other two characters will come in

541
00:21:20,549 --> 00:21:18,559
later

542
00:21:22,470 --> 00:21:20,559
came to my lab

543
00:21:25,669 --> 00:21:22,480
focused on this question of how cell

544
00:21:28,070 --> 00:21:25,679
contractility which is the cellular

545
00:21:29,350 --> 00:21:28,080
process that has to happen for cells to

546
00:21:31,110 --> 00:21:29,360
crawl

547
00:21:33,190 --> 00:21:31,120
how that might have first evolved and he

548
00:21:34,950 --> 00:21:33,200
wanted to look for this to address this

549
00:21:36,710 --> 00:21:34,960
question in choanoflagellates which i

550
00:21:39,029 --> 00:21:36,720
thought was foolhardy since they are

551
00:21:40,470 --> 00:21:39,039
only flagellates and never crawl

552
00:21:43,270 --> 00:21:40,480
but i was wrong

553
00:21:45,270 --> 00:21:43,280
and uh and and

554
00:21:47,510 --> 00:21:45,280
this was proven to me when tevo came

555
00:21:49,909 --> 00:21:47,520
rushing to my office to show me that in

556
00:21:52,149 --> 00:21:49,919
fact quantoflagellates ca could convert

557
00:21:53,830 --> 00:21:52,159
into an amoeboid cell and so here what

558
00:21:55,830 --> 00:21:53,840
you see on the left are two

559
00:21:57,990 --> 00:21:55,840
choanoflagellate cells that have been

560
00:22:00,149 --> 00:21:58,000
converted into this amoeboid state and

561
00:22:02,310 --> 00:22:00,159
on the right our cells are the same

562
00:22:04,630 --> 00:22:02,320
cells in which a particular protein has

563
00:22:07,029 --> 00:22:04,640

been labeled in red

564
00:22:10,549 --> 00:22:08,870
so hopefully you can see now that rather

565
00:22:13,270 --> 00:22:10,559
than swimming around beating their

566
00:22:15,750 --> 00:22:13,280
flagellum these are now moving around on

567
00:22:19,430 --> 00:22:15,760
the substrate by sending out these blebs

568
00:22:21,510 --> 00:22:19,440
and kind of crawling across surfaces

569
00:22:24,950 --> 00:22:21,520
now the way this happens the way he was

570
00:22:27,430 --> 00:22:24,960
able to induce this switch is through a

571
00:22:29,510 --> 00:22:27,440
process of cell confinement and so what

572
00:22:31,510 --> 00:22:29,520
you can see is how this works so on the

573
00:22:33,110 --> 00:22:31,520
left the quanta flagellates are allowed

574
00:22:33,990 --> 00:22:33,120
to swim around freely in the water

575
00:22:35,430 --> 00:22:34,000
column

576
00:22:38,310 --> 00:22:35,440
but on the right

577
00:22:41,350 --> 00:22:38,320
um he was able to apply

578
00:22:43,590 --> 00:22:41,360
apply confinement through this structure

579
00:22:45,909 --> 00:22:43,600
that with it has these little tiny micro

580
00:22:48,230 --> 00:22:45,919
spacers that he just inverted right down

581
00:22:50,549 --> 00:22:48,240
onto the choanoflagellates and what you

582
00:22:52,470 --> 00:22:50,559
can see is that that had produced a

583
00:22:56,230 --> 00:22:52,480
defined space in which the

584
00:22:57,110 --> 00:22:56,240
coanoflagellates would become squeezed

585
00:22:59,350 --> 00:22:57,120
so

586
00:23:02,630 --> 00:22:59,360
this is a data heavy slide but the sim

587
00:23:04,870 --> 00:23:02,640
the point i want to make is that this

588
00:23:07,270 --> 00:23:04,880

conversion from being a flagellate to a

589
00:23:09,270 --> 00:23:07,280
single cell can be tightly regulated by

590
00:23:11,350 --> 00:23:09,280
the level of confinement and so on the

591
00:23:12,549 --> 00:23:11,360
left you can see examples of cells that

592
00:23:14,710 --> 00:23:12,559
have been

593
00:23:17,510 --> 00:23:14,720
introduced to

594
00:23:19,510 --> 00:23:17,520
greater and greater confinement

595
00:23:21,190 --> 00:23:19,520
in this graph what you're seeing is the

596
00:23:24,390 --> 00:23:21,200
fraction of the cells with these

597
00:23:26,149 --> 00:23:24,400
protrusions that typify crawling cells

598
00:23:28,070 --> 00:23:26,159
and hopefully you can see that there's

599
00:23:30,710 --> 00:23:28,080
this reproducible

600
00:23:32,950 --> 00:23:30,720
production of cells with with dynamic

601
00:23:34,870 --> 00:23:32,960
protrusions as we increase the

602
00:23:35,750 --> 00:23:34,880
confinement or decrease the available

603
00:23:37,270 --> 00:23:35,760
space

604
00:23:39,270 --> 00:23:37,280
and then on the bottom

605
00:23:42,310 --> 00:23:39,280
it's meant to show you these are stills

606
00:23:44,149 --> 00:23:42,320
from movies that show you that

607
00:23:46,710 --> 00:23:44,159
the cells can be converted from being

608
00:23:51,190 --> 00:23:46,720
flagellates to amoeboids and then back

609
00:23:57,190 --> 00:23:54,310
so i thought that was super cool

610
00:23:59,830 --> 00:23:57,200
i had never seen a coinoflagelet be a

611
00:24:02,070 --> 00:23:59,840
crawling cell before but i was highly

612
00:24:03,909 --> 00:24:02,080
skeptical because of the way in which

613
00:24:06,149 --> 00:24:03,919

the transition was induced it seemed

614
00:24:08,149 --> 00:24:06,159
very artificial and it was hard for me

615
00:24:10,470 --> 00:24:08,159
to imagine when a quantum flagellate

616
00:24:13,190 --> 00:24:10,480
might ever encounter such confinement

617
00:24:15,269 --> 00:24:13,200
but here again i was wrong and that is

618
00:24:17,590 --> 00:24:15,279
because choanoflagellates

619
00:24:21,110 --> 00:24:17,600
sequences from quanta flagellates had

620
00:24:24,070 --> 00:24:21,120
actually been detected in silts that

621
00:24:26,870 --> 00:24:24,080
have um the same amount of space between

622
00:24:29,830 --> 00:24:26,880
grains that we see in our experiments

623
00:24:32,549 --> 00:24:29,840
that induce uh amoeboid the conversion

624
00:24:34,710 --> 00:24:32,559
to an amoeboid state and so actually we

625
00:24:37,269 --> 00:24:34,720
know that choanoflagellates exist in

626
00:24:39,110 --> 00:24:37,279
highly confined environments but they've

627
00:24:40,870 --> 00:24:39,120
never been studied in that context

628
00:24:43,830 --> 00:24:40,880
before because it wasn't recognized that

629
00:24:50,070 --> 00:24:46,870
so why are they converting to this

630
00:24:51,830 --> 00:24:50,080
amoeboid state under confinement and so

631
00:24:53,990 --> 00:24:51,840
what you're seeing here on the left is

632
00:24:56,230 --> 00:24:54,000
one of these micro pillars that's

633
00:24:58,310 --> 00:24:56,240
confining the choanoflagellates and the

634
00:25:00,789 --> 00:24:58,320
cells that are outside the circle are

635
00:25:02,789 --> 00:25:00,799
actually free to swim and what you can

636
00:25:05,190 --> 00:25:02,799
see if you focus on individuals that are

637
00:25:07,190 --> 00:25:05,200
near the edge of this pillar

638
00:25:08,710 --> 00:25:07,200

they actually send out protrusions and

639
00:25:11,110 --> 00:25:08,720
are able to

640
00:25:13,269 --> 00:25:11,120
escape from confinement

641
00:25:15,350 --> 00:25:13,279
so hopefully this movie will play yes

642
00:25:16,870 --> 00:25:15,360
and so you can focus on individual cells

643
00:25:18,950 --> 00:25:16,880
that are near the

644
00:25:20,710 --> 00:25:18,960
periphery and you can see that they can

645
00:25:23,510 --> 00:25:20,720
actually escape and i'll show you this

646
00:25:25,830 --> 00:25:23,520
in a zoom in in a moment

647
00:25:27,909 --> 00:25:25,840
okay so we're going to zoom in

648
00:25:29,590 --> 00:25:27,919
now we're just looking at one cell

649
00:25:31,669 --> 00:25:29,600
that's near the edge of one of these

650
00:25:33,669 --> 00:25:31,679
pillars here it is

651
00:25:36,230 --> 00:25:33,679
here it is in fluorescent form and the

652
00:25:38,070 --> 00:25:36,240
point here is that we can actually

653
00:25:40,230 --> 00:25:38,080
segment these so that we can quantify

654
00:25:41,510 --> 00:25:40,240
this behavior and so i'm going to start

655
00:25:43,990 --> 00:25:41,520
the movie and you're going to see that

656
00:25:45,750 --> 00:25:44,000
the the cell actually crawls out from

657
00:25:51,269 --> 00:25:45,760
the confinement and then it can convert

658
00:25:55,669 --> 00:25:53,830
okay so is this something special to the

659
00:25:58,230 --> 00:25:55,679
one choanoflagellate we've been studying

660
00:26:00,789 --> 00:25:58,240
or is it widespread and in fact this

661
00:26:02,630 --> 00:26:00,799
amoeboid behavior seems to exist in

662
00:26:04,789 --> 00:26:02,640
every choanoflagellate that tebow has

663
00:26:06,950 --> 00:26:04,799

looked at so this is a

664
00:26:09,110 --> 00:26:06,960
fundamental highly conserved behavior of

665
00:26:11,029 --> 00:26:09,120
these cells but one that had not

666
00:26:16,390 --> 00:26:11,039
previously been observed because people

