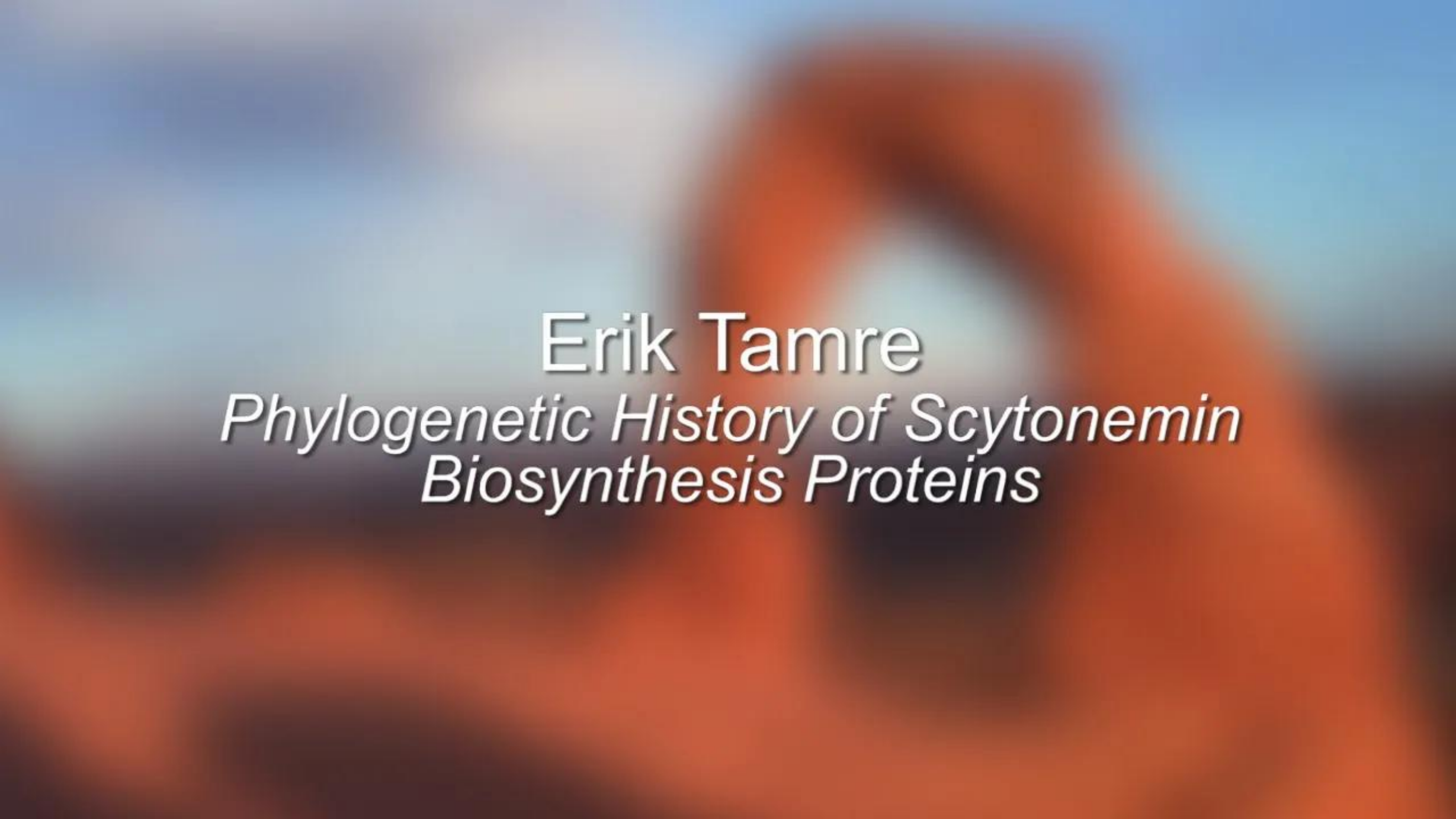
Erik Tamre
Phylogenetic History of Scytonemin
Biosynthesis Proteins

1
00:00:00,240 --> 00:00:11,049
[Music]

