Panelists

Attendees (7)

- Hosts (1)
  - Mike Toillion
- Presenters (2)
  - Andy Burnett
  - James Lyons
- Participants (4)
  - Lee Bebout
  - Lindsay Hays
  - Niki Parenteau
  - Pauli Laine

Open Chat (Everyone)

--------- (01/30/2014 10:43) ---------

Mike Toillion: Hi James, you should now be able to start your webcam and control the slides.

Mike Toillion: Please dial into the presenter telecon that was sent to you via email (the one below is for participants). Thanks!

Audio Instructions (Participants)

Teleconference Line: 866-692-3158
Passcode: 9109668#
Please use *6 (STAR, then 6) to MUTE your phone's mic when not speaking.
More info: https://astrobiologyfuture.org

Lyons Roadmap presentation Jan30.ppt

Full Screen

Introduction

Some broad questions:

How soon after the origin of life did photosynthesis arise?

Did simpler forms of light-driven energy transduction precede anoxygenic photosynthesis?

When did organisms evolve oxygenic photosynthesis?

'Early' here means up to the 'great oxidation event' (GOE). So we're not including endosymbiosis or photosynthetic eukaryotes.

1
00:00:15,379 --> 00:00:12,379
welcome to our ultimate webinar I've

2
00:00:17,570 --> 00:00:15,389
been waiting a while to say that now we

3
00:00:19,279 --> 00:00:17,580
have a slight technical problem so we

4
00:00:20,929 --> 00:00:19,289
won't be able to see James today unless

5
00:00:24,290 --> 00:00:20,939
miracles happen during the course of

6
00:00:26,210 --> 00:00:24,300
presentation so brief overview the

7
00:00:28,460 --> 00:00:26,220
slides for this presentation are already

8
00:00:30,200 --> 00:00:28,470
uploaded they're linked through the

9
00:00:34,130 --> 00:00:30,210
event link on the front of the website

10
00:00:36,650 --> 00:00:34,140
the document has just been updated so if

11
00:00:39,310 --> 00:00:36,660
you went to look at that link half an

12
00:00:42,229 --> 00:00:39,320
hour or so ago it would have been a

13
00:00:44,930 --> 00:00:42,239

relatively sparsely populated document

14
00:00:48,110 --> 00:00:44,940
it is now full of interesting words so I

15
00:00:50,029 --> 00:00:48,120
encourage you to go back to that this

16
00:00:52,910 --> 00:00:50,039
session is being recorded everything you

17
00:00:56,630 --> 00:00:52,920
say and type is going to be put out onto

18
00:00:58,400 --> 00:00:56,640
the internet and I think black is about

19
00:01:01,420 --> 00:00:58,410
that so I'm going to save myself into

20
00:01:04,119 --> 00:01:01,430
the background and pass over to James

21
00:01:07,039 --> 00:01:04,129
okay well what I want to talk about is

22
00:01:09,580 --> 00:01:07,049
what I think are relevant and pressing

23
00:01:14,390 --> 00:01:09,590
questions on the topic of the origin and

24
00:01:15,950 --> 00:01:14,400
early evolution photosynthesis you can

25
00:01:18,020 --> 00:01:15,960
see the first slide their introductory

26
00:01:20,570 --> 00:01:18,030
slide just some some very broad

27
00:01:21,830 --> 00:01:20,580
questions how soon after what we're

28
00:01:23,929 --> 00:01:21,840
trying to address here is how soon after

29
00:01:27,469 --> 00:01:23,939
the origin of life it photosynthesis

30
00:01:29,899 --> 00:01:27,479
arrives did simpler forms of like urban

31
00:01:32,420 --> 00:01:29,909
energy transduction proceed anoxygenic

32
00:01:34,460 --> 00:01:32,430
photosynthesis we are pretty sure a max

33
00:01:37,580 --> 00:01:34,470
genic photosynthesis preceded oxygen

34
00:01:39,590 --> 00:01:37,590
explosions when did organisms evolve

35
00:01:42,289 --> 00:01:39,600
oxygen influences and of course we have

36
00:01:44,590 --> 00:01:42,299
a fair bit of geological constraints on

37
00:01:48,380 --> 00:01:44,600
that topic and i'll mention some of it

38
00:01:50,420 --> 00:01:48,390

now that the title of this is origin and

39
00:01:52,490 --> 00:01:50,430
early evolution of photosynthesis and

40
00:01:53,990 --> 00:01:52,500
what I mean by early here is I'm

41
00:01:57,440 --> 00:01:54,000
basically just going up to the great

42
00:01:59,870 --> 00:01:57,450
oxidation event we don't you have

43
00:02:04,190 --> 00:01:59,880
something on the order of 2.4 billion

44
00:02:06,350 --> 00:02:04,200
years or so in age we're not I'm not

45
00:02:10,359 --> 00:02:06,360
really focused on photosynthetic

46
00:02:12,280 --> 00:02:10,369
eukaryotes and endosymbiosis all

47
00:02:14,350 --> 00:02:12,290
that which is all very interesting and

48
00:02:16,259 --> 00:02:14,360
very complicated in some ways that at

49
00:02:18,820 --> 00:02:16,269
least be your periods very complicated

50
00:02:21,100 --> 00:02:18,830
so I'm just not really prepared to talk

51
00:02:23,890 --> 00:02:21,110
about them there is of course the

52
00:02:25,600 --> 00:02:23,900
interesting aspect of oxygen rise in the

53
00:02:27,190 --> 00:02:25,610
neoproterozoic which almost certainly

54
00:02:30,640 --> 00:02:27,200
involves you care about our synthetic

55
00:02:35,110 --> 00:02:30,650
you carry it so it's a skip over them ok

56
00:02:38,319 --> 00:02:35,120
so moving on to the next slide just a

57
00:02:40,330 --> 00:02:38,329
summary of the net reactions of

58
00:02:42,430 --> 00:02:40,340
photosynthesis the first reaction you

59
00:02:45,910 --> 00:02:42,440
that you see there and it's not now I I

60
00:02:50,860 --> 00:02:45,920
suppose I don't know there's a pointer

61
00:02:52,119 --> 00:02:50,870
ok there we go students they say you

62
00:02:55,330 --> 00:02:52,129
should be able to see that green arrow

63
00:02:58,360 --> 00:02:55,340

if you're on Adobe Connect and you see

64
00:03:01,720 --> 00:02:58,370
the just the sort of generic net

65
00:03:06,190 --> 00:03:01,730
reaction for photosynthesis co 2 plus 2

66
00:03:09,970 --> 00:03:06,200
h 2 a where a sulfur oxygen number of

67
00:03:13,630 --> 00:03:09,980
nothing be hydrogen plus photons yields

68
00:03:17,289 --> 00:03:13,640
a reduced carbon in this case written in

69
00:03:20,349 --> 00:03:17,299
the in the form of what looks like

70
00:03:23,759 --> 00:03:20,359
formaldehyde but it's really Lukos and

71
00:03:28,330 --> 00:03:23,769
things advance work plus water plus some

72
00:03:32,770 --> 00:03:28,340
oxidized opponent how the original

73
00:03:35,220 --> 00:03:32,780
productive so the that's that's just the

74
00:03:38,379 --> 00:03:35,230
generic reaction for photosynthesis

75
00:03:41,650 --> 00:03:38,389
oxygenic photosynthesis synthesis of

76
00:03:46,000 --> 00:03:41,660
course the h-2a with the h2o wate water

77
00:03:47,740 --> 00:03:46,010
and we've the liberating oxygen this

78
00:03:51,039 --> 00:03:47,750
obviously the source of it in our

79
00:03:53,409 --> 00:03:51,049
atmosphere writing this there's never

80
00:03:59,349 --> 00:03:53,419
any action out in a bit more detail you

81
00:04:03,369 --> 00:03:59,359
see here the more detailed oxygen egg

82
00:04:05,080 --> 00:04:03,379
form of its showing that you're actually

83
00:04:09,099 --> 00:04:05,090
making glucose therefore of course you

84
00:04:11,470 --> 00:04:09,109
need more of everything oh and it just

85
00:04:13,869 --> 00:04:11,480
gets a bit more deal detail and traces

86
00:04:15,789 --> 00:04:13,879
the oxygen so the oxygen in the skip 2

87
00:04:18,819 --> 00:04:15,799
goes into the glucose the oxygen from

88
00:04:21,819 --> 00:04:18,829

the water goes into launched Michael

89
00:04:23,800 --> 00:04:21,829
oxygen in the atmosphere okay and

90
00:04:27,610 --> 00:04:23,810
oxygenic photosynthesis e

91
00:04:29,170 --> 00:04:27,620
is also very important and as I already

92
00:04:32,470 --> 00:04:29,180
mentioned probably preceded oxygen

93
00:04:35,350 --> 00:04:32,480
ecosystems really earth and there are a

94
00:04:41,770 --> 00:04:35,360
number of reductions possible there

95
00:04:45,610 --> 00:04:41,780
including sulfides hydrogen is in the

96
00:04:48,730 --> 00:04:45,620
wrong sulfides hydrogen and ferrous iron

97
00:04:50,860 --> 00:04:48,740
all of which of especially the ferrous

98
00:04:57,030 --> 00:04:50,870
iron sulfide very likely to have been

99
00:05:01,560 --> 00:04:57,040
abundant on the early Archaean earth and

100
00:05:06,580 --> 00:05:01,570
so these are all velopment process well

101
00:05:07,750 --> 00:05:06,590
hey going on to carbon isotopes so this

102
00:05:11,320 --> 00:05:07,760
is what I'm going to do is just give a

103
00:05:13,810 --> 00:05:11,330
brief introduction to what theological