667
00:26:20,549 --> 00:26:18,310
and this is actually very interesting

668
00:26:23,830 --> 00:26:20,559
because it parallels a cell biology that

669
00:26:26,710 --> 00:26:23,840
we see in animals called the epithelial

670
00:26:28,310 --> 00:26:26,720
mesenchymal transition in which the cell

671
00:26:31,029 --> 00:26:28,320
types that have

672
00:26:32,710 --> 00:26:31,039
collar complexes shown here on the left

673
00:26:35,909 --> 00:26:32,720
the epithelia

674
00:26:38,310 --> 00:26:35,919
can convert into crawling type cells or

675
00:26:40,789 --> 00:26:38,320
contractile cells here on the right and

676
00:26:43,830 --> 00:26:40,799
they do this in part in response to

677
00:26:47,190 --> 00:26:43,840
confinement and compression

678
00:26:48,789 --> 00:26:47,200
and so what we see now is that

679
00:26:50,549 --> 00:26:48,799
and i'm bringing together a lot of

680
00:26:52,789 --> 00:26:50,559
evidence not just from what i just told

681
00:26:55,430 --> 00:26:52,799
you but from the field in general is

682
00:26:57,190 --> 00:26:55,440
that choanoflagellates are capable of

683
00:26:59,430 --> 00:26:57,200
converting from a flagellate to an

684
00:27:01,269 --> 00:26:59,440
amoeboid cell and even to an

685
00:27:03,830 --> 00:27:01,279
intermediate cell called an amoeba

686
00:27:06,470 --> 00:27:03,840
flagellate i told you previously that

687
00:27:08,870 --> 00:27:06,480
sponges can exist both as

688
00:27:10,549 --> 00:27:08,880

these amoeboid cells called archaeocytes

689
00:27:13,669 --> 00:27:10,559
but also as

690
00:27:16,710 --> 00:27:13,679
color cells koanocytes and vertebrates

691
00:27:19,590 --> 00:27:16,720
also undergo these types of transitions

692
00:27:21,269 --> 00:27:19,600
and so what this suggests is that animal

693
00:27:23,750 --> 00:27:21,279
amoeboid cells

694
00:27:25,990 --> 00:27:23,760
that we see the hard hard programmed

695
00:27:27,990 --> 00:27:26,000
into the developmental program might

696
00:27:29,750 --> 00:27:28,000
actually evolve from a phenotype that

697
00:27:31,990 --> 00:27:29,760
was regulated by the environment

698
00:27:33,990 --> 00:27:32,000
previously and so that's what this shows

699
00:27:35,269 --> 00:27:34,000
here choanoflagellates and animals are

700
00:27:36,870 --> 00:27:35,279
sister group

701
00:27:38,950 --> 00:27:36,880
we think that they evolved from an

702
00:27:41,269 --> 00:27:38,960
organism that was capable of alternating

703
00:27:42,710 --> 00:27:41,279
between an amoeboid and a flagellated

704
00:27:45,590 --> 00:27:42,720
cell type so that there was this

705
00:27:47,990 --> 00:27:45,600
plasticity and that within the animals

706
00:27:49,430 --> 00:27:48,000
the reason that we're able to get this

707
00:27:51,990 --> 00:27:49,440
well-programmed

708
00:27:53,430 --> 00:27:52,000
cell differentiation is that that switch

709
00:27:55,110 --> 00:27:53,440
between the amoeboid cell and the

710
00:27:57,430 --> 00:27:55,120
flagellated cell

711
00:28:00,149 --> 00:27:57,440
became hardwired into the developmental

712
00:28:04,070 --> 00:28:03,110
okay so that was our first hint

713
00:28:07,750 --> 00:28:04,080

that

714
00:28:09,269 --> 00:28:07,760
the prevailing idea about animal origins

715
00:28:12,070 --> 00:28:09,279
and the nature of the cells from which

716
00:28:13,990 --> 00:28:12,080
animals might have evolved was not wrong

717
00:28:16,630 --> 00:28:14,000
but incomplete

718
00:28:19,430 --> 00:28:16,640
it showed us that these simple seemingly

719
00:28:21,990 --> 00:28:19,440
simple cells were able to take on many

720
00:28:23,510 --> 00:28:22,000
different cellular behaviors

721
00:28:26,710 --> 00:28:23,520
in response to changes in the

722
00:28:29,590 --> 00:28:26,720
environment and it suggested that

723
00:28:31,909 --> 00:28:29,600
much of the the hardware for making

724
00:28:34,149 --> 00:28:31,919
different cell types might have predated

725
00:28:36,470 --> 00:28:34,159
animal origins

726
00:28:39,190 --> 00:28:36,480
and simply become become

727
00:28:42,070 --> 00:28:39,200
more strictly hardwired in animals

728
00:28:43,990 --> 00:28:42,080
so i'm going to tell you about a similar

729
00:28:45,990 --> 00:28:44,000
unexpected finding that came out of

730
00:28:48,630 --> 00:28:46,000
field work that really has given us more

731
00:28:49,669 --> 00:28:48,640
insight into the ancestral biology of

732
00:28:51,990 --> 00:28:49,679
animals

733
00:28:53,990 --> 00:28:52,000
and this again was work uh

734
00:28:56,230 --> 00:28:54,000
that included tebow brunei who now has

735
00:28:58,149 --> 00:28:56,240
his own lab at the uh pastor institute

736
00:29:00,789 --> 00:28:58,159
in paris and two graduate students at

737
00:29:03,110 --> 00:29:00,799
the time tess linden and ben larson and

738
00:29:05,830 --> 00:29:03,120

we joke that this picture actually

739
00:29:07,909 --> 00:29:05,840
depicts the way they were uh as

740
00:29:10,149 --> 00:29:07,919
researchers been diving in

741
00:29:10,950 --> 00:29:10,159
full-heartedly this is a hyper saline

742
00:29:12,149 --> 00:29:10,960
lake

743
00:29:14,149 --> 00:29:12,159
tests

744
00:29:17,029 --> 00:29:14,159
documenting everything very carefully

745
00:29:19,110 --> 00:29:17,039
and analyzing it and then tebow uh

746
00:29:21,029 --> 00:29:19,120
is the uh you know

747
00:29:22,950 --> 00:29:21,039
supervising and making sure everything

748
00:29:25,269 --> 00:29:22,960
is done properly so he was ready to be a

749
00:29:28,070 --> 00:29:25,279
pi at that point um

750
00:29:31,269 --> 00:29:28,080
okay so when we went to curse sound to

751
00:29:32,470 --> 00:29:31,279
do field work um it was as part of a a

752
00:29:34,310 --> 00:29:32,480
group that was

753
00:29:37,029 --> 00:29:34,320
looking at microbial ecology in

754
00:29:38,950 --> 00:29:37,039
particular around coral reefs

755
00:29:40,549 --> 00:29:38,960
but we were particularly interested in

756
00:29:43,669 --> 00:29:40,559
understanding what was the diversity of

757
00:29:46,070 --> 00:29:43,679
coinoflagellates on this island and i

758
00:29:47,750 --> 00:29:46,080
i'm not a field biologist i'm learning

759
00:29:49,190 --> 00:29:47,760
to be a field biologist and i wasn't

760
00:29:52,149 --> 00:29:49,200
sure what we could do that would be

761
00:29:55,029 --> 00:29:52,159
useful but i thought you know just as a

762
00:29:57,029 --> 00:29:55,039
to set a low bar um we would start by

763
00:29:59,830 --> 00:29:57,039

simply describing quantum flagellate

764
00:30:01,590 --> 00:29:59,840
diversity so we went all over the island

765
00:30:03,350 --> 00:30:01,600
collecting in lots of different places

766
00:30:04,710 --> 00:30:03,360
and then bringing them back to the

767
00:30:07,029 --> 00:30:04,720
bringing the water samples back to the

768
00:30:08,149 --> 00:30:07,039
marine station to look at what we found

769
00:30:10,789 --> 00:30:08,159
and see if there was anything

770
00:30:16,070 --> 00:30:14,070
and so we did this for about a week uh

771
00:30:17,750 --> 00:30:16,080
and we found you know pretty

772
00:30:21,269 --> 00:30:17,760
run-of-the-mill quanoflagel it's nothing

773
00:30:23,350 --> 00:30:21,279
exciting until we sampled from

774
00:30:25,669 --> 00:30:23,360
what i've learned is called a splash

775
00:30:27,510 --> 00:30:25,679
pool so this is actually a very harsh

776
00:30:29,750 --> 00:30:27,520
environment this is on the windward side

777
00:30:31,430 --> 00:30:29,760
of this island of curacao

778
00:30:33,190 --> 00:30:31,440
in the background you might be able to

779
00:30:34,310 --> 00:30:33,200
see the

780
00:30:37,669 --> 00:30:34,320
windmills

781
00:30:41,190 --> 00:30:37,679
it's very warm it's in the the mid to

782
00:30:43,350 --> 00:30:41,200
upper 80s um warm to a californian sorry

783
00:30:45,510 --> 00:30:43,360
um

784
00:30:47,750 --> 00:30:45,520
and there are these little pools that

785
00:30:50,310 --> 00:30:47,760
are in fact not tide pools they're not

786
00:30:52,470 --> 00:30:50,320
fed by the tide but they're fed by spray

787
00:30:55,510 --> 00:30:52,480
or splash coming off of these waves

788
00:30:57,190 --> 00:30:55,520

crashing and so these pools vary quite a

789
00:31:00,310 --> 00:30:57,200
bit they're they're sort of an extreme

790
00:31:01,190 --> 00:31:00,320
environment because they get very warm

791
00:31:03,669 --> 00:31:01,200
they

792
00:31:05,830 --> 00:31:03,679
evaporate and become hyper saline and

793
00:31:09,110 --> 00:31:05,840
there's a lot of interesting biology

794
00:31:11,909 --> 00:31:09,120
in these pools so when tebow and

795
00:31:14,149 --> 00:31:11,919