2
00:00:18,830 --> 00:00:16,250
hi I'm Eric and this is an ice shelf

3
00:00:23,120 --> 00:00:18,840
just off the north coast of Ellesmere

4
00:00:24,970 --> 00:00:23,130
Island in the Canadian Arctic and this

5
00:00:29,590 --> 00:00:24,980
is interesting for my purposes because

6
00:00:32,779 --> 00:00:29,600
this ice shelf has relatively extensive

7
00:00:36,110 --> 00:00:32,789
microbial mats covering it that are

8
00:00:39,560 --> 00:00:36,120
dominated by cyanobacteria and in

9
00:00:42,380 --> 00:00:39,570
particular the cyanobacteria have some

10
00:00:44,630 --> 00:00:42,390
of the highest concentrations of site

11
00:00:46,489 --> 00:00:44,640
aneema in a pigment that we're going to

12
00:00:49,189 --> 00:00:46,499
be talking about this is a photo

13
00:00:51,200 --> 00:00:49,199

protective pigment it absorbs UV

14
00:00:55,309 --> 00:00:51,210
radiation and helps protect the sign of

15
00:00:58,040 --> 00:00:55,319
bacterial cells and it makes sense that

16
00:01:00,799 --> 00:00:58,050
in this kind of environment say the

17
00:01:02,689 --> 00:01:00,809
bacteria would produce quite a lot of it

18
00:01:04,370 --> 00:01:02,699
because this is a very exposed

19
00:01:07,220 --> 00:01:04,380
environment and not only is the sun

20
00:01:09,470 --> 00:01:07,230
shining from the top but also there's a

21
00:01:11,750 --> 00:01:09,480
very reflective surface and thus it's

22
00:01:13,910 --> 00:01:11,760
very hard to escape this this radiation

23
00:01:15,500 --> 00:01:13,920
as anyone would know who has maybe spent

24
00:01:18,710 --> 00:01:15,510
some time skiing in the in the spring

25
00:01:23,660 --> 00:01:18,720
it's very hard to avoid getting

26
00:01:25,190 --> 00:01:23,670
sunburned so if we look at zoomed in

27
00:01:26,810 --> 00:01:25,200
pictures of these types of nets we can

28
00:01:30,440 --> 00:01:26,820
see quite a bit of this this this

29
00:01:32,600 --> 00:01:30,450
brownish or dark orange pigment which is

30
00:01:36,620 --> 00:01:32,610
which is what sites and even looks like

31
00:01:38,630 --> 00:01:36,630
invisible light here is an absorption

32
00:01:41,660 --> 00:01:38,640
spectrum of sites anemia this is the the

33
00:01:46,370 --> 00:01:41,670
solid line with an S and you can see

34
00:01:51,080 --> 00:01:46,380
that it is best at absorbing in the long

35
00:01:55,970 --> 00:01:51,090
wavelength end of the of the UV spectrum

36
00:01:58,130 --> 00:01:55,980
so 2 UV a is is where it where it

37
00:02:00,020 --> 00:01:58,140
absorbs the best and you can also see

38
00:02:01,580 --> 00:02:00,030

that in the visible light it doesn't

39
00:02:03,500 --> 00:02:01,590
really absorb anything instead of the

40
00:02:05,780 --> 00:02:03,510
the yellow and red region that's why it

41
00:02:08,440 --> 00:02:05,790
white looks yellowish and and reddish in

42
00:02:12,319 --> 00:02:08,450
their visible lights there is another

43
00:02:12,930 --> 00:02:12,329
set of compounds that cyanobacteria use

44
00:02:14,520 --> 00:02:12,940
for the

45
00:02:18,390 --> 00:02:14,530
you refer to protection they are the

46
00:02:19,740 --> 00:02:18,400
micros foreign like amino acids and this

47
00:02:24,350 --> 00:02:19,750
is something that I want to look at in

48
00:02:29,280 --> 00:02:24,360
future work so when we first started

49
00:02:34,800 --> 00:02:29,290
looking at this particular compound and

50
00:02:36,570 --> 00:02:34,810
the history of its biosynthesis one

51
00:02:38,340 --> 00:02:36,580
thing that that occurred to us is a

52
00:02:41,820 --> 00:02:38,350
relevant environmental factor that would

53
00:02:44,220 --> 00:02:41,830
influence the production of site anemia

54
00:02:45,450 --> 00:02:44,230
in the past is is obviously the oxygen

55
00:02:48,060 --> 00:02:45,460
level because because in in today's

56
00:02:50,880 --> 00:02:48,070
world at least it is the ozone layer

57
00:02:53,070 --> 00:02:50,890