104
00:05:17,350 --> 00:05:13,820
and this very brief introduction to what

105
00:05:20,620 --> 00:05:17,360
geological constraints we have on Rose

106
00:05:22,750 --> 00:05:20,630
emphasis and its occurrence and some of

107
00:05:25,810 --> 00:05:22,760
the most important of those are of

108
00:05:27,820 --> 00:05:25,820
course the carbon isotope record in

109
00:05:29,770 --> 00:05:27,830
sedimentary rocks and and by that I mean

110
00:05:32,920 --> 00:05:29,780
comparison of the carbonized protein

111
00:05:37,830 --> 00:05:32,930
carbonates versus organics in the same

112
00:05:41,170 --> 00:05:37,840
rocks and so the what you see here is

113
00:05:43,120 --> 00:05:41,180

just I just swiped this from the web

114
00:05:46,210 --> 00:05:43,130
item I didn't really have a handy pod

115
00:05:49,510 --> 00:05:46,220
for this and what you see here is Delta

116
00:05:51,300 --> 00:05:49,520
Z 13 of the organics relative to their

117
00:05:54,460 --> 00:05:51,310
should be peedee peedee belemnite

118
00:05:56,409 --> 00:05:54,470
burning and see that everything is

119
00:05:58,150 --> 00:05:56,419
negative so all these organics are

120
00:05:59,650 --> 00:05:58,160
negative off their negative in the range

121
00:06:01,990 --> 00:05:59,660
of kind of mind mostly in a range of

122
00:06:05,710 --> 00:06:02,000
minus 22 minus forty four mil relative

123
00:06:10,360 --> 00:06:05,720
carbonate and some of them going even

124
00:06:14,350 --> 00:06:10,370
lower than 60 or so per mil oh and this

125
00:06:16,629 --> 00:06:14,360
is all interpreted as evidence for

126
00:06:19,600 --> 00:06:16,639
carbon fixation in my carbon fixation

127
00:06:22,409 --> 00:06:19,610
could be via photosynthesis or it could

128
00:06:26,230 --> 00:06:22,419
be by some other form of auto trophy in

129
00:06:28,240 --> 00:06:26,240
when we talk about very old urban

130
00:06:33,159 --> 00:06:28,250
isotopes we don't really know what it is

131
00:06:35,740 --> 00:06:33,169
we know better when you go into the mid

132
00:06:37,850 --> 00:06:35,750
40 rizzo 'ok really photosynthetic and

133
00:06:40,109 --> 00:06:37,860
it certainly is in the phanerozoic

134
00:06:43,669 --> 00:06:40,119
photosynthesis is is creating this

135
00:06:49,319 --> 00:06:43,679
distribution box governess these these

136
00:06:53,059 --> 00:06:49,329
old August samples right here this is

137
00:06:54,929 --> 00:06:53,069
should be a cute from the Achille rocks

138
00:06:56,879 --> 00:06:54,939

or at least some of them are from

139
00:07:04,859 --> 00:06:56,889
achillea maybe some from ish with these

140
00:07:06,659 --> 00:07:04,869
are likely these are quite metamorphose

141
00:07:08,819 --> 00:07:06,669
rocks and so it's not entirely clear

142
00:07:10,859 --> 00:07:08,829
what has happened there it is possible

143
00:07:14,249 --> 00:07:10,869
that this is evidence for oxygen akoto

144
00:07:15,869 --> 00:07:14,259
synthesis that long ago we don't really

145
00:07:17,909 --> 00:07:15,879
know exactly how to interpret these

146
00:07:19,489 --> 00:07:17,919
there have been some other suggestions

147
00:07:25,229 --> 00:07:19,499
for how long could do this pre by up

148
00:07:27,509 --> 00:07:25,239
abiotic ly in fact that's not clear okay

149
00:07:31,379 --> 00:07:27,519
so but the main point is that there's a

150
00:07:33,149 --> 00:07:31,389
consistent record over quite essentially

151
00:07:36,659 --> 00:07:33,159
all of our history that we have in

152
00:07:39,979 --> 00:07:36,669
carbon isotopes of some kind of carbon

153
00:07:43,879 --> 00:07:39,989
fixation and quite possibly Photosynth

154
00:07:48,359 --> 00:07:43,889
ok these are figures from bill shops

155
00:07:50,819 --> 00:07:48,369
review paper in 2011 looking at the

156
00:07:54,029 --> 00:07:50,829
sites at which microfossils are

157
00:07:56,339 --> 00:07:54,039
collected and the carbon isotopes in the

158
00:07:57,929 --> 00:07:56,349
organics associated with those rocks in

159
00:08:00,509 --> 00:07:57,939
it in addition I will show the actual

160
00:08:02,189 --> 00:08:00,519
microphones date in a minute but again

161
00:08:03,719 --> 00:08:02,199
you see that in a number of these old

162
00:08:07,919 --> 00:08:03,729
sites from which microphones are

163
00:08:09,779 --> 00:08:07,929

collected are also similar carbon

164
00:08:13,109 --> 00:08:09,789
isotope values so on the order of minus

165
00:08:14,669 --> 00:08:13,119
20-30 famille relative to the carbonates

166
00:08:19,019 --> 00:08:14,679
you be in this case written correctly

167
00:08:21,689 --> 00:08:19,029
and same up here so this is just a

168
00:08:23,790 --> 00:08:21,699
broader span of time but again you see

169
00:08:27,359 --> 00:08:23,800
the same general trend but the

170
00:08:30,709 --> 00:08:27,369
interpretation generally is this is

171
00:08:35,610 --> 00:08:30,719
evidence for oxygen or at least

172
00:08:37,679 --> 00:08:35,620
photosynthesis need not be this down

173
00:08:39,839 --> 00:08:37,689
here need not be oxygen acota synthesis

174
00:08:43,049 --> 00:08:39,849
but it certainly some kind of

175
00:08:44,999 --> 00:08:43,059
photosynthesis but again we really can't

176
00:08:48,079 --> 00:08:45,009
just based on these carbon isotope

177
00:08:51,150 --> 00:08:48,089
values alone rule out other forms of

178
00:08:51,630 --> 00:08:51,160
chemo with Auto trophy expense or they

179
00:09:00,120 --> 00:08:51,640
can

180
00:09:03,120 --> 00:09:00,130
carbon with flow 13 okay these are some

181
00:09:05,160 --> 00:09:03,130
of the microfossils again just reviewing

182
00:09:06,800 --> 00:09:05,170
some of this the kind of evidence or

183
00:09:09,270 --> 00:09:06,810
what is presented as evidence for

184
00:09:12,930 --> 00:09:09,280
photosynthesis these are from the apex

185
00:09:16,560 --> 00:09:12,940
church about 3.45 or so billion years in

186
00:09:19,820 --> 00:09:16,570
western australia um various for

187
00:09:22,350 --> 00:09:19,830
micrographs and analyses in ramen

188
00:09:24,750 --> 00:09:22,360

showing arguing really develop chavez

189
00:09:28,610 --> 00:09:24,760
arguing here for for the similarity of

190
00:09:34,170 --> 00:09:28,620
these organisms or what he thinks are

191
00:09:36,120 --> 00:09:34,180
microfossils to cyanobacteria and it's

192
00:09:38,220 --> 00:09:36,130
certainly a possibility we don't know I

193
00:09:40,520 --> 00:09:38,230
think it's entirely clear chances

194
00:09:42,540 --> 00:09:40,530
definitely made the case that these are

195
00:09:47,550 --> 00:09:42,550
carbon these are truly organic

196
00:09:49,710 --> 00:09:47,560
containing microfossils there was quite

197
00:09:52,260 --> 00:09:49,720
a debate about that whether they are

198
00:09:55,110 --> 00:09:52,270
cyanobacteria or not is of course that

199
00:09:57,060 --> 00:09:55,120
is a much harder thing to determine may

200
00:10:00,060 --> 00:09:57,070
not even really be determinable at this

201
00:10:05,670 --> 00:10:00,070
point but problem morphologically they

202
00:10:07,380 --> 00:10:05,680
are similar but as my more biologically

203
00:10:08,820 --> 00:10:07,390
inclined colleagues will point out there

204
00:10:12,120 --> 00:10:08,830
are many things that can look like this

205
00:10:13,770 --> 00:10:12,130
so I mean I'm victory but the point is

206
00:10:16,560 --> 00:10:13,780
these these are in the rocks they

207
00:10:18,960 --> 00:10:16,570
definitely contain organics and it

208
00:10:20,640 --> 00:10:18,970
appears to be by organics so it's so

209
00:10:22,950 --> 00:10:20,650
it's very compelling evidence at three

210
00:10:24,900 --> 00:10:22,960
and a half million years for carbon

211
00:10:27,600 --> 00:10:24,910
fixers comments corps commander

212
00:10:32,040 --> 00:10:27,610
certainly wasn't possible photos

213
00:10:33,240 --> 00:10:32,050

innocence okay so a but I don't know if

214
00:10:34,560 --> 00:10:33,250
you guys can all hear me I assume you

215
00:10:39,870 --> 00:10:34,570
can't just jump in anytime with

216
00:10:42,000 --> 00:10:39,880
questions oh I'm totally accepted

217
00:10:44,040 --> 00:10:42,010
questions here these are some of the

218
00:10:46,260 --> 00:10:44,050
carbon isotopes I think this is

219
00:10:49,260 --> 00:10:46,270
basically all carbon isotopes reported

220
00:10:51,930 --> 00:10:49,270
for various microfossils of different

221
00:10:54,090 --> 00:10:51,940