tess and ben sampled from this pool and

796
00:31:16,870 --> 00:31:14,159
brought it back they found something

797
00:31:19,190 --> 00:31:16,880
shocking that completely changed the

798
00:31:21,110 --> 00:31:19,200
nature of our sampling on this island

799
00:31:23,269 --> 00:31:21,120
this is what they found

800
00:31:25,830 --> 00:31:23,279
this is a

801
00:31:27,110 --> 00:31:25,840
colonial clanoflagelet that forms a

802
00:31:27,990 --> 00:31:27,120
sheet

803
00:31:35,110 --> 00:31:28,000
and

804
00:31:37,590 --> 00:31:35,120
seeing the lip of the cup right now

805
00:31:39,190 --> 00:31:37,600
you'll also see these predatory

806
00:31:40,549 --> 00:31:39,200
flagellates swimming around and you

807
00:31:42,789 --> 00:31:40,559
don't need to worry about those just

808
00:31:44,950 --> 00:31:42,799
focus on this sheet and this is what

809
00:31:46,950 --> 00:31:44,960
they saw this this

810
00:31:48,870 --> 00:31:46,960
video actually came from the marine

811
00:31:58,070 --> 00:31:48,880
station on the day that they discovered

812
00:32:01,110 --> 00:31:59,990
so these are these little flagellate

813
00:32:03,110 --> 00:32:01,120

cells

814
00:32:05,430 --> 00:32:03,120
but they've formed a multicellular

815
00:32:07,029 --> 00:32:05,440
structure that's able to do coordinated

816
00:32:10,230 --> 00:32:07,039
morphogenetic

817
00:32:12,149 --> 00:32:10,240
folding this was a complete shock to us

818
00:32:15,029 --> 00:32:12,159
and it's not something that had been

819
00:32:18,870 --> 00:32:15,039
reported before really amazing how are

820
00:32:22,070 --> 00:32:20,710
so we decided to try to study it in

821
00:32:24,310 --> 00:32:22,080
detail

822
00:32:27,430 --> 00:32:24,320
and we discussed first our question was

823
00:32:28,950 --> 00:32:27,440
what causes this inversion to happen and

824
00:32:31,269 --> 00:32:28,960
it turns out that a lot of things can

825
00:32:33,350 --> 00:32:31,279
cause it so one example is mechanical

826
00:32:36,070 --> 00:32:33,360
signals

827
00:32:36,950 --> 00:32:36,080
and this is a bit brutal but if we stab

828
00:32:42,630 --> 00:32:36,960
it

829
00:32:45,190 --> 00:32:42,640
on the right you can see that along the

830
00:32:47,110 --> 00:32:45,200
y-axis we're measuring the percentage of

831
00:32:49,750 --> 00:32:47,120
cells that have their flagella out

832
00:32:51,590 --> 00:32:49,760
versus in and if the cells are kept in a

833
00:32:53,430 --> 00:32:51,600
static environment without any sort of

834
00:32:56,070 --> 00:32:53,440
turbulence

835
00:32:58,950 --> 00:32:56,080
they remain with their flagella in which

836
00:33:01,110 --> 00:32:58,960
is the the image on the left

837
00:33:04,149 --> 00:33:01,120
and if we shake them which creates a lot

838
00:33:07,269 --> 00:33:04,159

of turbulence and mechanical uh signals

839
00:33:09,590 --> 00:33:07,279
then they uh entirely invert and put

840
00:33:11,990 --> 00:33:09,600
their flagella in the collar complex on

841
00:33:14,549 --> 00:33:12,000
the outside

842
00:33:16,870 --> 00:33:14,559
but what really shocked us was that

843
00:33:19,190 --> 00:33:16,880
light to dark transitions can also

844
00:33:20,389 --> 00:33:19,200
induce this so on the left here you're

845
00:33:24,230 --> 00:33:20,399
seeing

846
00:33:26,630 --> 00:33:24,240
a low magnification image of a culture

847
00:33:27,990 --> 00:33:26,640
and each of these shiny blobs is one of

848
00:33:30,549 --> 00:33:28,000
those colonies with hundreds and

849
00:33:31,909 --> 00:33:30,559
hundreds of cells and so what you'll see

850
00:33:34,389 --> 00:33:31,919
here

851
00:33:37,029 --> 00:33:34,399
is that as we

852
00:33:39,590 --> 00:33:37,039
turn the lights off suddenly the vast

853
00:33:41,990 --> 00:33:39,600
majority of these colonies invert ball

854
00:33:44,310 --> 00:33:42,000
up and start swimming around and in fact

855
00:33:46,310 --> 00:33:44,320
this inversion really is switching the

856
00:33:48,310 --> 00:33:46,320
quantum flagellates from

857
00:33:50,950 --> 00:33:48,320
a state in which they're sedentary but

858
00:33:52,789 --> 00:33:50,960
actually feeding eating lots of bacteria

859
00:33:55,509 --> 00:33:52,799
to one in which they're swimming around

860
00:33:57,990 --> 00:33:55,519
and it's perhaps an escape mechanism and

861
00:34:00,149 --> 00:33:58,000
again we can quantify this and so you

862
00:34:03,190 --> 00:34:00,159
can see here again we're measuring in

863
00:34:06,230 --> 00:34:03,200

this case the normalized sheet area

864
00:34:08,470 --> 00:34:06,240
and before we turn the lights off this

865
00:34:10,230 --> 00:34:08,480
remains at about one and when we turn

866
00:34:12,069 --> 00:34:10,240
the lights off they invert and that

867
00:34:13,909 --> 00:34:12,079
leads to the sheet area

868
00:34:16,950 --> 00:34:13,919
becoming much smaller and that so that's

869
00:34:19,109 --> 00:34:16,960
our proxy for inversion

870
00:34:21,030 --> 00:34:19,119
so the first question we had was

871
00:34:24,550 --> 00:34:21,040
they don't have an eye they don't have

872
00:34:26,389 --> 00:34:24,560
any pigment how are they detecting

873
00:34:27,510 --> 00:34:26,399
light or darkness

874
00:34:29,270 --> 00:34:27,520
and we're not going to go into the

875
00:34:31,190 --> 00:34:29,280
evidence but just tell you that we were

876
00:34:33,109 --> 00:34:31,200
very lucky

877
00:34:35,909 --> 00:34:33,119
in in that we were able to quickly

878
00:34:38,550 --> 00:34:35,919
identify the protein through which

879
00:34:41,990 --> 00:34:38,560
photoreception occurs and so this is a

880
00:34:45,270 --> 00:34:42,000
protein that has two parts one part is

881
00:34:48,470 --> 00:34:45,280
shown here it's related to rhodopsins

882
00:34:50,710 --> 00:34:48,480
that allow both bacteria and

883
00:34:52,629 --> 00:34:50,720
in animals to detect light

884
00:34:55,990 --> 00:34:52,639
and the second part of the protein is an

885
00:34:57,910 --> 00:34:56,000
enzyme called a phosphodiesterase

886
00:34:59,670 --> 00:34:57,920
the name isn't important what's

887
00:35:02,550 --> 00:34:59,680
important has this activity that it

888
00:35:04,630 --> 00:35:02,560

switches one molecule a cyclic tmp into

889
00:35:07,190 --> 00:35:04,640
a different type of molecule a five

890
00:35:09,750 --> 00:35:07,200
prime gmp so simply

891
00:35:11,750 --> 00:35:09,760
by shining light on the choanoflagellate

892
00:35:14,470 --> 00:35:11,760
you can drive this conversion from

893
00:35:16,550 --> 00:35:14,480
cyclic gmp to five prime gmp but if you

894
00:35:19,109 --> 00:35:16,560
turn the lights off you accumulate an

895
00:35:21,190 --> 00:35:19,119
entirely different molecule cyclic gmp

896
00:35:22,550 --> 00:35:21,200
and this alone can change the behavior

897
00:35:24,150 --> 00:35:22,560
of the cells

898
00:35:26,150 --> 00:35:24,160
okay so that's interesting we know how

899
00:35:29,190 --> 00:35:26,160
it's regulated but how does that

900
00:35:31,349 --> 00:35:29,200
actually happen at the structural level

901
00:35:33,750 --> 00:35:31,359
and it turns out that that is driven by

902
00:35:35,829 --> 00:35:33,760
a change in the angle of the collar that

903
00:35:39,510 --> 00:35:35,839
we've been talking about so in the

904
00:35:43,109 --> 00:35:39,520
flagella in state all of the collars are

905
00:35:44,710 --> 00:35:43,119
straight and and parallel and so

906
00:35:47,349 --> 00:35:44,720
because they're so

907
00:35:48,470 --> 00:35:47,359
close together it changes the angle of

908
00:36:00,069 --> 00:35:48,480
the

909
00:36:02,950 --> 00:36:00,079
neighbors around and so now you get this

910
00:36:04,870 --> 00:36:02,960
inversion into a different curvature

911
00:36:06,710 --> 00:36:04,880
and this is actually regulated by a

912
00:36:08,390 --> 00:36:06,720
group of proteins that sit at the bottom

913
00:36:10,069 --> 00:36:08,400

of the collar

914
00:36:11,990 --> 00:36:10,079
shown in this ring and i'm going to talk

915
00:36:14,710 --> 00:36:12,000
about it in a moment these are called

916
00:36:18,069 --> 00:36:14,720
this is the actimiacin complex

917
00:36:21,190 --> 00:36:18,079
okay so when this ring is wide

918
00:36:23,829 --> 00:36:21,200
then you have the small collar angle

919
00:36:25,670 --> 00:36:23,839
but when the ring of proteins it

920
00:36:27,750 --> 00:36:25,680
contracts

921
00:36:31,030 --> 00:36:27,760
then the collar opens up and that

922
00:36:33,589 --> 00:36:31,040
changes the entire behavior of the whole

923
00:36:35,670 --> 00:36:33,599
layer of cells

924
00:36:37,510 --> 00:36:35,680
okay so what is this mysterious protein