that mostly modulates how much UV

58
00:02:55,080 --> 00:02:53,080
radiation gets onto the ground and and

59
00:03:00,210 --> 00:02:55,090
how much the organisms have to deal with

60
00:03:03,600 --> 00:03:00,220
it and so this is a famous graph by by

61
00:03:08,010 --> 00:03:03,610
Tim Lyons and others and depicts the the

62
00:03:10,410 --> 00:03:08,020
oxygen history on earth showing sort of

63
00:03:15,800 --> 00:03:10,420

two general increases in oxygen level

64
00:03:17,790 --> 00:03:15,810
one about 2.4 2.3 billion years ago

65
00:03:20,100 --> 00:03:17,800
referred to as the great oxygenation

66
00:03:25,440 --> 00:03:20,110
event and one in that in the lake near

67
00:03:29,580 --> 00:03:25,450
Perth or Zurich about 600 650 million

68
00:03:31,290 --> 00:03:29,590
years ago and so this clearly would have

69
00:03:33,480 --> 00:03:31,300
had an influence on the presence of the

70
00:03:36,270 --> 00:03:33,490
ozone layer because those onus is made

71
00:03:38,340 --> 00:03:36,280
out of oxygen photochemically so before

72
00:03:40,230 --> 00:03:38,350
here there will be very little those are

73
00:03:42,180 --> 00:03:40,240
layer here things would change a bit and

74
00:03:44,550 --> 00:03:42,190
here you know something close to the

75
00:03:47,610 --> 00:03:44,560
modern an ozone layer but probably

76
00:03:49,440 --> 00:03:47,620
appear now this this UVA radiation is

77
00:03:51,240 --> 00:03:49,450
interesting in that the ozone layer

78
00:03:54,330 --> 00:03:51,250
doesn't really do much to it to be

79
00:03:59,130 --> 00:03:54,340
honest but what is interesting about it

80
00:04:01,410 --> 00:03:59,140
is that this UVA radiation actually

81
00:04:04,560 --> 00:04:01,420
becomes dangerous to organisms in the

82
00:04:06,330 --> 00:04:04,570
presence of oxygen because UVA is very

83
00:04:09,090 --> 00:04:06,340
good at making various reactive oxygen

84
00:04:12,030 --> 00:04:09,100
radicals that are then injurious to

85
00:04:15,540 --> 00:04:12,040
living cells so for our purposes

86
00:04:18,510 --> 00:04:15,550
actually this curve is more relevant as

87
00:04:21,510 --> 00:04:18,520
a time as a showing when the exactly

88
00:04:25,520 --> 00:04:21,520

oxygen arose in such a way that perhaps

89
00:04:28,460 --> 00:04:25,530
now UVA protection would be necessary

90
00:04:31,430 --> 00:04:28,470
another thing that as children the first

91
00:04:34,970 --> 00:04:31,440
picture might influence satiny

92
00:04:36,470 --> 00:04:34,980
mid-levels in organisms is glaciations

93
00:04:38,510 --> 00:04:36,480
and in particular perhaps the most

94
00:04:39,920 --> 00:04:38,520
extensive and and then largest ones the

95
00:04:43,010 --> 00:04:39,930
global they see Asians of the Paleo

96
00:04:44,480 --> 00:04:43,020
Proterozoic at the neoproterozoic and so

97
00:04:47,120 --> 00:04:44,490
you know especially in some of the more

98
00:04:48,560 --> 00:04:47,130
extreme hard snowball scenarios that

99
00:04:50,840 --> 00:04:48,570
people have proposed you know where you

100
00:04:52,010 --> 00:04:50,850
have a global sea glacier where all the

101
00:04:53,660 --> 00:04:52,020
oceans are covered with hundreds of

102
00:04:59,150 --> 00:04:53,670
meters of water well the central

103
00:05:00,680 --> 00:04:59,160
questions is how to sustain complex life

104
00:05:02,720 --> 00:05:00,690
in these systems which which did happen

105
00:05:05,210 --> 00:05:02,730
and one necessary component for that is

106
00:05:07,490 --> 00:05:05,220
obviously that someone somewhere needs

107
00:05:11,120 --> 00:05:07,500
to do photosynthesis and one thing that

108
00:05:15,470 --> 00:05:11,130
has been proposed is that perhaps there

109
00:05:18,740 --> 00:05:15,480
were cyanobacteria in enough water ponds

110
00:05:20,540 --> 00:05:18,750
probably close to the equator and then

111
00:05:22,400 --> 00:05:20,550
perhaps these environments do not look

112