ages of going from moderately recent

222
00:10:56,280 --> 00:10:54,100
stuff here Springs formation Australia

223
00:10:58,740 --> 00:10:56,290
850 million years the gunflint at one

224
00:11:02,130 --> 00:10:58,750
point nine billion all the way down to

225
00:11:03,810 --> 00:11:02,140
microfossils from 3.5 billion in the

226
00:11:04,860 --> 00:11:03,820
dresser formation again in Australia

227
00:11:08,550 --> 00:11:04,870
what's really

228
00:11:11,040 --> 00:11:08,560
and the same story basically you see the

229
00:11:14,160 --> 00:11:11,050
same kind of minus-30 remove all though

230
00:11:16,079 --> 00:11:14,170
these are getting quite light sorry when

231
00:11:19,710 --> 00:11:16,089
you're either getting quite like here

232
00:11:21,420 --> 00:11:19,720
the high then with fairly large error

233
00:11:23,810 --> 00:11:21,430
bars I I don't really know what what's

234
00:11:29,220 --> 00:11:23,820
going to happen there you be a pretty

235
00:11:32,040 --> 00:11:29,230
consistent finest 30 ish per mil value

236
00:11:36,810 --> 00:11:32,050
for these actual of minus-30 minus-40

237
00:11:39,240 --> 00:11:36,820
promote for these microfossils um the

238
00:11:41,040 --> 00:11:39,250

exceptionally perhaps being most recent

239
00:11:44,420 --> 00:11:41,050
water springs which are more than the

240
00:11:49,790 --> 00:11:44,430
mines 22 but the point is this these

241
00:11:53,670 --> 00:11:49,800
certainly look like evidence again for

242
00:11:57,900 --> 00:11:53,680
microfossils that's our carbon fixers in

243
00:12:03,540 --> 00:11:57,910
some form five good questions yes please

244
00:12:08,810 --> 00:12:03,550
pin sigmar this Bob Blankenship hi Bo hi

245
00:12:11,970 --> 00:12:08,820
if you can go back to that yeah um the

246
00:12:15,900 --> 00:12:11,980
carbon fractionation in the various

247
00:12:21,060 --> 00:12:15,910
anoxygenic photo shows has been looked

248
00:12:22,829 --> 00:12:21,070
at but not very extensively can you can

249
00:12:24,540 --> 00:12:22,839
you maybe remind us what sort of

250
00:12:27,810 --> 00:12:24,550
fractionation you get from things like

251
00:12:30,660 --> 00:12:27,820
green sulfur bacteria purple bacteria

252
00:12:32,960 --> 00:12:30,670
and so on which have at least the green

253
00:12:37,860 --> 00:12:32,970
sulfur's have a very different carbon

254
00:12:40,380 --> 00:12:37,870
fixation pathway yeah no I i do not have

255
00:12:43,490 --> 00:12:40,390
those numbers off the top of my head my

256
00:12:46,980 --> 00:12:43,500
understanding is that they're really not

257
00:12:49,230 --> 00:12:46,990
tremendously different but it's it's a

258
00:12:51,300 --> 00:12:49,240
reasonable question and I certainly can

259
00:12:53,490 --> 00:12:51,310
add that i do not have I haven't looked

260
00:12:54,720 --> 00:12:53,500
at that reason yeah that that was my

261
00:12:56,640 --> 00:12:54,730
understanding too but these that are

262
00:12:59,730 --> 00:12:56,650
down there about minus 40 are getting

263
00:13:02,100 --> 00:12:59,740

pretty pretty light yes indeed I it

264
00:13:05,130 --> 00:13:02,110
wasn't fair of those numbers no I

265
00:13:06,780 --> 00:13:05,140
actually was not either until I pulled

266
00:13:08,850 --> 00:13:06,790
up this paper and i have to say i'm

267
00:13:13,319 --> 00:13:08,860
frankly a little bit surprised allow

268
00:13:15,390 --> 00:13:13,329
that and yeah I I would be I would say

269
00:13:17,460 --> 00:13:15,400
take this with a grain of salt these are

270
00:13:18,510 --> 00:13:17,470
relatively recent results I know these

271
00:13:21,000 --> 00:13:18,520
did not exist

272
00:13:24,440 --> 00:13:21,010
as of ten years ago or whatever so

273
00:13:28,370 --> 00:13:24,450
they're relatively recent work and I

274
00:13:32,700 --> 00:13:28,380
like we can talk more about that but I

275
00:13:34,260 --> 00:13:32,710
would definitely take them as I said

276
00:13:38,150 --> 00:13:34,270
with a grain of salt I think they may

277
00:13:45,030 --> 00:13:41,580
there might be a place for her arguing

278
00:13:47,970 --> 00:13:45,040
to require some additional data of this

279
00:13:49,560 --> 00:13:47,980
sort yep which I think to be reasonably

280
00:13:52,760 --> 00:13:49,570
straightforward and you know all those

281
00:13:56,430 --> 00:13:52,770
cultures of the various groups of

282
00:13:58,860 --> 00:13:56,440
anoxygenic bacteria are available in

283
00:14:02,610 --> 00:13:58,870
various neighborhoods so I really I

284
00:14:04,740 --> 00:14:02,620
really mean it could be my I would be

285
00:14:07,380 --> 00:14:04,750
just shocked if that has not been that

286
00:14:11,570 --> 00:14:07,390
has not all been done on X and organisms

287
00:14:14,220 --> 00:14:11,580
I mean that would be pretty surprising

288
00:14:15,720 --> 00:14:14,230

but I really haven't I haven't looked so

289
00:14:22,260 --> 00:14:15,730
yeah it's just it's certainly worth

290
00:14:30,180 --> 00:14:22,270
pointing out i will make make a quick

291
00:14:34,160 --> 00:14:30,190
note of that okay let's see damn right

292
00:14:38,010 --> 00:14:34,170
here at this kevin writing are you Kim

293
00:14:42,420 --> 00:14:38,020
hey I'm the only paper I know was

294
00:14:46,280 --> 00:14:42,430
published in 1977 Bob you can was on

295
00:14:49,890 --> 00:14:46,290
that where they compared chloro biam

296
00:14:53,430 --> 00:14:49,900
thiosulfate Oh cillum with a purples and

297
00:14:55,110 --> 00:14:53,440
a climate amonos for good measure and I

298
00:14:58,200 --> 00:14:55,120
don't have the details like Laura biam

299
00:15:01,350 --> 00:14:58,210
was different as I recall okay if the

300
00:15:03,660 --> 00:15:01,360
ones all right interestingly everything

301
00:15:05,880 --> 00:15:03,670
else uses rubisco and Claudia this is

302
00:15:08,310 --> 00:15:05,890
reversed TCA cycle so clarity

303
00:15:11,040 --> 00:15:08,320
intelligent be enriched in carbon

304
00:15:12,900 --> 00:15:11,050
isotopes this is Linda Hayes yeah

305
00:15:16,020 --> 00:15:12,910
Caribbean because they reuse a reverse

306
00:15:17,550 --> 00:15:16,030
TCA cycle in the carbon fixation pathway

307
00:15:21,710 --> 00:15:17,560
the carbons that they have tend to be

308
00:15:27,030 --> 00:15:21,720
enriched how enriched irisha what I

309
00:15:29,960 --> 00:15:27,040
enriched in carbon 13 okay but what do

310
00:15:33,500 --> 00:15:29,970
you may have either okay I we're between

311
00:15:37,740 --> 00:15:33,510
I don't know

312
00:15:41,790 --> 00:15:37,750
10 per mil or so do you mean minus 10

313
00:15:43,770 --> 00:15:41,800

per mil or intentionally / / relative to

314
00:15:46,800 --> 00:15:43,780
other things that are using other carbon

315
00:15:51,180 --> 00:15:46,810
fixation red ribbon yeah that makes

316
00:15:53,100 --> 00:15:51,190
sense okay so that that is the error bar

317
00:15:55,620 --> 00:15:53,110
for many of these measurements on the

318
00:15:58,440 --> 00:15:55,630
microfossils you know sort of 10 / milk

319
00:16:00,030 --> 00:15:58,450
but that is a significant difference for

320
00:16:08,070 --> 00:16:00,040
definitely something we should have

321
00:16:11,490 --> 00:16:08,080
shown good point okay let's move on no

322
00:16:13,830 --> 00:16:11,500
more questions on carbon another

323
00:16:18,690 --> 00:16:13,840
constraint from the geological record is

324
00:16:21,750 --> 00:16:18,700
of course the what record we have of

325
00:16:25,590 --> 00:16:21,760
oxygen in the atmosphere and the banded

326
00:16:28,320 --> 00:16:25,600
iron formations themselves which is in

327
00:16:33,990 --> 00:16:28,330
this next figure I lost my pointer

328
00:16:36,780 --> 00:16:34,000
humans like I don't see their juice okay

329
00:16:40,710 --> 00:16:36,790
okay so they banded iron formations are

330
00:16:45,120 --> 00:16:40,720
here in red oxygen levels inferred are

331
00:16:47,570 --> 00:16:45,130
in blue and so it's pretty clear that

332
00:16:53,010 --> 00:16:47,580
something was causing ferrous iron to

333
00:16:57,810 --> 00:16:53,020
crash out and deposit as magnetite and

334
00:17:00,690 --> 00:16:57,820
hematite in the rtm and early

335
00:17:04,050 --> 00:17:00,700
proterozoic ocean exactly what the cause

336
00:17:06,570 --> 00:17:04,060
of that is is still debated and I mean

337
00:17:07,830 --> 00:17:06,580
one it is possible that it is at least I

338
00:17:11,040 --> 00:17:07,840