925
00:36:39,829 --> 00:36:37,520
complex i mentioned it's called

926
00:36:42,230 --> 00:36:39,839
actimiacin and here we've stained it

927
00:36:45,349 --> 00:36:42,240
we've stained one component myosin and

928
00:36:47,109 --> 00:36:45,359
green and the other component actin

929
00:36:49,030 --> 00:36:47,119
here it's showing in magenta i'm not

930
00:36:49,910 --> 00:36:49,040
sure what you guys are seeing

931
00:36:52,310 --> 00:36:49,920
so

932
00:36:54,470 --> 00:36:52,320
this is a large colony that's been

933
00:36:56,470 --> 00:36:54,480
stained for these two proteins but if we

934
00:36:59,589 --> 00:36:56,480
zoom in i hope you can see that the

935
00:37:02,790 --> 00:36:59,599
myosin forms these little green rings

936
00:37:04,870 --> 00:37:02,800
and the actin comes in and touches the

937
00:37:07,670 --> 00:37:04,880
rings and it's the connection between

938
00:37:09,990 --> 00:37:07,680

those two types of proteins that allows

939
00:37:11,990 --> 00:37:10,000
them to

940
00:37:14,710 --> 00:37:12,000
contract and change the angle of the

941
00:37:17,910 --> 00:37:16,550
and so here we can zoom in on it a

942
00:37:21,430 --> 00:37:17,920
little bit

943
00:37:23,190 --> 00:37:21,440
and you can see in a relaxed apical ring

944
00:37:26,150 --> 00:37:23,200
this uh

945
00:37:27,190 --> 00:37:26,160
you have the small collar angle so here

946
00:37:29,349 --> 00:37:27,200
these

947
00:37:31,030 --> 00:37:29,359
molecules are pushing out the proteins

948
00:37:33,589 --> 00:37:31,040
are pushing out and that's drawing the

949
00:37:36,710 --> 00:37:33,599
collar in

950
00:37:39,190 --> 00:37:36,720
when we turn the lights off now the

951
00:37:42,230 --> 00:37:39,200
proteins contract in on each other and

952
00:37:43,990 --> 00:37:42,240
that opens up the collar ring sorry

953
00:37:45,910 --> 00:37:44,000
which you can see here

954
00:37:47,670 --> 00:37:45,920
now how do we know that this is what's

955
00:37:49,270 --> 00:37:47,680
actually going on it turns out that

956
00:37:51,349 --> 00:37:49,280
there are a lot of

957
00:37:53,430 --> 00:37:51,359
drugs that molecular biologists have

958
00:37:55,190 --> 00:37:53,440
developed to disrupt the functions of

959
00:37:57,910 --> 00:37:55,200
these proteins and you don't need to

960
00:37:59,430 --> 00:37:57,920
know what these drugs are

961
00:38:01,829 --> 00:37:59,440
named but here they are for the

962
00:38:04,550 --> 00:38:01,839
aficionados the main point is if we

963
00:38:07,829 --> 00:38:04,560

treat with any drug that disrupts either

964
00:38:10,630 --> 00:38:07,839
actin or myosin what we see here

965
00:38:13,990 --> 00:38:10,640
is that now the cells are not responsive

966
00:38:15,589 --> 00:38:14,000
to light they can't do the contraction

967
00:38:17,750 --> 00:38:15,599
when the lights are turned off the way

968
00:38:20,230 --> 00:38:17,760
they could if they weren't and weren't

969
00:38:21,750 --> 00:38:20,240
exposed to these drugs and so that tells

970
00:38:25,109 --> 00:38:21,760
us that these proteins are very

971
00:38:25,910 --> 00:38:25,119
important for this inversion process

972
00:38:27,589 --> 00:38:25,920
okay

973
00:38:29,349 --> 00:38:27,599
so um

974
00:38:31,589 --> 00:38:29,359
what i've told you then

975
00:38:33,109 --> 00:38:31,599
is that there are two states for this

976
00:38:36,870 --> 00:38:33,119
coin of flagellate which we've named

977
00:38:39,030 --> 00:38:36,880
c-flexa one is with the flagella in

978
00:38:43,349 --> 00:38:39,040
this occurs when the this ring of

979
00:38:46,710 --> 00:38:43,359
proteins is relaxed and opened up

980
00:38:49,030 --> 00:38:46,720
and if we turn off the lights that ring

981
00:38:50,870 --> 00:38:49,040
of proteins contracts and when it does

982
00:38:53,670 --> 00:38:50,880
that it leads to this collar opening

983
00:38:55,910 --> 00:38:53,680
which i'm showing you here

984
00:38:58,310 --> 00:38:55,920
why is this so interesting to us well

985
00:39:01,109 --> 00:38:58,320
first of all it's just cool biology and

986
00:39:02,550 --> 00:39:01,119
it's neat to see um single-celled

987
00:39:05,190 --> 00:39:02,560
eukaryotes doing this kind of

988
00:39:06,630 --> 00:39:05,200

complicated morphogenetic behavior

989
00:39:09,670 --> 00:39:06,640
um

990
00:39:11,990 --> 00:39:09,680
but what is additionally interesting is

991
00:39:14,630 --> 00:39:12,000
that this connection between this myosin

992
00:39:16,710 --> 00:39:14,640
ring and morphology here

993
00:39:19,030 --> 00:39:16,720
actually parallel something that happens

994
00:39:21,349 --> 00:39:19,040
in animals in which animals

995
00:39:23,990 --> 00:39:21,359
start early in development to form this

996
00:39:25,670 --> 00:39:24,000
hollow sphere of cells that are tightly

997
00:39:27,030 --> 00:39:25,680
connected to each other

998
00:39:28,470 --> 00:39:27,040
like the cells are in the quantum

999
00:39:30,790 --> 00:39:28,480
flagellate

1000
00:39:33,430 --> 00:39:30,800
and they have the same type of proteins

1001
00:39:36,150 --> 00:39:33,440
actimicin and when those contract along

1002
00:39:38,790 --> 00:39:36,160
one surface it causes the

1003
00:39:40,710 --> 00:39:38,800
ball of cells to fold in and that is the

1004
00:39:43,750 --> 00:39:40,720
beginning of forming new types of

1005
00:39:46,230 --> 00:39:43,760
tissues and new cell types so this

1006
00:39:48,150 --> 00:39:46,240
molecular connection seems to be highly

1007
00:39:50,069 --> 00:39:48,160
conserved

1008
00:39:51,910 --> 00:39:50,079
so where does that leave us

1009
00:39:53,990 --> 00:39:51,920
well i told you

1010
00:39:55,750 --> 00:39:54,000
in the first part of my talk that

1011
00:39:58,230 --> 00:39:55,760
choanoflagellates which have always been

1012
00:40:00,790 --> 00:39:58,240
thought of as flagellates are capable of

1013
00:40:02,550 --> 00:40:00,800

forming amoeboid cells and it turns out

1014
00:40:04,150 --> 00:40:02,560
that they do it through mechanisms that

1015
00:40:05,430 --> 00:40:04,160
are very similar to those used in

1016
00:40:07,829 --> 00:40:05,440
animals

1017
00:40:10,790 --> 00:40:07,839
and now i've told you that a different

1018
00:40:13,910 --> 00:40:10,800
species of choanoflagellate can undergo

1019
00:40:15,750 --> 00:40:13,920
tissue morphogenesis again using very

1020
00:40:17,670 --> 00:40:15,760
similar types of molecules to those

1021
00:40:20,710 --> 00:40:17,680
found in animals

1022
00:40:22,950 --> 00:40:20,720
so with these types of observations in

1023
00:40:25,190 --> 00:40:22,960
living single-celled relatives of

1024
00:40:27,589 --> 00:40:25,200
animals we're starting to get a much

1025
00:40:30,150 --> 00:40:27,599
richer view of what

1026
00:40:32,550 --> 00:40:30,160
of their own biology and the biology of

1027
00:40:35,109 --> 00:40:32,560
the last common ancestor of animals and

1028
00:40:38,230 --> 00:40:35,119
so what i want to leave you with is this

1029
00:40:40,150 --> 00:40:38,240
rather complex view of the progenitor of

1030
00:40:43,990 --> 00:40:40,160
animals

1031
00:40:46,470 --> 00:40:44,000
that shows that we now think that

1032
00:40:48,550 --> 00:40:46,480
that an ancestral flagellate was

1033
00:40:51,030 --> 00:40:48,560
actually capable of responding to

1034
00:40:54,069 --> 00:40:51,040
different environmental cues to either

1035
00:40:56,950 --> 00:40:54,079
display simple multicellularity attached

1036
00:40:58,790 --> 00:40:56,960
to substrates convert into amoeboid

1037
00:41:01,829 --> 00:40:58,800
stain

1038
00:41:04,950 --> 00:41:01,839

form a an environmentally hearty cyst

1039
00:41:07,670 --> 00:41:04,960
and even convert from an asexual to a

1040
00:41:09,990 --> 00:41:07,680
sexual stage with dimorphic gametes and

1041
00:41:13,109 --> 00:41:10,000
so what we see is that much of the cell

1042
00:41:15,750 --> 00:41:13,119
biology that typifies animals

1043
00:41:18,470 --> 00:41:15,760
actually probably predates animal bio or

1044
00:41:21,270 --> 00:41:18,480
animal origins and was controlled by

1045
00:41:23,829 --> 00:41:21,280
environmental cues and

1046
00:41:26,470 --> 00:41:23,839
was typified by lots of plasticity and

1047
00:41:28,069 --> 00:41:26,480
the ability to change between different

1048
00:41:30,470 --> 00:41:28,079
cell types

1049
00:41:33,589 --> 00:41:30,480
and so with that i'm going to thank my

1050
00:41:39,430 --> 00:41:33,599
wonderful laboratory our funding and i'm

1051
00:41:39,440 --> 00:41:47,109
i guess i can keep this off

1052
00:41:52,550 --> 00:41:49,589
well thank you nicole for a marvelous

1053
00:41:54,950 --> 00:41:52,560