00:05:24,220 --> 00:05:22,410
unlike what we see today and in places

113
00:05:27,230 --> 00:05:24,230

like Ellis Muir Island

114
00:05:29,380 --> 00:05:27,240
so again if this was the case then

115
00:05:31,520 --> 00:05:29,390
perhaps we would we would expect to see

116
00:05:33,770 --> 00:05:31,530
interesting developments in sites and

117
00:05:36,260 --> 00:05:33,780
even production at at these times and

118
00:05:37,550 --> 00:05:36,270
then maybe more so than in today's polar

119
00:05:39,320 --> 00:05:37,560
environments because here we're talking

120
00:05:42,500 --> 00:05:39,330
about equatorial environments where

121
00:05:45,860 --> 00:05:42,510
where the intensity of radiation is is

122
00:05:51,170 --> 00:05:45,870
harsher than then today in the polar

123
00:05:53,480 --> 00:05:51,180
areas so very briefly saturnine in is is

124
00:05:56,200 --> 00:05:53,490
this this pigment here it is it is

125
00:05:58,909 --> 00:05:56,210
synthesized based on relatively

126
00:06:01,520 --> 00:05:58,919
relatively basic organic compounds

127
00:06:05,210 --> 00:06:01,530
tryptophan prep inator are some

128
00:06:07,820 --> 00:06:05,220
precursors and there is the set of of a

129
00:06:09,800 --> 00:06:07,830
proteins called saya through through CF

130
00:06:12,800 --> 00:06:09,810
that do most of the synthesis synthesis

131
00:06:16,310 --> 00:06:12,810
and I'll briefly also be mentioning some

132
00:06:20,780 --> 00:06:16,320
other proteins that mainly that mainly

133
00:06:27,350 --> 00:06:20,790
make the precursors for this for this

134
00:06:28,610 --> 00:06:27,360
synthesis now these relevant genes which

135
00:06:31,820 --> 00:06:28,620
contain the information for these

136
00:06:33,380 --> 00:06:31,830
proteins are collected into one cluster

137
00:06:35,300 --> 00:06:33,390
in the genomes of organisms the

138
00:06:36,409 --> 00:06:35,310

heather's there there one operon and we

139
00:06:40,460 --> 00:06:36,419
will be talking most about the yellow

140
00:06:45,260 --> 00:06:43,010
this is a a phylogenetic tree of one of

141
00:06:47,030 --> 00:06:45,270
them of saisi it's versions in different

142
00:06:48,470 --> 00:06:47,040
organisms I don't expect you to be able

143
00:06:50,890 --> 00:06:48,480
to read the names but I will talk about

144
00:06:53,930 --> 00:06:50,900
the general structure of this tree

145
00:06:55,720 --> 00:06:53,940
this shows how this isyes in different

146
00:06:58,040 --> 00:06:55,730
organisms are related to each other and

147
00:07:00,290 --> 00:06:58,050
we can see that there is this there is

148
00:07:01,910 --> 00:07:00,300
this large group of um gnostic Ailey's

149
00:07:05,570 --> 00:07:01,920
these are certain mostly mostly

150
00:07:08,780 --> 00:07:05,580
terrestrial cyanobacteria that live in

151
00:07:10,610 --> 00:07:08,790
large colonies and and if we look

152
00:07:11,900 --> 00:07:10,620
actually at that this help free or even

153
00:07:13,880 --> 00:07:11,910
if we look within the star Kaylee's we

154
00:07:15,320 --> 00:07:13,890
can actually see that this that the

155
00:07:18,320 --> 00:07:15,330
screen reflects the species tree

156
00:07:19,790 --> 00:07:18,330
relatively well and even if we look

157
00:07:22,070 --> 00:07:19,800
beyond the duster Kaylee's we see that

158
00:07:23,240 --> 00:07:22,080
the closest sister group is this genus

159
00:07:25,640 --> 00:07:23,250
crawl coccidiosis

160
00:07:29,210 --> 00:07:25,650
and beyond that we have some some more

161
00:07:32,270 --> 00:07:29,220
distantly related cyanobacteria this

162
00:07:37,550 --> 00:07:32,280
basically looks exactly the same as a

163
00:07:40,250 --> 00:07:37,560

species tree of all above this clade of

164
00:07:41,600 --> 00:07:40,260
cyanobacteria here we can see the here

165
00:07:45,050 --> 00:07:41,610
we can see the Noster Kaylee's we can

166
00:07:46,670 --> 00:07:45,060
see curl coccidiosis the the closest