think it's still considered possible

339
00:17:12,840 --> 00:17:11,050
that it is simply the reaction of oxygen

340
00:17:16,610 --> 00:17:12,850
with ferrous iron aqueous reaction of

341
00:17:19,230 --> 00:17:16,620
oxygen with ferrous iron causing it to

342
00:17:24,660 --> 00:17:19,240
oxidizing that fares in turn or it could

343
00:17:28,110 --> 00:17:24,670
be could be somewhat more interesting

344
00:17:30,800 --> 00:17:28,120
and involve an oxygen accord isms that

345
00:17:36,480 --> 00:17:30,810
use ferrous iron as reductant and

346
00:17:38,490 --> 00:17:36,490
precipitate out feo h3 and and I think

347
00:17:41,510 --> 00:17:38,500
there is in fact iron isotope evidence I

348
00:17:44,640 --> 00:17:41,520
do not get a chance to pull that up but

349
00:17:46,320 --> 00:17:44,650
at some point there is in fact iron i'm

350
00:17:48,750 --> 00:17:46,330
quite sure there's ionized of evidence

351
00:17:50,279 --> 00:17:48,760
favor of the ladder and there's even a

352
00:17:54,240 --> 00:17:50,289
third possibility and that is the topic

353
00:17:56,639 --> 00:17:54,250
fatalis of ferrous iron complexes can

354
00:17:58,139 --> 00:17:56,649
also you can photo oxidized ferrous iron

355
00:18:00,120 --> 00:17:58,149
and surface water although there have

356
00:18:02,970 --> 00:18:00,130
been some arguments pretty substantial

357
00:18:05,759 --> 00:18:02,980
arguments against them but the bottom

358
00:18:09,960 --> 00:18:05,769
line is that the biss are it's a truly

359
00:18:13,350 --> 00:18:09,970
massive amount of iron and one really

360
00:18:16,669 --> 00:18:13,360
does have to understand how its formed

361
00:18:20,220 --> 00:18:16,679
why that ferrous iron was oxidized and

362
00:18:24,509 --> 00:18:20,230
it is either evidence for very oxygen

363
00:18:27,509 --> 00:18:24,519

early oxygenic photosynthesis or it as

364
00:18:31,789 --> 00:18:27,519
evidence for the ferrous iron the an

365
00:18:37,139 --> 00:18:31,799
oxygen combine their ferrous iron reduce

366
00:18:39,389 --> 00:18:37,149
oxygen so it's it's a interesting part

367
00:18:41,250 --> 00:18:39,399
of the story and I think we still don't

368
00:18:45,090 --> 00:18:41,260
know exactly how to interpret it in

369
00:18:48,360 --> 00:18:45,100
terms of photosynthesis particularly is

370
00:18:49,980 --> 00:18:48,370
this evidence I mean is it evidence for

371
00:18:53,039 --> 00:18:49,990
oxygenic photosynthesis I think that's

372
00:18:54,659 --> 00:18:53,049
really the issue that is oxygen in

373
00:18:59,840 --> 00:18:54,669
photosynthesis eating the archaean very

374
00:19:03,240 --> 00:18:59,850
early okay what else is on this slide

375
00:19:06,240 --> 00:19:03,250
alright they're just showing the roughly

376
00:19:09,509 --> 00:19:06,250
the time of arrival of various processes

377
00:19:11,370 --> 00:19:09,519
in organisms so again this is late rise

378
00:19:12,480 --> 00:19:11,380
in oxygen which we're not going to get

379
00:19:14,669 --> 00:19:12,490
into here but it's quite interesting

380
00:19:17,279 --> 00:19:14,679
really in the neoproterozoic is

381
00:19:22,049 --> 00:19:17,289
apparently associated with land-based

382
00:19:25,440 --> 00:19:22,059
eukaryotes he's over here and vascular

383
00:19:29,250 --> 00:19:25,450
plants transmitted later but the index

384
00:19:33,659 --> 00:19:29,260
emulator but it's it's a worthy topic

385
00:19:35,549 --> 00:19:33,669
and I just sort beyond completely beyond

386
00:19:41,060 --> 00:19:35,559
my knowledge I'm just not going to worry

387
00:19:49,259 --> 00:19:44,159
probably the most quantitative record we

388
00:19:50,940 --> 00:19:49,269

have for the occurrence of oxygen in the

389
00:19:53,159 --> 00:19:50,950
atmosphere is this mass independent

390
00:19:56,370 --> 00:19:53,169
fractionation of sulfur isotopes so this

391
00:19:58,830 --> 00:19:56,380
quantity here this cap 33s I guess most

392
00:19:59,650 --> 00:19:58,840
of you are familiar with this of me I

393
00:20:02,260 --> 00:19:59,660
know

394
00:20:04,690 --> 00:20:02,270
most part I don't want to get into a

395
00:20:08,470 --> 00:20:04,700
bunch of detail about this i work on

396
00:20:10,020 --> 00:20:08,480
this topic and it's you just be a bit of

397
00:20:13,840 --> 00:20:10,030
an aside for we've got at the moment but

398
00:20:19,360 --> 00:20:13,850
this is a measure this kappa delta 33 s

399
00:20:21,510 --> 00:20:19,370
is a measure of excess 33 sulfur in a

400
00:20:26,370 --> 00:20:21,520
given example that you're looking at and

401
00:20:30,370 --> 00:20:26,380
so in most samples you look in the first

402
00:20:33,550 --> 00:20:30,380
from essentially present-day up to 2.4

403
00:20:37,720 --> 00:20:33,560
or so billion years sedimentary rocks

404
00:20:40,390 --> 00:20:37,730
and virtually everything organisms all

405
00:20:43,990 --> 00:20:40,400
just everything we look at in sulfur

406
00:20:46,060 --> 00:20:44,000
isotopes has no unusual excess of 33

407
00:20:49,630 --> 00:20:46,070
sulfur it has the expected amount based

408
00:20:51,340 --> 00:20:49,640
on isotopic equilibrium arguments as

409
00:20:53,320 --> 00:20:51,350
arguments are applied to rocks normally

410
00:20:58,060 --> 00:20:53,330
but you can apply them to other things

411
00:21:01,030 --> 00:20:58,070
as well but when you go back beyond 2.4

412
00:21:06,700 --> 00:21:01,040
billion you suddenly see that's quite

413
00:21:10,090 --> 00:21:06,710

noticeable rise in excess 33s being

414
00:21:13,300 --> 00:21:10,100
positive 33 values and also in negative

415
00:21:14,860 --> 00:21:13,310
33 s values these are mostly in

416
00:21:19,680 --> 00:21:14,870
barrett's here there's a mostly in

417
00:21:22,060 --> 00:21:19,690
pyrites and there's a lot of speculation

418
00:21:23,290 --> 00:21:22,070
about what exactly is causing this

419
00:21:26,170 --> 00:21:23,300
interpretation that was offered

420
00:21:29,920 --> 00:21:26,180
initially and it is still essentially

421
00:21:33,430 --> 00:21:29,930
interpretation is that this reflects so2

422
00:21:37,600 --> 00:21:33,440
fatalis in the atmosphere and the

423
00:21:40,420 --> 00:21:37,610
difference was that here where you're

424
00:21:43,360 --> 00:21:40,430
seeing this signature there would photo

425
00:21:45,490 --> 00:21:43,370
eyes so you can photo ID SS or tune the

426
00:21:50,590 --> 00:21:45,500
atmosphere of volcanic so2 or whatever

427
00:21:52,810 --> 00:21:50,600
as o2 at any time but any prior to an

428
00:21:54,790 --> 00:21:52,820
oxygen oxygenated atmosphere when you

429
00:21:56,620 --> 00:21:54,800
photo eyes lettuce 02 you would produce

430
00:21:58,180 --> 00:21:56,630
two reservoirs essentially two

431
00:22:00,960 --> 00:21:58,190
reservoirs a sulfur one of them being

432
00:22:03,130 --> 00:22:00,970
elemental sulfur and the other sulfate

433
00:22:08,020 --> 00:22:03,140
once you've oxidized that as though two

434
00:22:10,540 --> 00:22:08,030
and all because all of the sulfur was

435
00:22:13,210 --> 00:22:10,550
not oxidized into one reservoir it is

436
00:22:15,399 --> 00:22:13,220
possible to produce an isotope effect

437
00:22:16,930 --> 00:22:15,409
in the Fatah lessness process this is

438
00:22:19,870 --> 00:22:16,940

the part that I work on in some detail

439
00:22:21,430 --> 00:22:19,880
in preserve it preserve it because you

440
00:22:23,350 --> 00:22:21,440
actually have two reservoirs you have

441
00:22:25,029 --> 00:22:23,360
the elemental sulfur msl fate and they

442
00:22:28,620 --> 00:22:25,039
don't do the same thing when they get

443
00:22:31,990 --> 00:22:28,630
into the ocean sedimentary environment

444
00:22:34,779 --> 00:22:32,000
now in present time and since we've had

445
00:22:38,080 --> 00:22:34,789
an oxygenated atmosphere all of the

446
00:22:40,990 --> 00:22:38,090
sulfur is regardless you can photo eyes

447
00:22:42,730 --> 00:22:41,000
so2 you photo eyes h2s cs2 anything that

448
00:22:45,669 --> 00:22:42,740
you put in the atmosphere sulfur bearing

449
00:22:47,440 --> 00:22:45,679
that is and you fertilize that or photo

450
00:22:49,210 --> 00:22:47,450
process it in any way it all ends up

451
00:22:51,310 --> 00:22:49,220
oxidized and converted into sulfuric

452
00:22:53,380 --> 00:22:51,320
acids you have one reservoir anything

453
00:22:57,399 --> 00:22:53,390
that you've done photochemically to

454
00:23:00,010 --> 00:22:57,409