talk i i usually do not use the word

1054
00:41:57,670 --> 00:41:54,960
awesome but uh

1055
00:41:58,870 --> 00:41:57,680
i'm really impressed by

1056
00:42:01,109 --> 00:41:58,880
number one

1057
00:42:04,390 --> 00:42:01,119
the audacity you know of one of your

1058
00:42:05,990 --> 00:42:04,400
post-docs to to to do that experiment

1059
00:42:09,670 --> 00:42:06,000
and secondly

1060
00:42:12,390 --> 00:42:09,680
uh the the wonder of new insights from

1061
00:42:14,390 --> 00:42:12,400
discovering a new type of organism i i

1062
00:42:15,910 --> 00:42:14,400
that really took my breath away when i

1063
00:42:17,750 --> 00:42:15,920

saw that

1064
00:42:19,589 --> 00:42:17,760
that's amazing yeah me too

1065
00:42:22,870 --> 00:42:19,599
i'm sure there are a lot of questions

1066
00:42:25,670 --> 00:42:22,880
and i don't want to hog the uh

1067
00:42:27,750 --> 00:42:25,680
the question scene so uh this gentleman

1068
00:42:30,470 --> 00:42:27,760
over there could you identify yourself

1069
00:42:31,750 --> 00:42:30,480
and pose your question please sure hi

1070
00:42:33,670 --> 00:42:31,760
i'm mike long from the carnegie

1071
00:42:36,230 --> 00:42:33,680
institution for science that was a

1072
00:42:39,030 --> 00:42:36,240
fabulous talk i learned so much oh good

1073
00:42:41,109 --> 00:42:39,040
um so i was wondering given what we know

1074
00:42:43,430 --> 00:42:41,119
now about the environmental factors that

1075
00:42:45,270 --> 00:42:43,440
contributed to the emergence of animal

1076
00:42:47,270 --> 00:42:45,280
life here on earth if you had any

1077
00:42:48,870 --> 00:42:47,280
speculations about whether or not this

1078
00:42:51,589 --> 00:42:48,880
same kind of major transition would

1079
00:42:54,069 --> 00:42:51,599
occur on an icy subsurface ocean world

1080
00:42:55,190 --> 00:42:54,079
like europa or enceladus

1081
00:42:57,670 --> 00:42:55,200
interesting

1082
00:43:01,670 --> 00:42:59,270
to me the

1083
00:43:04,550 --> 00:43:01,680
when i think about life on other planets

1084
00:43:06,950 --> 00:43:04,560
it's difficult for me to anticipate what

1085
00:43:09,750 --> 00:43:06,960
it would look like or whether it will

1086
00:43:10,870 --> 00:43:09,760
closely mimic what we have on earth

1087
00:43:12,870 --> 00:43:10,880
but what i

1088
00:43:14,710 --> 00:43:12,880

do think is a reasonable inference is

1089
00:43:16,309 --> 00:43:14,720
that we've under-appreciated the

1090
00:43:19,750 --> 00:43:16,319
diversity of

1091
00:43:22,550 --> 00:43:19,760
physiological states of uh of microbes

1092
00:43:25,510 --> 00:43:22,560
on this planet

1093
00:43:27,670 --> 00:43:25,520
and that that plasticity and ability to

1094
00:43:29,589 --> 00:43:27,680
respond dynamically to different

1095
00:43:31,910 --> 00:43:29,599
environmental states i think is probably

1096
00:43:34,230 --> 00:43:31,920
has evolved under selection has been

1097
00:43:35,829 --> 00:43:34,240
important for their survival and so i

1098
00:43:37,510 --> 00:43:35,839
would anticipate that you would see

1099
00:43:39,589 --> 00:43:37,520
similar types of

1100
00:43:41,589 --> 00:43:39,599
flexibility and plasticity in life

1101
00:43:43,910 --> 00:43:41,599
evolving elsewhere

1102
00:43:45,910 --> 00:43:43,920
but whether it would look like

1103
00:43:50,150 --> 00:43:45,920
exactly like the types of transitions

1104
00:43:52,870 --> 00:43:50,160
i've described is i i have no idea

1105
00:43:54,630 --> 00:43:52,880
cool thank you thank you

1106
00:43:57,270 --> 00:43:54,640
hello

1107
00:43:58,309 --> 00:43:57,280
tony brunetti here from uh georgia tech

1108
00:44:01,030 --> 00:43:58,319
and

1109
00:44:04,870 --> 00:44:01,040
i was curious i couldn't help but notice

1110
00:44:07,670 --> 00:44:04,880
when you poked those uh things and they

1111
00:44:09,589 --> 00:44:07,680
invert in response to it yeah the whole

1112
00:44:11,829 --> 00:44:09,599
thing does not just where you poke it i

1113
00:44:15,030 --> 00:44:11,839

wonder if you know if these guys are

1114
00:44:17,589 --> 00:44:15,040
passing signals to each other and if so

1115
00:44:20,710 --> 00:44:17,599
what those signals might be right

1116
00:44:23,109 --> 00:44:20,720
very good observation um

1117
00:44:25,829 --> 00:44:23,119
we tried to test that because we can we

1118
00:44:28,069 --> 00:44:25,839
know that we can uh

1119
00:44:29,670 --> 00:44:28,079
let me back up i suspect that they are

1120
00:44:32,870 --> 00:44:29,680
mechanically coupled

1121
00:44:36,710 --> 00:44:32,880
so if you poke one and it starts and it

1122
00:44:38,950 --> 00:44:36,720
pulls its flagella in or pushes them out

1123
00:44:41,109 --> 00:44:38,960
that movement by one cell is going to be

1124
00:44:44,309 --> 00:44:41,119
perceived by its neighboring cells and i

1125
00:44:46,309 --> 00:44:44,319
suspect they respond to that not to a

1126
00:44:48,790 --> 00:44:46,319
chemical signal

1127
00:44:51,109 --> 00:44:48,800
we tried to test that by actually

1128
00:44:53,109 --> 00:44:51,119
specifically shining light on one part

1129
00:44:55,190 --> 00:44:53,119
of a colony and not others and we

1130
00:44:56,230 --> 00:44:55,200
haven't worked that out yet but it's

1131
00:45:01,510 --> 00:44:56,240
definitely something we're very

1132
00:45:06,309 --> 00:45:04,230
thank you nicole that was great um i'm

1133
00:45:08,630 --> 00:45:06,319
able mendes from university of puerto

1134
00:45:13,190 --> 00:45:08,640
rico at the receivo and i am very

1135
00:45:14,790 --> 00:45:13,200
intrigued because we can probably not

1136
00:45:15,670 --> 00:45:14,800
look today

1137
00:45:18,069 --> 00:45:15,680
at

1138
00:45:20,870 --> 00:45:18,079

a another origin of life because there's

1139
00:45:22,390 --> 00:45:20,880
life already present and that would be a

1140
00:45:25,109 --> 00:45:22,400
competition there

1141
00:45:26,309 --> 00:45:25,119
but can we say that these antivoid

1142
00:45:29,349 --> 00:45:26,319
structures

1143
00:45:31,349 --> 00:45:29,359
are leaving examples today of lying

1144
00:45:32,630 --> 00:45:31,359
trying to a second generation for

1145
00:45:34,870 --> 00:45:32,640
complex life

1146
00:45:35,829 --> 00:45:34,880
or do you think maybe not the same as

1147
00:45:37,109 --> 00:45:35,839
before

1148
00:45:39,750 --> 00:45:37,119
but

1149
00:45:41,910 --> 00:45:39,760
something that we can say is uh a good

1150
00:45:44,470 --> 00:45:41,920
example of the second genesis for

1151
00:45:47,030 --> 00:45:44,480
complex life today

1152
00:45:49,109 --> 00:45:47,040
a second genesis for the complex life

1153
00:45:51,190 --> 00:45:49,119
today

1154
00:45:52,950 --> 00:45:51,200
so if we were allowed if we were to come

1155
00:45:54,790 --> 00:45:52,960
back and look a few

1156
00:45:57,670 --> 00:45:54,800
100 million years from now would we see

1157
00:45:59,670 --> 00:45:57,680
that qanoflagellates had spawned

1158
00:46:00,390 --> 00:45:59,680
um another complex lineage is that the

1159
00:46:01,030 --> 00:46:00,400
question

1160
00:46:03,990 --> 00:46:01,040
or

1161
00:46:06,390 --> 00:46:04,000
yeah i i mean if these uh structures

1162
00:46:09,190 --> 00:46:06,400
this time avoid today are examples

1163
00:46:11,910 --> 00:46:09,200

living examples today of second genesis

1164
00:46:15,349 --> 00:46:11,920
of a complex life yeah not probably the

1165
00:46:18,470 --> 00:46:15,359
same as happened originally right but we

1166
00:46:19,750 --> 00:46:18,480
can say that we should make that a big

1167
00:46:21,109 --> 00:46:19,760
conclusion

1168
00:46:23,030 --> 00:46:21,119
yeah

1169
00:46:24,390 --> 00:46:23,040
i think we need more evidence before we

1170
00:46:26,230 --> 00:46:24,400
can go there but i think it's really

1171
00:46:29,670 --> 00:46:26,240
interesting idea

1172
00:46:32,230 --> 00:46:29,680
thank you thank you

1173
00:46:35,829 --> 00:46:32,240
hi uh i'm pavel clear post stuck at nasa

1174
00:46:37,270 --> 00:46:35,839
ames um and uh my question was um you

1175
00:46:39,990 --> 00:46:37,280
had um

1176
00:46:41,829 --> 00:46:40,000
some annotations on one of your slides

1177
00:46:42,790 --> 00:46:41,839
when you were talking about some of the

1178
00:46:45,430 --> 00:46:42,800
um

1179
00:46:47,829 --> 00:46:45,440
transitions between the states where you

1180
00:46:49,430 --> 00:46:47,839
had labeled um certain transitions as

1181
00:46:50,870 --> 00:46:49,440
happening post-transcriptionally versus

1182
00:46:52,170 --> 00:46:50,880
transcriptionally and i wondered i meant

1183
00:46:54,150 --> 00:46:52,180
to remove all of that but yeah

1184
00:46:55,990 --> 00:46:54,160
[Laughter]