167
00:07:48,740 --> 00:07:46,680
sister group in our study as well and

168
00:07:52,550 --> 00:07:48,750
some of the things so them in the top

169
00:07:54,409 --> 00:07:52,560
part of the LR tree here are these

170
00:07:57,500 --> 00:07:54,419
things that our sister - - Gnostic

171
00:08:00,080 --> 00:07:57,510
aalesunds and curl coccidiosis so

172
00:08:04,070 --> 00:08:00,090
basically it seems that what has

173
00:08:07,100 --> 00:08:04,080
happened is that the capacity to produce

174
00:08:10,130 --> 00:08:07,110
such an amine arose in some common

175
00:08:13,490 --> 00:08:10,140
ancestor of this clade here and has

176
00:08:16,340 --> 00:08:13,500
since been vertically inherited by by

177
00:08:21,460 --> 00:08:16,350
its descendants losted some of them but

178
00:08:25,070 --> 00:08:21,470
but not not that many of them so so here

179
00:08:27,920 --> 00:08:25,080
now we this is an existing species creed

180
00:08:31,100 --> 00:08:27,930
cyanobacteria that was made a few years

181
00:08:33,529 --> 00:08:31,110
ago many different well conserved genes

182
00:08:34,880 --> 00:08:33,539
including ribosomal protein irreversible

183
00:08:37,370 --> 00:08:34,890
protein genes and things like that were

184
00:08:40,219 --> 00:08:37,380
used for that and so what the reason why

185
00:08:41,750 --> 00:08:40,229
I wanted to want you to check my tree

186
00:08:44,270 --> 00:08:41,760
against this is mainly to date when

187
00:08:47,840 --> 00:08:44,280
exactly sites anemic production would

188
00:08:49,040 --> 00:08:47,850

have appeared and basically that would

189
00:08:50,660 --> 00:08:49,050
mean that we would need to determine

190
00:08:53,930 --> 00:08:50,670
where exactly

191
00:08:55,550 --> 00:08:53,940
this last common ancestor of the clades

192
00:08:58,070 --> 00:08:55,560
that have the sight anemia production

193
00:09:02,420 --> 00:08:58,080
capacity existed and so there's no

194
00:09:06,590 --> 00:09:02,430
disorder about here so so maybe is

195
00:09:08,600 --> 00:09:06,600
somewhere between 2.0 and 2.5 billion

196
00:09:11,330 --> 00:09:08,610
years ago is when when this claim with

197
00:09:13,040 --> 00:09:11,340
sites and even diverges from from other

198
00:09:17,120 --> 00:09:13,050
cyanobacteria that do not have site

199
00:09:18,770 --> 00:09:17,130
anemia below I have a different tree

200
00:09:20,560 --> 00:09:18,780
which is from the same paper it just

201
00:09:24,950 --> 00:09:20,570
makes slightly different assumptions

202
00:09:27,140 --> 00:09:24,960
about molecular evolution rates and uses

203
00:09:30,470 --> 00:09:27,150
slightly different calibrations and you

204
00:09:32,920 --> 00:09:30,480
can see that here this relevant relevant

205
00:09:35,300 --> 00:09:32,930
branching event is prospectus lightly

206
00:09:36,950 --> 00:09:35,310
slightly more to about two point two

207
00:09:38,510 --> 00:09:36,960
point find again with with some

208
00:09:44,630 --> 00:09:38,520
uncertainties as you can see from the

209
00:09:46,490 --> 00:09:44,640
error bars over here so that's so from

210
00:09:48,020 --> 00:09:46,500
our study it seems that this is

211
00:09:49,790 --> 00:09:48,030
something that was developed made

212
00:09:52,880 --> 00:09:49,800
somewhere between two and two and a half

213
00:09:54,500 --> 00:09:52,890

billion years ago and and there was very

214
00:09:58,040 --> 00:09:54,510
recently about about two months ago

215
00:10:00,260 --> 00:09:58,050
another paper by by people from Arizona

216
00:10:05,380 --> 00:10:00,270
State University where they also made an

217
00:10:09,200 --> 00:10:05,390
effort to to date cyanobacteria

218
00:10:10,700 --> 00:10:09,210
production of sites and even they used a

219
00:10:12,710 --> 00:10:10,710
different set of genes they actually

220
00:10:14,780 --> 00:10:12,720
looked at these at these genes that are

221
00:10:18,290 --> 00:10:14,790