impart a sulfur fractionation to that in

455
00:23:01,450 --> 00:23:00,020
any of those steps they simply erased

456
00:23:03,520 --> 00:23:01,460
because everything is added back

457
00:23:05,169 --> 00:23:03,530
together in stuck in one compound and

458
00:23:07,810 --> 00:23:05,179
that is essentially sulfuric acid

459
00:23:10,630 --> 00:23:07,820
sulphate so we lose that signature all

460
00:23:13,810 --> 00:23:10,640
through here but we still have it here

461
00:23:18,370 --> 00:23:13,820
and so this is used as a just a real

462
00:23:21,159 --> 00:23:18,380
hard marker for the rise of o2 in the

463
00:23:23,289 --> 00:23:21,169

atmosphere and it certainly is a very

464
00:23:26,590 --> 00:23:23,299
sensible interpretation there are

465
00:23:29,230 --> 00:23:26,600
details in terms of working out exactly

466
00:23:32,470 --> 00:23:29,240
whether you get the expected signatures

467
00:23:34,180 --> 00:23:32,480
from so2 fatalis and all laugh that one

468
00:23:35,740 --> 00:23:34,190
expects that one sees in the rocks do

469
00:23:37,659 --> 00:23:35,750
you get that when you you actually photo

470
00:23:41,649 --> 00:23:37,669
lies as it's in the lab of that bad as a

471
00:23:44,560 --> 00:23:41,659
in-depth and heavily worked on topic at

472
00:23:47,380 --> 00:23:44,570
the moment by myself included in my

473
00:23:49,960 --> 00:23:47,390
spectroscopy colleagues so oh but but

474
00:23:51,640 --> 00:23:49,970
right now the interpretation and I think

475
00:23:54,630 --> 00:23:51,650
it's quite reasonable is that this right

476
00:23:58,510 --> 00:23:54,640
here marks somewhere very close in here

477
00:24:01,720 --> 00:23:58,520
about 2.45 2.5 billion years marks the

478
00:24:03,779 --> 00:24:01,730
transition from very low low two levels

479
00:24:06,970 --> 00:24:03,789
less than kind of ppm levels to

480
00:24:12,760 --> 00:24:06,980
something above that so you know it

481
00:24:14,260 --> 00:24:12,770
might only be a 100 ppm or something

482
00:24:16,360 --> 00:24:14,270
that sort but it was high enough that it

483
00:24:18,130 --> 00:24:16,370
caused it affected by atmospheric

484
00:24:21,669 --> 00:24:18,140
processing of so2 and turned everything

485
00:24:23,620 --> 00:24:21,679
in this office ok so there's of course a

486
00:24:25,570 --> 00:24:23,630
relatively spotty record there are

487
00:24:26,799 --> 00:24:25,580
details that you hear different

488
00:24:29,470 --> 00:24:26,809

variations in the

489
00:24:30,700 --> 00:24:29,480
magnitude of the signature all all stuff

490
00:24:33,580 --> 00:24:30,710
that can be explained in various ways

491
00:24:35,860 --> 00:24:33,590
that I'm not going to get into now but

492
00:24:37,919 --> 00:24:35,870
it's a very powerful record and has had

493
00:24:40,810 --> 00:24:37,929
a profound impact and how we interpret

494
00:24:44,379 --> 00:24:40,820
oxygen the arrival of oxygen in the

495
00:24:46,600 --> 00:24:44,389
atmosphere okay so getting onto then

496
00:24:49,299 --> 00:24:46,610
photosynthesis so those are really i

497
00:24:50,470 --> 00:24:49,309
think the left out the iron isotope

498
00:24:52,480 --> 00:24:50,480
stuff but those are those other

499
00:24:53,950 --> 00:24:52,490
principal geological constraints your

500
00:24:56,680 --> 00:24:53,960
chemical constraints we have on

501
00:24:59,049 --> 00:24:56,690
photosynthesis I'll bet valve the oxygen

502
00:25:05,200 --> 00:24:59,059
you know the carbon isotopes for an

503
00:25:07,720 --> 00:25:05,210
oxygen oxygen species as well but ok so

504
00:25:11,259 --> 00:25:07,730
then what about photosynthesis of

505
00:25:15,129 --> 00:25:11,269
memphis is going to be just a very

506
00:25:17,529 --> 00:25:15,139
simple overview there are some experts

507
00:25:20,739 --> 00:25:17,539
on the phone here who i invite you to

508
00:25:22,629 --> 00:25:20,749
jump in and correct something if I don't

509
00:25:26,590 --> 00:25:22,639
say it enough detail if I say something

510
00:25:30,340 --> 00:25:26,600
incorrectly so this is what I'm showing

511
00:25:33,940 --> 00:25:30,350
here is one of the simplest light

512
00:25:35,799 --> 00:25:33,950
gathering systems we have it's it's not

513
00:25:38,109 --> 00:25:35,809

photosynthesis puces of our Dobson

514
00:25:41,739 --> 00:25:38,119
system this is for this is a light

515
00:25:47,859 --> 00:25:41,749
driven energy transduction system if you

516
00:25:50,499 --> 00:25:47,869
will and it's the so what I want from

517
00:25:53,039 --> 00:25:50,509
here is a membrane layer and light

518
00:25:56,799 --> 00:25:53,049
indicated by these yellow pulse

519
00:26:00,190 --> 00:25:56,809
lightning bolts and the rhodopsins take

520
00:26:02,769 --> 00:26:00,200
in the actually the broad out some

521
00:26:05,609 --> 00:26:02,779
protein is down here this little picture

522
00:26:09,489 --> 00:26:05,619
so it's a heptamer of alpha helixes

523
00:26:12,340 --> 00:26:09,499
connected by loops and inside in no of

524
00:26:15,009 --> 00:26:12,350
those alpha human sees is a retinal

525
00:26:17,529 --> 00:26:15,019
pigment so a carotenoid is hanging in

526
00:26:22,060 --> 00:26:17,539
there capable of absorbing visible light

527
00:26:24,070 --> 00:26:22,070
and this move that down to remember to

528
00:26:26,049 --> 00:26:24,080
move the right pointer ok there's the

529
00:26:29,919 --> 00:26:26,059
retinal there it absorbs a photon

530
00:26:31,149 --> 00:26:29,929
visible photon at an appropriate range

531
00:26:34,509 --> 00:26:31,159
of wavelengths and undergoes

532
00:26:39,850 --> 00:26:34,519
isomerization which allows for proton

533
00:26:40,480 --> 00:26:39,860
transduction through this through this

534
00:26:42,220 --> 00:26:40,490
channel

535
00:26:44,799 --> 00:26:42,230
to the roy thomson and so you actually

536
00:26:49,600 --> 00:26:44,809
get light-driven movements of protons

537
00:26:52,330 --> 00:26:49,610
into the cell and et pas which is also

538
00:26:56,020 --> 00:26:52,340

an integral membrane bound found

539
00:27:01,150 --> 00:26:56,030
structure is able to take those protons

540
00:27:03,730 --> 00:27:01,160
and use it to drive ATP synthesis ok so

541
00:27:06,400 --> 00:27:03,740
this is this is a it's really just it's

542
00:27:08,860 --> 00:27:06,410
a beautiful system it's so simple taking

543
00:27:10,419 --> 00:27:08,870
photon photo energy light energy and

544
00:27:12,970 --> 00:27:10,429
converting it directly into chemical

545
00:27:15,669 --> 00:27:12,980
energy used by the cell as we all know

546
00:27:18,070 --> 00:27:15,679
ATP is just you know of such fundamental

547
00:27:21,070 --> 00:27:18,080
importance in every single organism that

548
00:27:25,030 --> 00:27:21,080
we know it's almost hard to overstate it

549
00:27:31,030 --> 00:27:25,040
but so this really is a marvelously a

550
00:27:34,180 --> 00:27:31,040
simple and effective system for ion

551
00:27:36,100 --> 00:27:34,190
movement for I am transaction and it's

552
00:27:38,890 --> 00:27:36,110
we use for chloride ions used for

553
00:27:41,049 --> 00:27:38,900
protons as it's mentioned and it's it's

554
00:27:43,390 --> 00:27:41,059
fairly prevalent but it's not as

555
00:27:47,290 --> 00:27:43,400
prevalent as one might expect it's

556
00:27:48,850 --> 00:27:47,300
primarily in archaea I again when the

557
00:27:51,190 --> 00:27:48,860
audience here can correct me if I'm

558
00:27:53,520 --> 00:27:51,200
wrong about them it's also widespread

559
00:27:56,100 --> 00:27:53,530
and it's also widespread in certain

560
00:27:59,799 --> 00:27:56,110
proteobacteria these are the marine

561
00:28:01,480 --> 00:27:59,809
proteobacteria I think well yeah so it I

562
00:28:04,960 --> 00:28:01,490
mean that you know I have to say as

563
00:28:07,480 --> 00:28:04,970

someone who hasn't thought as much about

564
00:28:10,660 --> 00:28:07,490
these topics as some of you guys have I

565
00:28:12,910 --> 00:28:10,670
look at this and I just think why isn't

566
00:28:16,210 --> 00:28:12,920
this used in some fashion more I mean

567
00:28:19,120 --> 00:28:16,220
it's just so elegant and so you know I

568
00:28:21,280 --> 00:28:19,130
like the simplicity of it it just kind

569
00:28:25,510 --> 00:28:21,290
of surprised me but there are reasons I

570
00:28:26,740 --> 00:28:25,520
guess but it's and that this is Magnus

571
00:28:28,390 --> 00:28:26,750
spent too much time talking about this

572