1185
00:46:57,829 --> 00:46:56,000
i didn't know how i was wondering if you

1186
00:46:59,829 --> 00:46:57,839
wanted to uh like discuss that a little

1187
00:47:01,670 --> 00:46:59,839
bit more and so you know what are some

1188
00:47:03,589 --> 00:47:01,680

of the like genetic mechanisms there and

1189
00:47:05,750 --> 00:47:03,599
how that might be different in animals

1190
00:47:09,109 --> 00:47:05,760
versus the queen of flags sure

1191
00:47:11,190 --> 00:47:09,119
so um yeah i was trying not to uh

1192
00:47:14,230 --> 00:47:11,200
get too much into the genetics but in

1193
00:47:15,349 --> 00:47:14,240
animals development is regulated large

1194
00:47:17,510 --> 00:47:15,359
well

1195
00:47:20,069 --> 00:47:17,520
largely transcriptionally so that's

1196
00:47:22,630 --> 00:47:20,079
where this unfolding of cell

1197
00:47:25,190 --> 00:47:22,640
differentiation and cell states

1198
00:47:27,030 --> 00:47:25,200
is ultimately regulated is at the level

1199
00:47:30,390 --> 00:47:27,040
of which genes are turned on and off and

1200
00:47:32,230 --> 00:47:30,400
when there's also post translational

1201
00:47:33,190 --> 00:47:32,240
regulation that occurs

1202
00:47:34,150 --> 00:47:33,200
um

1203
00:47:36,230 --> 00:47:34,160
but

1204
00:47:37,829 --> 00:47:36,240
you know for all intents and purposes we

1205
00:47:40,150 --> 00:47:37,839
can start with transcriptional

1206
00:47:41,750 --> 00:47:40,160
regulation and that is hardwiring you

1207
00:47:44,710 --> 00:47:41,760
know that

1208
00:47:46,870 --> 00:47:44,720
i i'm oversimplifying it but it's

1209
00:47:48,309 --> 00:47:46,880
that is reproducible from generation to

1210
00:47:51,030 --> 00:47:48,319
generation

1211
00:47:53,349 --> 00:47:51,040
in choanoflagellates these responses are

1212
00:47:54,390 --> 00:47:53,359
reversible they don't go in order

1213
00:47:57,670 --> 00:47:54,400

there's no

1214
00:47:59,990 --> 00:47:57,680
program it's just an on the fly oh damn

1215
00:48:01,589 --> 00:48:00,000
i'm you know stuck between this silt

1216
00:48:05,030 --> 00:48:01,599
i've got to do something different and

1217
00:48:08,390 --> 00:48:05,040
they do it very rapidly at

1218
00:48:11,270 --> 00:48:08,400
um at speeds that are too fast for it to

1219
00:48:12,870 --> 00:48:11,280
be explained by turning on and off

1220
00:48:15,309 --> 00:48:12,880
different genes so we think that it's

1221
00:48:17,270 --> 00:48:15,319
happening post translation and

1222
00:48:18,069 --> 00:48:17,280
post-translationally it's happening

1223
00:48:21,349 --> 00:48:18,079
through

1224
00:48:24,470 --> 00:48:21,359
the rapid activation of proteins and the

1225
00:48:26,150 --> 00:48:24,480
modification of proteins as opposed to

1226
00:48:28,630 --> 00:48:26,160
at the level of transcribing different

1227
00:48:29,990 --> 00:48:28,640
sets of genes does that

1228
00:48:31,349 --> 00:48:30,000
yeah i guess as a follow-up question

1229
00:48:32,870 --> 00:48:31,359
also do you think that there was a point

1230
00:48:34,870 --> 00:48:32,880
in like

1231
00:48:36,710 --> 00:48:34,880
a distinct point in the evolutionary

1232
00:48:37,589 --> 00:48:36,720
history where there was a transition

1233
00:48:39,430 --> 00:48:37,599
from

1234
00:48:41,670 --> 00:48:39,440
like post-translational responses to

1235
00:48:44,150 --> 00:48:41,680
transcriptional responses in like the

1236
00:48:46,950 --> 00:48:44,160
kind of point of fledgling to animal

1237
00:48:49,990 --> 00:48:46,960
uh transition yeah i mean i think that

1238
00:48:51,270 --> 00:48:50,000

it's clear that cell differentiation in

1239
00:48:53,430 --> 00:48:51,280
animals

1240
00:48:54,630 --> 00:48:53,440
does unfold as part of a program and

1241
00:48:56,510 --> 00:48:54,640
largely that goes back to

1242
00:48:58,069 --> 00:48:56,520
transcriptional regulation and

1243
00:49:00,790 --> 00:48:58,079
choanoflagellates

1244
00:49:03,109 --> 00:49:00,800
to my eye it's really a matter of how

1245
00:49:05,190 --> 00:49:03,119
quickly a cell state transition has to

1246
00:49:07,589 --> 00:49:05,200
happen so for instance we can convert

1247
00:49:10,309 --> 00:49:07,599
them from being haploid to dip or sorry

1248
00:49:13,270 --> 00:49:10,319
from sexual to asexual and back again

1249
00:49:16,069 --> 00:49:13,280
and that process can take over two weeks

1250
00:49:18,270 --> 00:49:16,079
and likely does involve transcriptional

1251
00:49:20,470 --> 00:49:18,280
changes but these

1252
00:49:22,549 --> 00:49:20,480
amoeboid-flagellate state

1253
00:49:25,270 --> 00:49:22,559
transitions happen on the order of

1254
00:49:27,510 --> 00:49:25,280
minutes that's too fast it has to be

1255
00:49:29,589 --> 00:49:27,520
translational so i don't

1256
00:49:30,710 --> 00:49:29,599
know that there's going to be a hard and

1257
00:49:32,870 --> 00:49:30,720
fast

1258
00:49:36,150 --> 00:49:32,880
it was post-translational before animal

1259
00:49:37,750 --> 00:49:36,160
origins it's transcriptional

1260
00:49:39,190 --> 00:49:37,760
in animals i don't think there's going

1261
00:49:41,670 --> 00:49:39,200
to be that clear divide i think it's

1262
00:49:43,990 --> 00:49:41,680
going to be situation specific but in

1263
00:49:45,750 --> 00:49:44,000

animals we do see a predominance of

1264
00:49:47,829 --> 00:49:45,760
these

1265
00:49:50,069 --> 00:49:47,839
reproducible

1266
00:49:52,390 --> 00:49:50,079
programs that get recapitulated from

1267
00:49:54,630 --> 00:49:52,400
generation to generation and that's very

1268
00:49:56,309 --> 00:49:54,640
different from what we see in microbial

1269
00:49:57,190 --> 00:49:56,319
eukaryotes

1270
00:49:58,790 --> 00:49:57,200
thank you very much it was very

1271
00:50:00,870 --> 00:49:58,800
interesting talking thank you all right

1272
00:50:02,630 --> 00:50:00,880
lynn rothschild nasa ames i really don't

1273
00:50:04,630 --> 00:50:02,640
have a question just i wanted to

1274
00:50:06,710 --> 00:50:04,640
congratulate you for a really fabulous

1275
00:50:09,349 --> 00:50:06,720
talk and frank for having the insight to

1276
00:50:11,270 --> 00:50:09,359
have a protozoologist first as an old

1277
00:50:13,190 --> 00:50:11,280
protozoologist myself

1278
00:50:14,630 --> 00:50:13,200
and really a comment to the younger

1279
00:50:17,430 --> 00:50:14,640
people in the audience i'm not going to

1280
00:50:19,190 --> 00:50:17,440
put an age limit on it but notice that

1281
00:50:21,349 --> 00:50:19,200
all this started with observations

1282
00:50:24,069 --> 00:50:21,359
through a microscope not with going into

1283
00:50:26,150 --> 00:50:24,079
the lab in sequencing and that much of

1284
00:50:27,990 --> 00:50:26,160
these hypotheses have been around for

1285
00:50:30,549 --> 00:50:28,000
150 years

1286
00:50:32,710 --> 00:50:30,559
and so it is well worth dusting off your

1287
00:50:34,309 --> 00:50:32,720
microscope looking through it and in

1288
00:50:36,710 --> 00:50:34,319

this case it's the molecular data to

1289
00:50:40,790 --> 00:50:36,720
confirm the microscopy so thank you very

1290
00:50:47,190 --> 00:50:44,309
hi anthony segura from mexico city um

1291
00:50:49,589 --> 00:50:47,200
the national university of mexico um

1292
00:50:51,750 --> 00:50:49,599
i'm no biologist

1293
00:50:52,790 --> 00:50:51,760
but for what i understand all these

1294
00:50:55,910 --> 00:50:52,800
changes

1295
00:50:57,829 --> 00:50:55,920