responsible for the production of the

222
00:10:22,280 --> 00:10:18,300
precursors to the sites and even

223
00:10:27,920 --> 00:10:22,290
biosynthesis and in the in the orange

224
00:10:29,420 --> 00:10:27,930
here you can see the dates for origin of

225
00:10:31,010 --> 00:10:29,430
secondary production that they got from

226
00:10:33,620 --> 00:10:31,020
looking at different genes they made

227
00:10:35,300 --> 00:10:33,630
separate molecular clocks for for each

228
00:10:37,220 --> 00:10:35,310
of these genes and you can see that

229
00:10:41,420 --> 00:10:37,230
there is quite a bit of variability but

230
00:10:45,500 --> 00:10:41,430
in general again the placement would be

231
00:10:47,660 --> 00:10:45,510
somewhere here just above two billion

232
00:10:53,420 --> 00:10:47,670
years ago I marked that the goe here in

233
00:10:55,940 --> 00:10:53,430
in blue so this timing is interesting

234
00:11:00,220 --> 00:10:55,950
not just for four sites at first sight

235
00:11:04,160 --> 00:11:00,230
and even then for understanding UV

236
00:11:05,540 --> 00:11:04,170
radiation protection but also

237
00:11:09,400 --> 00:11:05,550
obviously it says something more

238
00:11:11,240 --> 00:11:09,410

generally about when Santa bacteria

239
00:11:13,010 --> 00:11:11,250
developed and when important

240
00:11:15,620 --> 00:11:13,020
evolutionary events concerning them

241
00:11:17,210 --> 00:11:15,630
happens so this is this is here a set of

242
00:11:21,170 --> 00:11:17,220
their estimated from the same molecular

243
00:11:23,480 --> 00:11:21,180
clocks for the for the time of origin of

244
00:11:25,880 --> 00:11:23,490
crown group cyanobacteria again quite a

245
00:11:27,590 --> 00:11:25,890
bit of variation but but the clear

246
00:11:30,890 --> 00:11:27,600
consensus that this is something that

247
00:11:32,570 --> 00:11:30,900
happened well before the goe and then

248
00:11:33,640 --> 00:11:32,580
people have have argued about this quite

249
00:11:39,520 --> 00:11:33,650
a bit

250
00:11:43,550 --> 00:11:39,530
so just to recap it does look like the

251
00:11:46,780 --> 00:11:43,560
relevant biochemical pathway arose about

252
00:11:49,880 --> 00:11:46,790
two two and a half billion years ago in

253
00:11:51,440 --> 00:11:49,890
some commonest ancestor of these what

254
00:11:52,690 --> 00:11:51,450
are today mostly terrestrial

255
00:11:55,580 --> 00:11:52,700
cyanobacteria

256
00:11:58,070 --> 00:11:55,590
and has has been vertically inherited

257
00:12:00,080 --> 00:11:58,080
ever since it's interesting that the

258
00:12:01,820 --> 00:12:00,090
origin of this pathway coincides well

259
00:12:04,010 --> 00:12:01,830
with both the great oxygenation event

260
00:12:06,230 --> 00:12:04,020
and and the Paleozoic glacial events

261
00:12:07,430 --> 00:12:06,240
that might have been related to that and

262
00:12:09,940 --> 00:12:07,440
that's interesting because you know

263
00:12:12,950 --> 00:12:09,950

again if our hypothesis is that this UVA

264
00:12:15,980 --> 00:12:12,960
sunscreen became necessary upon the

265
00:12:18,220 --> 00:12:15,990
introduction of oxygen which suddenly

266
00:12:23,420 --> 00:12:18,230
may you be a dangerous because it made

267
00:12:26,960 --> 00:12:23,430
these reactive oxygen species that means

268
00:12:32,240 --> 00:12:26,970
that perhaps this hypothesis agrees with

269
00:12:36,130 --> 00:12:32,250
our with our dating finally what I would

270
00:12:39,920 --> 00:12:36,140
say is that the beyond this idea that

271
00:12:42,080 --> 00:12:39,930
perhaps we have found this correlation

272
00:12:47,390 --> 00:12:42,090
between the physical environment events

273
00:12:50,480 --> 00:12:47,400
and the observation of having this site

274
00:12:53,600 --> 00:12:50,490
an amine biosynthesis pathway we can

275
00:12:58,970 --> 00:12:53,610
also flip this whole exercise on our

276
00:13:02,180 --> 00:12:58,980
head and ask if we believe that certain