00:28:29,919 --> 00:28:28,400
but one can't help but imagine that

573
00:28:33,549 --> 00:28:29,929
something like this would have developed

574
00:28:36,130 --> 00:28:33,559
certainly well before Anna oxygen ixora

575
00:28:38,590 --> 00:28:36,140
synthesis with its double photosystems

576
00:28:40,600 --> 00:28:38,600
no this is just so much input but of

577
00:28:42,730 --> 00:28:40,610
course this does not forget you reducing

578
00:28:44,830 --> 00:28:42,740
engine using equivalent so you're you're

579
00:28:47,890 --> 00:28:44,840
not Purdue you're not converting co2

580
00:28:51,549 --> 00:28:47,900
into those from from this process this

581
00:28:53,860 --> 00:28:51,559
is just to generate ATP okay so so

582
00:28:56,290 --> 00:28:53,870
that's okay you can you can you you can

583
00:28:59,020 --> 00:28:56,300
use that ATP to the dr of reverse

584
00:29:00,820 --> 00:28:59,030
electron flow to do reduction and so

585
00:29:03,430 --> 00:29:00,830
that's how the purple photosynthetic

586
00:29:05,799 --> 00:29:03,440
bacteria do it and so principal this

587
00:29:09,490 --> 00:29:05,809
could provide this could provide the

588
00:29:12,340 --> 00:29:09,500

energy for the carbon fixation practice

589
00:29:16,600 --> 00:29:12,350
I don't know of any organisms that are

590
00:29:19,270 --> 00:29:16,610
real photo autotrophic using wood option

591
00:29:23,620 --> 00:29:19,280
based photosynthesis it's just have a

592
00:29:27,000 --> 00:29:23,630
thing to give you enough of to to really

593
00:29:29,650 --> 00:29:27,010
power your whole your whole metabolism

594
00:29:32,500 --> 00:29:29,660
okay is that partly because it's not

595
00:29:36,430 --> 00:29:32,510
such a great collector or photons or is

596
00:29:38,500 --> 00:29:36,440
there some better reason for them well

597
00:29:40,240 --> 00:29:38,510
it only uses a fairly narrow region of

598
00:29:43,660 --> 00:29:40,250
the solar spectrum so you don't have a

599
00:29:45,640 --> 00:29:43,670
lot of of solar flux that you can

600
00:29:47,830 --> 00:29:45,650
harvest using these pigments although

601
00:29:49,840 --> 00:29:47,840
you could imagine that evolution could

602
00:29:52,030 --> 00:29:49,850
have broadened it out as it has in a lot

603
00:29:54,880 --> 00:29:52,040
of visual system exactly I don't have a

604
00:29:56,890 --> 00:29:54,890
good explanation for why I agree with

605
00:30:01,000 --> 00:29:56,900
you it's beautiful elegant simple system

606
00:30:04,930 --> 00:30:01,010
and it's it's surprising that you look

607
00:30:06,250 --> 00:30:04,940
out in the world is a purple but no it

608
00:30:09,220 --> 00:30:06,260
is the case that you look out in the

609
00:30:12,790 --> 00:30:09,230
world is me and so wow this is obviously

610
00:30:17,260 --> 00:30:12,800
an important and important and and

611
00:30:20,200 --> 00:30:17,270
possibly a very early assistant it

612
00:30:23,549 --> 00:30:20,210
hasn't become the dominant mode in the

613
00:30:29,830 --> 00:30:23,559

biosphere today obviously right right

614
00:30:32,110 --> 00:30:29,840
okay all right then the systems that are

615
00:30:34,299 --> 00:30:32,120
in fact dominant are just very

616
00:30:36,990 --> 00:30:34,309
generically indicated here again taking

617
00:30:38,860 --> 00:30:37,000
some taking figures just straight out of

618
00:30:41,980 --> 00:30:38,870
Homeland Marriott and Blankenship's

619
00:30:45,430 --> 00:30:41,990
paper 2011 nice review paper on

620
00:30:47,740 --> 00:30:45,440
evolution photosynthesis of what so

621
00:30:51,549 --> 00:30:47,750
what's shown here in this one labeled B

622
00:30:53,470 --> 00:30:51,559
is this is again photons coming into

623
00:30:55,870 --> 00:30:53,480
what's called a queue type reaction

624
00:31:01,090 --> 00:30:55,880
center the clinton phenol a known type

625
00:31:04,090 --> 00:31:01,100
reactions there and this is a very

626
00:31:06,970 --> 00:31:04,100
simple system in its utilizing cyclic

627
00:31:09,850 --> 00:31:06,980
electron flow okay so

628
00:31:13,659 --> 00:31:09,860
my pointer is here okay cyclic electron

629
00:31:16,360 --> 00:31:13,669
flow here and it's more or less i would

630
00:31:21,100 --> 00:31:16,370
say the simplest of the true

631
00:31:23,400 --> 00:31:21,110
photosynthetic systems not counting or

632
00:31:26,770 --> 00:31:23,410
dobson is a term photosynthetic system

633
00:31:29,880 --> 00:31:26,780
and although similar again in that it's

634
00:31:32,980 --> 00:31:29,890
really then you're just using this

635
00:31:38,980 --> 00:31:32,990
energy this proton gradient generated to

636
00:31:43,030 --> 00:31:38,990
use ATP okay and i think they remind me

637
00:31:48,310 --> 00:31:43,040
is this is a fair summary of the purple

638
00:31:51,669 --> 00:31:48,320

bacteria or is that not correct yeah

639
00:31:55,600 --> 00:31:51,679
that's true okay yeah that's not to be

640
00:31:58,390 --> 00:31:55,610
the purple bacteria okay papi right

641
00:32:02,860 --> 00:31:58,400
exactly okay and then the the lower one

642
00:32:05,020 --> 00:32:02,870
is now this is same situation photons

643
00:32:08,830 --> 00:32:05,030
coming in reaction center here now using

644
00:32:11,770 --> 00:32:08,840
I'm and sulfur cluster it's my iron

645
00:32:14,770 --> 00:32:11,780
sulfur type reaction Center so as

646
00:32:16,090 --> 00:32:14,780
opposed to the Q type known type

647
00:32:23,020 --> 00:32:16,100
reactions near here so different

648
00:32:26,230 --> 00:32:23,030
electron carrier and so that debate a

649
00:32:30,419 --> 00:32:26,240
great sulfur bacteria this is green

650
00:32:33,400 --> 00:32:30,429
sulfur yes and the point here is this is

651
00:32:37,299 --> 00:32:33,410
just creating reducing equivalents to be

652
00:32:41,110 --> 00:32:37,309
used in carbon and nitrogen fixation so

653
00:32:43,330 --> 00:32:41,120
this this really is so I guess what we

654
00:32:47,230 --> 00:32:43,340
would call it's closed for photosystem 1

655
00:32:48,940 --> 00:32:47,240
in some ways right that's right but you

656
00:32:52,000 --> 00:32:48,950
have to realize that those guys are also

657
00:32:53,830 --> 00:32:52,010
doing a cycle as well so there is a

658
00:32:56,650 --> 00:32:53,840
cycle there is a good I mean you have to

659
00:32:59,080 --> 00:32:56,660
return electrons right well I mean you

660
00:33:01,180 --> 00:32:59,090
need to pump protons to get to make ATP

661
00:33:04,390 --> 00:33:01,190
so so that's going to be going on as

662
00:33:06,669 --> 00:33:04,400
well Oh in addition to the electrons are

663
00:33:09,430 --> 00:33:06,679

going out of the cycle to drive carbon

664
00:33:10,690 --> 00:33:09,440
and nitrogen fixation right yeah like

665
00:33:12,850 --> 00:33:10,700
heaven says they're going to have both

666
00:33:15,870 --> 00:33:12,860
but interestingly I don't think we

667
00:33:18,100 --> 00:33:15,880
really understand that the kind of

668
00:33:19,930 --> 00:33:18,110
partitioning between those two modes of

669
00:33:20,740 --> 00:33:19,940
electrons flow very well and those kinds

670
00:33:24,880 --> 00:33:20,750
of organisms

671
00:33:28,750 --> 00:33:24,890
or at all yeah what we've understood in

672
00:33:32,530 --> 00:33:28,760
that respect Paul rank are the least

673
00:33:37,990 --> 00:33:32,540
understood in which you mean that's

674
00:33:42,370 --> 00:33:38,000
where you have both slow 23 reducing

675
00:33:44,710 --> 00:33:42,380
equivalents and leave return flow I'm

676
00:33:48,070 --> 00:33:44,720
not quite like like versus the noncyclic

677
00:33:51,490 --> 00:33:48,080
swollen and now that how that works in

678
00:33:54,070 --> 00:33:51,500
these organisms okay there's just a huge

679
00:34:03,510 --> 00:33:54,080
there's a huge gap in our understanding

680
00:34:10,930 --> 00:34:03,520
about that got you okay all right okay

681
00:34:12,430 --> 00:34:10,940
well this is just a generic view of

682
00:34:15,580 --> 00:34:12,440
reactions conventions engineer a

683
00:34:18,669 --> 00:34:15,590
schematic view of reaction centers again

684
00:34:21,909 --> 00:34:18,679
different different organisms here so

685
00:34:24,550 --> 00:34:21,919
the purple bacteria Diana bacteria this

686
00:34:26,320 --> 00:34:24,560
is a system to of the cyanobacterium

687
00:34:28,570 --> 00:34:26,330
photo system one of those nine bacteria

688
00:34:32,110 --> 00:34:28,580

and green sulfur bacteria and helio