from going to to create animals

1296
00:51:00,870 --> 00:50:57,839
were more biological

1297
00:51:02,630 --> 00:51:00,880
so at what point this became something

1298
00:51:04,549 --> 00:51:02,640
that were passed from generation to

1299
00:51:07,270 --> 00:51:04,559
generation because i mean if it's only

1300
00:51:09,670 --> 00:51:07,280
more morphological than its behavior

1301
00:51:11,670 --> 00:51:09,680
then how do you make one generation

1302
00:51:14,150 --> 00:51:11,680
after generation and then you make

1303
00:51:16,710 --> 00:51:14,160
animals yeah what happened there

1304
00:51:18,390 --> 00:51:16,720
i think that is a brilliant question

1305
00:51:20,710 --> 00:51:18,400
and something that i didn't get a chance

1306
00:51:21,829 --> 00:51:20,720
to talk about is the fact that

1307
00:51:24,470 --> 00:51:21,839
we think that animals and

1308
00:51:27,030 --> 00:51:24,480
quantoflagellates diverged

1309
00:51:29,270 --> 00:51:27,040
you know we don't really know 750

1310
00:51:31,589 --> 00:51:29,280
million years ago a billion years ago we

1311
00:51:33,829 --> 00:51:31,599
don't know and we don't have any

1312
00:51:36,150 --> 00:51:33,839
intervening lineages

1313
00:51:38,390 --> 00:51:36,160

between the two they either they've all

1314
00:51:41,750 --> 00:51:38,400
gone extinct or

1315
00:51:43,670 --> 00:51:41,760
um or we haven't detected them and so

1316
00:51:45,670 --> 00:51:43,680
what i think is that there were there

1317
00:51:47,589 --> 00:51:45,680
had to have been early experiments with

1318
00:51:49,910 --> 00:51:47,599
multicellular you know stable

1319
00:51:52,069 --> 00:51:49,920
reproducible multicellularity that we

1320
00:51:54,710 --> 00:51:52,079
just don't have representation for today

1321
00:51:57,109 --> 00:51:54,720
so all we have now are animals and

1322
00:51:58,870 --> 00:51:57,119
animals have this very

1323
00:52:00,870 --> 00:51:58,880
uh

1324
00:52:02,230 --> 00:52:00,880
reproducible development from generation

1325
00:52:05,030 --> 00:52:02,240
to generation

1326
00:52:07,589 --> 00:52:05,040
and if and if they didn't

1327
00:52:09,990 --> 00:52:07,599
you know they wouldn't survive we assume

1328
00:52:11,750 --> 00:52:10,000
um but we don't have any examples today

1329
00:52:13,270 --> 00:52:11,760
of ones that

1330
00:52:15,670 --> 00:52:13,280
uh

1331
00:52:17,589 --> 00:52:15,680
are more flexible in that in that

1332
00:52:22,309 --> 00:52:17,599
process so i i think that brings up a

1333
00:52:25,670 --> 00:52:24,069
hi uh my name is matt reinhold from

1334
00:52:27,829 --> 00:52:25,680
stanford university and i want to point

1335
00:52:28,790 --> 00:52:27,839
out that was an amazing talk as well

1336
00:52:30,150 --> 00:52:28,800
um

1337
00:52:31,750 --> 00:52:30,160
it's out of my wheelhouse so i'm just

1338
00:52:34,470 --> 00:52:31,760

going to put out my i want to just get

1339
00:52:36,549 --> 00:52:34,480
your thoughts on a topic and that is

1340
00:52:39,190 --> 00:52:36,559
that for animal life and multicellular

1341
00:52:40,230 --> 00:52:39,200
animals and plants we have this long

1342
00:52:43,510 --> 00:52:40,240
lineage

1343
00:52:46,230 --> 00:52:43,520
of very complex big things right which

1344
00:52:48,069 --> 00:52:46,240
started at some point kind of quickly in

1345
00:52:51,030 --> 00:52:48,079
geologic time mm-hmm whereas the chrono

1346
00:52:53,190 --> 00:52:51,040
fragilants if i said it right yep um

1347
00:52:55,430 --> 00:52:53,200
have basically been doing what you'd

1348
00:52:58,069 --> 00:52:55,440
showed for all that time

1349
00:53:00,069 --> 00:52:58,079
and over the billions of years

1350
00:53:02,230 --> 00:53:00,079
there seems to be this long-term stasis

1351
00:53:03,910 --> 00:53:02,240
but animals decided to do something else

1352
00:53:05,270 --> 00:53:03,920
i was wanting to get your thoughts in

1353
00:53:08,950 --> 00:53:05,280
light of your talk

1354
00:53:10,549 --> 00:53:08,960
as to why what was that

1355
00:53:12,150 --> 00:53:10,559
yeah

1356
00:53:13,190 --> 00:53:12,160
so

1357
00:53:19,430 --> 00:53:13,200
the

1358
00:53:21,030 --> 00:53:19,440
kinds of multicellularity so plants

1359
00:53:23,990 --> 00:53:21,040
animals and fungi are what we call

1360
00:53:24,950 --> 00:53:24,000
clonal multicellularity they evolve by

1361
00:53:28,230 --> 00:53:24,960
um

1362
00:53:30,630 --> 00:53:28,240
stabilizing interactions between sister

1363
00:53:33,109 --> 00:53:30,640

cells after cell division so that first

1364
00:53:33,990 --> 00:53:33,119
cell divides the cells stay together

1365
00:53:35,990 --> 00:53:34,000
and

1366
00:53:38,710 --> 00:53:36,000
that's the kind of multicellularity that

1367
00:53:40,790 --> 00:53:38,720
has led to the complexity that we see in

1368
00:53:41,910 --> 00:53:40,800
animals plants and fungi

1369
00:53:44,549 --> 00:53:41,920
there's a second kind of

1370
00:53:46,790 --> 00:53:44,559
multicellularity called aggregation

1371
00:53:49,030 --> 00:53:46,800
and in this case different

1372
00:53:51,510 --> 00:53:49,040
cells from the same species can come

1373
00:53:54,309 --> 00:53:51,520
together and so you may have heard of an

1374
00:53:56,390 --> 00:53:54,319
organism called diction which is like a

1375
00:53:57,349 --> 00:53:56,400
great example of that the slime mold

1376
00:53:59,430 --> 00:53:57,359
where

1377
00:54:01,030 --> 00:53:59,440
these amoeboid cells are crawling around

1378
00:54:03,829 --> 00:54:01,040
in the soil but when they start to

1379
00:54:05,750 --> 00:54:03,839
starve they send out signals

1380
00:54:06,790 --> 00:54:05,760
that say hey i'm over here

1381
00:54:11,750 --> 00:54:06,800
and they

1382
00:54:13,349 --> 00:54:11,760
this multicellular stock-like structure

1383
00:54:16,069 --> 00:54:13,359
um

1384
00:54:19,430 --> 00:54:16,079
and that type of multicellular is also

1385
00:54:21,670 --> 00:54:19,440
widespread but does not become complex

1386
00:54:24,630 --> 00:54:21,680
and we can talk another time about why

1387
00:54:27,750 --> 00:54:24,640
that might be the case

1388
00:54:30,390 --> 00:54:27,760

so coinoflagellates actually do both

1389
00:54:31,589 --> 00:54:30,400
so they can do clonal multicellularity

1390
00:54:33,109 --> 00:54:31,599
and they can do aggregate of

1391
00:54:35,829 --> 00:54:33,119
multicellularity

1392
00:54:40,069 --> 00:54:37,750
and

1393
00:54:41,670 --> 00:54:40,079
i i suspect that they haven't become

1394
00:54:43,430 --> 00:54:41,680
more complex because they haven't needed

1395
00:54:45,109 --> 00:54:43,440
to you know for whatever reason they

1396
00:54:48,069 --> 00:54:45,119
occupy a niche where whatever they're

1397
00:54:50,230 --> 00:54:48,079
doing is good enough and animals evolve

1398
00:54:52,710 --> 00:54:50,240
multicellularity through

1399
00:54:55,430 --> 00:54:52,720
um it's a very long philosophical

1400
00:54:56,789 --> 00:54:55,440
discussion to have but a combination of

1401
00:54:58,870 --> 00:54:56,799
uh you know

1402
00:55:01,109 --> 00:54:58,880
contingency the type of genetic and

1403
00:55:02,870 --> 00:55:01,119
cellular machinery they inherited and

1404
00:55:04,870 --> 00:55:02,880
chance that they found themselves in

1405
00:55:06,630 --> 00:55:04,880
some environmental niche for which

1406
00:55:07,910 --> 00:55:06,640
multicellularity made sense and that

1407
00:55:09,670 --> 00:55:07,920
could have been

1408
00:55:11,270 --> 00:55:09,680