277
00:13:04,700 --> 00:13:02,190
diamond production should appear at this

278
00:13:07,480 --> 00:13:04,710
point in history where oxygen is

279
00:13:14,949 --> 00:13:07,490
introduced into the Earth's atmosphere

280
00:13:18,999 --> 00:13:14,959
then we can use our analysis to check

281
00:13:22,059 --> 00:13:19,009
any molecular clocks or cyanobacteria as

282
00:13:24,819 --> 00:13:22,069
a whole and we would know that okay this

283
00:13:27,280 --> 00:13:24,829
this note here where where cyano this

284
00:13:29,350 --> 00:13:27,290
branch here where cyanobacterial site

285
00:13:31,470 --> 00:13:29,360
anemic production appears needs to be

286
00:13:34,629 --> 00:13:31,480
somewhere around the goe

287
00:13:37,569 --> 00:13:34,639
right and this actually and then this

288
00:13:40,749 --> 00:13:37,579

actually would would determine quite a

289
00:13:42,639 --> 00:13:40,759
bit of when various other important

290
00:13:46,329 --> 00:13:42,649
divergence events inside a bacterial

291
00:13:48,129 --> 00:13:46,339
history appear and obviously it would

292
00:13:53,489 --> 00:13:48,139
push the the origin of crown group

293
00:13:57,699 --> 00:13:53,499
cyanobacteria into the past

294
00:13:59,679 --> 00:13:57,709
substantially beyond the goe so that's

295
00:14:01,540 --> 00:13:59,689
all currently and I'm happy to take

296
00:14:14,800 --> 00:14:01,550
questions thank you

297
00:14:21,010 --> 00:14:17,320
Oh sue I'm not sure if you highlighted

298
00:14:23,250 --> 00:14:21,020
this in detail but there bacteria

299
00:14:27,480 --> 00:14:23,260
archaea prokaryotes a whole host of

300
00:14:42,070 --> 00:14:27,490
mechanisms to deal with oxidative stress

301
00:14:43,570 --> 00:14:42,080
so related to this would you see also we

302
00:14:45,580 --> 00:14:43,580
have none at this point but it is

303
00:14:49,840 --> 00:14:45,590
definitely something that we want to do

304
00:14:53,260 --> 00:14:49,850
we want to in fact not only analyze the

305
00:14:55,300 --> 00:14:53,270
relevant genes for for other ways of

306
00:14:57,810 --> 00:14:55,310
dealing with oxidative stress their DNA

307
00:15:00,190 --> 00:14:57,820
repair mechanisms and all these things

308
00:15:03,100 --> 00:15:00,200
but another approach that we that we

309
00:15:04,660 --> 00:15:03,110
want to take is also that we're very

310
00:15:06,940 --> 00:15:04,670
welcome for any suggestions that we

311
00:15:10,110 --> 00:15:06,950
should in any particular genes or Dean

312
00:15:12,370 --> 00:15:10,120
families that we should look into for

313
00:15:14,230 --> 00:15:12,380

anything that might be relevant to the

314
00:15:16,300 --> 00:15:14,240
to the physical environment that we're

315
00:15:19,320 --> 00:15:16,310
looking into so if anyone has any

316
00:15:21,880 --> 00:15:19,330
suggestions about as you pointed out the

317
00:15:23,440 --> 00:15:21,890
relevant biological process that we're

318
00:15:25,570 --> 00:15:23,450
looking at and that might be informative

319
00:15:28,630 --> 00:15:25,580
over the same question or if anyone has

320
00:15:30,940 --> 00:15:28,640
any suggestions of any gene or gene

321
00:15:33,760 --> 00:15:30,950
family that might be particularly

322
00:15:35,560 --> 00:15:33,770
sensitive to perhaps the the snowball

323
00:15:37,270 --> 00:15:35,570
earth events coinciding with with a goe

324
00:15:39,610 --> 00:15:37,280
or the sub C or the subsequent near

325
00:15:41,170 --> 00:15:39,620
further zoic oxygenation event these

326
00:15:43,600 --> 00:15:41,180
suggestions are very very welcome and we

327
00:15:50,350 --> 00:15:43,610
in fact see this as a as a step in a

328
00:15:52,570 --> 00:15:50,360
larger study of of this type a very cool

329
00:15:54,970 --> 00:15:52,580
talk so I was interested about your

330
00:15:57,880 --> 00:15:54,980
molecular clock calibration how many

331
00:16:00,100 --> 00:15:57,890