689
00:34:33,520 --> 00:34:32,120
victory and the idea here is I'm not

690
00:34:37,090 --> 00:34:33,530
going to get into this any depth but

691
00:34:40,260 --> 00:34:37,100
just just to show what is what the

692
00:34:44,649 --> 00:34:40,270
reaction center actually looks like the

693
00:34:47,260 --> 00:34:44,659
each of these circles you see are an

694
00:34:51,460 --> 00:34:47,270
alpha helix so it's a membrane integral

695
00:34:56,260 --> 00:34:51,470
membrane spanning protein and there are

696
00:34:58,690 --> 00:34:56,270
each of these reaction centers okay this

697
00:35:01,380 --> 00:34:58,700
is what I'm referring to of this is the

698
00:35:04,330 --> 00:35:01,390
alpha helix here each of these circular

699
00:35:07,860 --> 00:35:04,340
turtles and each of these reaction

700
00:35:12,640 --> 00:35:07,870
centers is composed of a dimer of these

701
00:35:15,910 --> 00:35:12,650
transmembrane proteins five each dimer

702
00:35:19,150 --> 00:35:15,920
this case and some of the dimers are

703
00:35:21,040 --> 00:35:19,160
have some differences this that's what's

704
00:35:23,200 --> 00:35:21,050
indicated here by the red vs. blue so

705
00:35:27,280 --> 00:35:23,210
they refer to this is a heterodimer and

706
00:35:30,760 --> 00:35:27,290
some are very similar and preferred

707
00:35:32,440 --> 00:35:30,770
homodimer and i believe most of the the

708
00:35:33,970 --> 00:35:32,450
differences in the hetero versus

709
00:35:37,630 --> 00:35:33,980
homodimer are in

710
00:35:39,160 --> 00:35:37,640
we known transfer I understand that

711
00:35:42,790 --> 00:35:39,170
correctly which I I'm sure I have a

712
00:35:47,160 --> 00:35:42,800
rather simplistic understanding of that

713
00:35:50,050 --> 00:35:47,170

some antenna structures are here as well

714
00:35:52,810 --> 00:35:50,060
rate in the reaction center and the

715
00:35:56,530 --> 00:35:52,820
first there are as well there are more

716
00:36:00,510 --> 00:35:56,540
peripheral or distant light harvesting

717
00:36:05,109 --> 00:36:00,520
proteins pigments in the membrane also

718
00:36:07,330 --> 00:36:05,119
okay and so the idea here is just as you

719
00:36:10,420 --> 00:36:07,340
illustrate what these reaction centers

720
00:36:12,310 --> 00:36:10,430
look like there are many things in here

721
00:36:14,200 --> 00:36:12,320
as well i mean this is this is where you

722
00:36:15,460 --> 00:36:14,210
know this is really where the action is

723
00:36:19,420 --> 00:36:15,470
this is where the charge separation

724
00:36:23,349 --> 00:36:19,430
occurs and there are four knowns and

725
00:36:25,530 --> 00:36:23,359
chlorophylls this is what was known type

726
00:36:29,830 --> 00:36:25,540
reactions dinner here the Queen time

727
00:36:34,450 --> 00:36:29,840
various electron transfer transport

728
00:36:36,700 --> 00:36:34,460
elements and many of type I cannot do

729
00:36:39,250 --> 00:36:36,710
justice to this but and then when you

730
00:36:41,440 --> 00:36:39,260
move over to the to the more for a

731
00:36:43,210 --> 00:36:41,450
system one type but you type one

732
00:36:47,500 --> 00:36:43,220
reaction centers you see iron-sulfur

733
00:36:50,740 --> 00:36:47,510
clusters involved as well and again lots

734
00:36:53,349 --> 00:36:50,750
of stuff going on here a huge amount of

735
00:36:55,470 --> 00:36:53,359
work on this over the years and the

736
00:36:58,300 --> 00:36:55,480
evolution of this I would have to ask

737
00:37:01,300 --> 00:36:58,310
Bob or Kevin to speak to the evolution

738
00:37:03,340 --> 00:37:01,310

of these kinds of systems if they wish

739
00:37:06,460 --> 00:37:03,350
to because it's simply beyond my

740
00:37:10,240 --> 00:37:06,470
knowledge it's quite clear that there's

741
00:37:12,250 --> 00:37:10,250
been a lot of lateral gene transfer in

742
00:37:17,130 --> 00:37:12,260
these systems there they're related in

743
00:37:19,930 --> 00:37:17,140
many ways and fairly straightforwardly

744
00:37:21,970 --> 00:37:19,940
yeah I could just comment on a couple of

745
00:37:26,260 --> 00:37:21,980
things and then I'm sure Kevin campus of

746
00:37:29,080 --> 00:37:26,270
one of the key evolutionary development

747
00:37:32,140 --> 00:37:29,090
system is the issue of the dimer the

748
00:37:34,090 --> 00:37:32,150
heterodimerization of these systems so

749
00:37:37,690 --> 00:37:34,100
where you have the red and the blue

750
00:37:40,570 --> 00:37:37,700
there on the left that represents a

751
00:37:42,910 --> 00:37:40,580
heterodimer protein which is a protein

752
00:37:45,760 --> 00:37:42,920
that has resulted from a gene

753
00:37:47,770 --> 00:37:45,770
duplication and subsequent divergence to

754
00:37:50,560 --> 00:37:47,780
create two similar but not

755
00:37:52,930 --> 00:37:50,570
identical copies of the core reaction

756
00:37:56,890 --> 00:37:52,940
tennis pro key and you see that in the

757
00:38:00,250 --> 00:37:56,900
purples and in the cyano ps1 and ps2 but

758
00:38:02,470 --> 00:38:00,260
in the green sulfur bacteria Helio

759
00:38:04,360 --> 00:38:02,480
bacterium instead of bacteria you have

760
00:38:06,910 --> 00:38:04,370
what's called a homodimer and that's

761
00:38:10,060 --> 00:38:06,920
where you have a single gene that has

762
00:38:14,410 --> 00:38:10,070
not duplicated in so you have two copies

763
00:38:17,350 --> 00:38:14,420

of a single gene product that associate

764
00:38:19,720 --> 00:38:17,360
to form the reaction Center complex and

765
00:38:22,510 --> 00:38:19,730
that preventive represents an earlier

766
00:38:26,110 --> 00:38:22,520
form of evolution prior great gene

767
00:38:28,120 --> 00:38:26,120
duplication event so functionally what

768
00:38:32,350 --> 00:38:28,130
is the difference between the homo and

769
00:38:34,690 --> 00:38:32,360
heterodimer them well in the few types

770
00:38:36,430 --> 00:38:34,700
in the queue type so you have electron

771
00:38:40,300 --> 00:38:36,440
flow that goes down just one of those

772
00:38:44,890 --> 00:38:40,310
two branches down at the bottom left

773
00:38:48,370 --> 00:38:44,900
there just in the in the ps1 and Kevin

774
00:38:50,140 --> 00:38:48,380
can speak to this better than I you have

775
00:38:54,610 --> 00:38:50,150
you do have electron flow that goes down

776
00:38:57,490 --> 00:38:54,620
both both pathways and so the functional

777
00:39:00,010 --> 00:38:57,500
importance of the heterodimer in ps1 is

778
00:39:02,140 --> 00:39:00,020
is not very clear at least not to me all

779
00:39:04,650 --> 00:39:02,150
right and then the ones that are homo

780
00:39:08,770 --> 00:39:04,660
dimers almost certainly you have equal

781
00:39:10,990 --> 00:39:08,780
pathways such that either pathway can be

782
00:39:14,770 --> 00:39:11,000
op can be utilize but we don't have any

783
00:39:16,990 --> 00:39:14,780
real good structural data on those okay

784
00:39:20,200 --> 00:39:17,000
yeah yeah I would just add a bi agree

785
00:39:21,610 --> 00:39:20,210
with everything Bob just set for the

786
00:39:25,420 --> 00:39:21,620
type to reaction centers that the

787
00:39:27,400 --> 00:39:25,430
quinone sidekicks you type clearly the

788
00:39:28,990 --> 00:39:27,410

heterodimerization there is important

789
00:39:31,300 --> 00:39:29,000
first function to they only use one

790
00:39:34,600 --> 00:39:31,310
branch for like on transfer and they

791
00:39:36,430 --> 00:39:34,610
stabilize uh the semiquinone on the

792
00:39:38,070 --> 00:39:36,440
other side and then eventually double

793
00:39:42,010 --> 00:39:38,080
reduce it so that's part of their

794
00:39:43,810 --> 00:39:42,020
mechanism and I imagine that that header

795
00:39:45,640 --> 00:39:43,820
does that hitter a dimerization happened

796
00:39:47,830 --> 00:39:45,650
early on for those guys in fact it

797
00:39:49,630 --> 00:39:47,840
probably happened independently in the

798
00:39:52,570 --> 00:39:49,640
Lynn is leading the ps2 and the one

799
00:39:55,210 --> 00:39:52,580
leading to the Purple's for ps1 no it's

800
00:39:56,800 --> 00:39:55,220
a different case actually there even

801
00:39:58,690 --> 00:39:56,810
though they have heterodimers like Bob

802
00:40:00,730 --> 00:39:58,700
said we've shown for a while now that

803
00:40:01,570 --> 00:40:00,740
they use both sides and actually most

804
00:40:03,730 --> 00:40:01,580
the differences

805
00:40:05,350 --> 00:40:03,740
seem to be not in the middle with