because

1409
00:55:12,789 --> 00:55:11,280
it allowed them to collect different

1410
00:55:14,870 --> 00:55:12,799
kinds of prey

1411
00:55:16,390 --> 00:55:14,880
it might have allowed them to

1412
00:55:18,789 --> 00:55:16,400
survive

1413
00:55:20,789 --> 00:55:18,799

desiccation in a different way there's a

1414
00:55:21,990 --> 00:55:20,799
lot of we can speculate until the cows

1415
00:55:23,829 --> 00:55:22,000
come home and i don't think there's a

1416
00:55:26,630 --> 00:55:23,839
good answer but it's definitely

1417
00:55:28,309 --> 00:55:26,640
something that people think about okay a

1418
00:55:29,990 --> 00:55:28,319
quick little quick little side question

1419
00:55:32,230 --> 00:55:30,000
has someone done a genetic clock to see

1420
00:55:35,190 --> 00:55:32,240
like when the two groups

1421
00:55:36,390 --> 00:55:35,200
split off uh they have

1422
00:55:38,789 --> 00:55:36,400
and i would love to get all your

1423
00:55:42,309 --> 00:55:38,799
thoughts because i just without a fossil

1424
00:55:43,589 --> 00:55:42,319
record i don't trust the calibration but

1425
00:55:44,710 --> 00:55:43,599
i'm happy

1426
00:55:46,710 --> 00:55:44,720
to be

1427
00:55:48,549 --> 00:55:46,720
disabused of that notion i think you can

1428
00:55:50,710 --> 00:55:48,559
do molecular clocks in animals because

1429
00:55:53,109 --> 00:55:50,720
you have a very nice fossil record um

1430
00:55:54,309 --> 00:55:53,119
but with nothing in choanoflagellates i

1431
00:55:57,910 --> 00:55:54,319
just

1432
00:55:59,990 --> 00:55:57,920
hedge my bets and i say it's in this

1433
00:56:02,789 --> 00:56:00,000
general area

1434
00:56:04,710 --> 00:56:02,799
of time fair enough thanks

1435
00:56:06,630 --> 00:56:04,720
we have time for one more question i

1436
00:56:08,390 --> 00:56:06,640
believe

1437
00:56:09,750 --> 00:56:08,400
there's another one she was there first

1438
00:56:12,309 --> 00:56:09,760

okay

1439
00:56:13,910 --> 00:56:12,319
uh hello my name is amy fong and i'm a

1440
00:56:16,710 --> 00:56:13,920
student at the woods hall oceanographic

1441
00:56:18,549 --> 00:56:16,720
institution and i was wondering that you

1442
00:56:20,470 --> 00:56:18,559
mentioned that this inversion behavior

1443
00:56:23,109 --> 00:56:20,480
was observed in the samples that you

1444
00:56:24,789 --> 00:56:23,119
collected from the splash pools yes and

1445
00:56:27,349 --> 00:56:24,799
i was wondering if you had any

1446
00:56:28,870 --> 00:56:27,359
hypotheses as to why it had something to

1447
00:56:30,230 --> 00:56:28,880
do with like specifically the splash

1448
00:56:32,230 --> 00:56:30,240
pools and not the other samples

1449
00:56:34,230 --> 00:56:32,240
collected around the area and especially

1450
00:56:36,789 --> 00:56:34,240
since you mentioned that it was a more

1451
00:56:38,230 --> 00:56:36,799
uh it had a higher salinity environment

1452
00:56:39,349 --> 00:56:38,240
and it was a lot warmer and i was

1453
00:56:41,990 --> 00:56:39,359
wondering if that had something to do

1454
00:56:43,589 --> 00:56:42,000
with like the other uh kind of like

1455
00:56:45,270 --> 00:56:43,599
yeah just like in general if that had

1456
00:56:48,789 --> 00:56:45,280
something to do with it

1457
00:56:50,870 --> 00:56:48,799
yeah so we don't know i i told you don't

1458
00:56:52,470 --> 00:56:50,880
pay any attention to these predators but

1459
00:56:55,349 --> 00:56:52,480
actually if you do pay attention to the

1460
00:56:57,190 --> 00:56:55,359
predators uh one possibility is that

1461
00:56:59,510 --> 00:56:57,200
it's an escape mechanism and that when

1462
00:57:01,829 --> 00:56:59,520
they get bumped into by a predator

1463
00:57:05,670 --> 00:57:01,839

that that can cause them to invert and

1464
00:57:09,190 --> 00:57:07,270
i don't think there's any way to know

1465
00:57:10,710 --> 00:57:09,200
what the environmental

1466
00:57:13,510 --> 00:57:10,720
connections are or the ecological

1467
00:57:15,510 --> 00:57:13,520
connections until we sample more

1468
00:57:18,549 --> 00:57:15,520
or more different kinds of species we've

1469
00:57:20,630 --> 00:57:18,559
we've sampled this species repeatedly

1470
00:57:22,789 --> 00:57:20,640
and so for exactly that reason we're

1471
00:57:24,549 --> 00:57:22,799
planning to start sampling all over the

1472
00:57:26,630 --> 00:57:24,559
caribbean and going to different

1473
00:57:29,670 --> 00:57:26,640
environments and seeing if we can get

1474
00:57:31,670 --> 00:57:29,680
these types of quantum flagellates from

1475
00:57:32,870 --> 00:57:31,680
different species but from similar

1476
00:57:33,990 --> 00:57:32,880
environments

1477
00:57:36,950 --> 00:57:34,000
because

1478
00:57:39,190 --> 00:57:36,960
correlation is not causation so

1479
00:57:40,630 --> 00:57:39,200
so we just don't really know

1480
00:57:42,870 --> 00:57:40,640
if there's something special about that

1481
00:57:43,750 --> 00:57:42,880
environment or if it's just chance

1482
00:57:46,069 --> 00:57:43,760
yeah

1483
00:57:48,710 --> 00:57:46,079
thank you good question

1484
00:57:51,030 --> 00:57:48,720
we have we have a substantial online

1485
00:57:53,109 --> 00:57:51,040
participation and in recognition of that

1486
00:57:55,190 --> 00:57:53,119
i'm going to stretch it a little bit

1487
00:57:57,829 --> 00:57:55,200
and pose this question that's been

1488
00:57:59,030 --> 00:57:57,839

brought to my attention by ben pierce

1489
00:58:02,309 --> 00:57:59,040
and that is

1490
00:58:05,430 --> 00:58:02,319
does light only induce changes to gmp

1491
00:58:06,309 --> 00:58:05,440
nucleotides what about other nucleotides

1492
00:58:07,829 --> 00:58:06,319
ah

1493
00:58:10,470 --> 00:58:07,839
so um

1494
00:58:13,750 --> 00:58:10,480
yes we've tested and it really is cyclic

1495
00:58:17,109 --> 00:58:13,760
gmp to five prime gmp is the the readout

1496
00:58:19,829 --> 00:58:17,119
it's not any of the cyclic amp um

1497
00:58:22,789 --> 00:58:19,839
and uh and it's not just light so it

1498
00:58:24,150 --> 00:58:22,799
turns out mechanical induction light to

1499
00:58:26,309 --> 00:58:24,160
dark

1500
00:58:29,910 --> 00:58:26,319
we have paper i think it's out now on

1501
00:58:31,829 --> 00:58:29,920
nitric oxide signaling so no gas can

1502
00:58:34,069 --> 00:58:31,839
induce this and and we have others so we

1503
00:58:36,870 --> 00:58:34,079
think that there are many inputs but

1504
00:58:37,990 --> 00:58:36,880
they all seem to go through cyclic gmp

1505
00:58:40,150 --> 00:58:38,000
signaling

1506
00:58:42,710 --> 00:58:40,160
wonderful

1507
00:58:45,430 --> 00:58:42,720
all right ladies and gentlemen um

1508
00:58:47,589 --> 00:58:45,440
this concludes our session

1509
00:58:51,910 --> 00:58:47,599
i would like to thank nicole for a

1510
00:58:53,109 --> 00:58:51,920
really awesome a really beautiful talk

1511
00:58:55,349 --> 00:58:53,119
and

1512
00:58:56,470 --> 00:58:55,359
i've been told to remind everyone that

1513
00:58:58,870 --> 00:58:56,480

coffee

1514
00:59:01,670 --> 00:58:58,880
and refreshments are down on the first

1515
00:59:03,030 --> 00:59:01,680
floor not directly outside

1516
00:59:05,670 --> 00:59:03,040
and so i thank you for your

1517
00:59:08,870 --> 00:59:05,680
participation and for your interest

1518
00:59:10,789 --> 00:59:08,880
have a great day here at absycon and

1519
00:59:16,789 --> 00:59:10,799
let's give another round of applause to