micro fossils were using to calibrate it

332
00:16:02,080 --> 00:16:00,110
so again to clarify the molecular clock

333
00:16:08,200 --> 00:16:02,090
is not mine it is from Bettina cher

334
00:16:09,910 --> 00:16:08,210
Meister and others from 2015 the I would

335
00:16:11,830 --> 00:16:09,920
have to look up the exact number the

336
00:16:13,720 --> 00:16:11,840
number is small and the sign of

337
00:16:15,490 --> 00:16:13,730
bacterial trees are still dictated by

338
00:16:18,670 --> 00:16:15,500

the choice of individual calibration

339
00:16:22,180 --> 00:16:18,680
points the number is on the order of 3 5

340
00:16:24,520 --> 00:16:22,190
something like that I know that you know

341
00:16:27,540 --> 00:16:24,530
one that I think definitely is commonly

342
00:16:30,570 --> 00:16:27,550
used is is the first

343
00:16:34,170 --> 00:16:30,580
the first sign of bacteria with

344
00:16:38,520 --> 00:16:34,180
heterocysts so so these sections four

345
00:16:40,950 --> 00:16:38,530
and four and five here which are which

346
00:16:42,380 --> 00:16:40,960
is you know this this this here and i

347
00:16:44,430 --> 00:16:42,390
think this number two might actually

348
00:16:46,020 --> 00:16:44,440
correspond to one of the calibrations

349
00:16:48,630 --> 00:16:46,030
that they use but it's it's a small

350
00:16:50,520 --> 00:16:48,640
number that's why we still argue about

351
00:17:04,220 --> 00:16:50,530
sign of bacterial timing in history that

352
00:17:13,640 --> 00:17:07,079
simultaneous evolution of society si

353
00:17:17,910 --> 00:17:16,260
great question i didn't go into much of

354
00:17:23,180 --> 00:17:17,920
this sort of phylogenetic detail here

355
00:17:26,370 --> 00:17:23,190
but it is interesting that all of them

356
00:17:28,199 --> 00:17:26,380
all of them seem to be present or in

357
00:17:30,090 --> 00:17:28,209
fact all of them except for like side d

358
00:17:32,340 --> 00:17:30,100
which is not critical for making such an

359
00:17:35,970 --> 00:17:32,350
even anyway all of them seem to be

360
00:17:38,970 --> 00:17:35,980
present in this in this one group and in

361
00:17:41,040 --> 00:17:38,980
most organisms that have any of these

362
00:17:42,480 --> 00:17:41,050
they have all of these and he said so it

363
00:17:45,780 --> 00:17:42,490

does seem that they came in at the same

364
00:17:47,940 --> 00:17:45,790
time or or maybe maybe if they if they

365
00:17:49,470 --> 00:17:47,950
came in at first then you know these inc

366
00:17:55,680 --> 00:17:49,480
uptake pathways have not been preserved

367
00:17:57,360 --> 00:17:55,690
in terms of where they came from the if

368
00:17:59,810 --> 00:17:57,370
I recall correctly sigh see inside

369
00:18:02,610 --> 00:17:59,820
Beaver at least two of them had no

370
00:18:04,110 --> 00:18:02,620
closer love related genes whatsoever

371
00:18:06,030 --> 00:18:04,120
that you would find when you blast them

372
00:18:07,320 --> 00:18:06,040
or something like that so God knows

373
00:18:08,910 --> 00:18:07,330
there might have been a heart saltine

374
00:18:11,820 --> 00:18:08,920
transfer from this from an extinct

375
00:18:16,490 --> 00:18:11,830
lineage could be anything some of the

376
00:18:21,180 --> 00:18:16,500
others had somewhat closely related

377
00:18:24,330 --> 00:18:21,190
homologs among scientifically had maybe

378
00:18:26,160 --> 00:18:24,340
some other function before but how this

379
00:18:27,930 --> 00:18:26,170
campaign together this is this is very

380
00:18:29,940 --> 00:18:27,940
interesting because II do genes they're

381
00:18:33,210 --> 00:18:29,950
also critical for making sites and even

382
00:18:35,780 --> 00:18:33,220
they seem to be have the other most

383
00:18:37,920 --> 00:18:35,790
closely related things in Bacteroides

384
00:18:40,200 --> 00:18:37,930
again they do its own gene transfer

385
00:18:42,350 --> 00:18:40,210
event from there it's fascinating how