806
00:40:07,870 --> 00:40:05,360
electron transfer is occurring but more

807
00:40:10,660 --> 00:40:07,880
on the outside in order to make a

808
00:40:12,460 --> 00:40:10,670
symmetric binding site optimized binding

809
00:40:15,040 --> 00:40:12,470
of electron donor acceptor is outside

810
00:40:16,780 --> 00:40:15,050
the membrane and actually some work that

811
00:40:19,210 --> 00:40:16,790
we've done in jungle because then it

812
00:40:20,530 --> 00:40:19,220
kind of agrees that they may have done

813
00:40:24,010 --> 00:40:20,540

this in response to the presence of

814
00:40:26,730 --> 00:40:24,020
oxygen II so that is that this one may

815
00:40:28,900 --> 00:40:26,740
have evolved from a homodimeric ancestor

816
00:40:30,910 --> 00:40:28,910
in response to the presence of oxygen

817
00:40:33,040 --> 00:40:30,920
that's that's an idea but I think it

818
00:40:36,010 --> 00:40:33,050
fits the data pretty well that's an

819
00:40:39,280 --> 00:40:36,020
interesting I would be good to test ok

820
00:40:40,540 --> 00:40:39,290
so the ok I'm not going to we're we're

821
00:40:43,210 --> 00:40:40,550
actually taking quite a bit of time I'm

822
00:40:45,820 --> 00:40:43,220
not going to go through the redox

823
00:40:47,440 --> 00:40:45,830
energies of these systems I think if

824
00:40:51,130 --> 00:40:47,450
somebody wants to see that in some

825
00:40:54,940 --> 00:40:51,140
detail just ask it's it's well known for

826
00:40:57,730 --> 00:40:54,950
the different systems to let me

827
00:40:59,800 --> 00:40:57,740
literally just get this for now this is

828
00:41:02,650 --> 00:40:59,810
what we are just discussing these are

829
00:41:04,930 --> 00:41:02,660
individual sorry I'm fine pointer these

830
00:41:06,700 --> 00:41:04,940
are individual alpha helixes here just

831
00:41:09,910 --> 00:41:06,710
showing the process possible

832
00:41:11,530 --> 00:41:09,920
evolutionary processes of fusion and

833
00:41:14,170 --> 00:41:11,540
duplication divergence all the different

834
00:41:15,730 --> 00:41:14,180
things that can go on genomically to

835
00:41:19,390 --> 00:41:15,740
create different types of reaction

836
00:41:20,860 --> 00:41:19,400
centers and so let's let's push on to

837
00:41:22,420 --> 00:41:20,870
what the questions are because we have

838
00:41:26,680 --> 00:41:22,430

this long list of questions to go

839
00:41:29,080 --> 00:41:26,690
through and so I'm literally I just

840
00:41:32,790 --> 00:41:29,090
copied the questions and I'm just going

841
00:41:39,820 --> 00:41:37,320
you know what small comments added so

842
00:41:41,500 --> 00:41:39,830
looking at the geochemical fossil

843
00:41:46,360 --> 00:41:41,510
evidence what are the big issues related

844
00:41:47,770 --> 00:41:46,370
to photosynthesis one is the carbon

845
00:41:49,840 --> 00:41:47,780
isotope signatures in these graphs

846
00:41:51,580 --> 00:41:49,850
fitting conclusions in old rocks the

847
00:41:54,520 --> 00:41:51,590
oldest rocks 3.8 billion year old rocks

848
00:41:56,770 --> 00:41:54,530
achillea are there about minus twenty to

849
00:42:00,250 --> 00:41:56,780
thirty primeau relative to carbonates

850
00:42:01,870 --> 00:42:00,260
has talked about initially which is it's

851
00:42:03,430 --> 00:42:01,880
consistent with thermal processing and

852
00:42:05,410 --> 00:42:03,440
photos and photosynthetic lead arrived

853
00:42:08,230 --> 00:42:05,420
organics but is can this be an abiotic

854
00:42:14,980 --> 00:42:08,240
process also and this has been looked at

855
00:42:15,520 --> 00:42:14,990
someone by some some folks but i think

856
00:42:17,350 --> 00:42:15,530
it's something

857
00:42:20,470 --> 00:42:17,360
needs to be addressed in even more

858
00:42:22,390 --> 00:42:20,480
detail and Jack Hills if we go to the

859
00:42:24,340 --> 00:42:22,400
jack hill zircons these are the oldest

860
00:42:27,220 --> 00:42:24,350
rocks if you will that we have the

861
00:42:28,750 --> 00:42:27,230
really minerals but they these jack

862
00:42:30,730 --> 00:42:28,760
hills in Western Australia these zircons

863
00:42:33,280 --> 00:42:30,740

are four point three to four point

864
00:42:36,850 --> 00:42:33,290
billion years old will it based on your

865
00:42:39,220 --> 00:42:36,860
aim led ages and they apparently I did

866
00:42:43,000 --> 00:42:39,230
not know this but they contain evidence

867
00:42:44,740 --> 00:42:43,010
they contain some I should say do they

868
00:42:48,520 --> 00:42:44,750
contain contemporaneous organic

869
00:42:51,010 --> 00:42:48,530
prophetic matter they do contain

870
00:42:53,050 --> 00:42:51,020
something that is they do contain some

871
00:42:54,340 --> 00:42:53,060
carbon whisper to them I whether it's

872
00:42:57,100 --> 00:42:54,350
truly contemporaneous or not I don't

873
00:42:59,620 --> 00:42:57,110
know if it is and it certainly would be

874
00:43:00,820 --> 00:42:59,630
good if it is then someone's going to

875
00:43:02,200 --> 00:43:00,830
measure the carbon isotopes at some

876
00:43:04,540 --> 00:43:02,210
point I don't think that's been done yet

877
00:43:08,080 --> 00:43:04,550
certainly should be done and if it comes

878
00:43:10,240 --> 00:43:08,090
out in this- 22-30 range is this again

879
00:43:12,400 --> 00:43:10,250
evidence for life and photosynthesis in

880
00:43:14,290 --> 00:43:12,410
this very early now we're talking about

881
00:43:16,150 --> 00:43:14,300
a very early window that's four point

882
00:43:19,540 --> 00:43:16,160
three to four point oh I mean this this

883
00:43:22,270 --> 00:43:19,550
is really the only handle we have at the

884
00:43:26,680 --> 00:43:22,280
present time on carbon isotopes from

885
00:43:28,510 --> 00:43:26,690
this pre 3.8 periods so the this it's

886
00:43:30,670 --> 00:43:28,520
very important to at least try to do

887
00:43:33,280 --> 00:43:30,680
these measurements and then we can argue

888
00:43:37,030 --> 00:43:33,290

about what it means if if it means

889
00:43:38,560 --> 00:43:37,040
anything but it's certainly there's no

890
00:43:41,460 --> 00:43:38,570
other way that I'm aware of to get at

891
00:43:45,160 --> 00:43:41,470
that time period on on earth apart from

892
00:43:47,620 --> 00:43:45,170
finding lunar crust blasted off in an

893
00:43:49,480 --> 00:43:47,630
impact on the moon from that age but

894
00:43:52,380 --> 00:43:49,490
good luck finding them I mean it's

895
00:43:54,880 --> 00:43:52,390
probably there would be hard to find oh

896
00:43:58,270 --> 00:43:54,890
ok another question are the apex Church

897
00:44:00,760 --> 00:43:58,280
microfossils really cyanobacteria how

898
00:44:03,100 --> 00:44:00,770
can we differentiate these we can't

899
00:44:04,660 --> 00:44:03,110
simply assert that they are because they

900
00:44:06,760 --> 00:44:04,670
happen to you know have some

901
00:44:09,070 --> 00:44:06,770
morphological similarity there has to be

902
00:44:10,600 --> 00:44:09,080
something a little better than that and

903
00:44:14,080 --> 00:44:10,610
I I don't know what that is but that's

904
00:44:16,540 --> 00:44:14,090
something that needs to be also dug into

905
00:44:18,310 --> 00:44:16,550
in a bit more detail he'll shops main

906
00:44:20,920 --> 00:44:18,320
they say that he's already but that's

907
00:44:23,740 --> 00:44:20,930
assault issue I don't know but it

908
00:44:25,300 --> 00:44:23,750
doesn't seem to me that it is before

909
00:44:26,860 --> 00:44:25,310
here were abandoned our information is

910
00:44:28,849 --> 00:44:26,870
primarily a product of xanax during

911
00:44:30,079 --> 00:44:28,859
photosynthesis using Ferris on okay

912
00:44:32,779 --> 00:44:30,089
is this is something being actively

913
00:44:34,700 --> 00:44:32,789

worked on the Iron isotopes and perhaps

914
00:44:36,950 --> 00:44:34,710
other methods as well so I think that

915
00:44:40,099 --> 00:44:36,960
there is there will be progress on that

916
00:44:41,769 --> 00:44:40,109
and has been something already and fell

917
00:44:44,690 --> 00:44:41,779
for mass independent fractionation

918
00:44:46,640 --> 00:44:44,700
argues for oxygen and photosynthesis by

919
00:44:49,309 --> 00:44:46,650
at least a two point four billion years

920
00:44:51,499 --> 00:44:49,319
well but how much earlier coulda did

921
00:44:53,660 --> 00:44:51,509
them and maybe this is maybe it's more

922
00:44:55,370 --> 00:44:53,670
accurate to this about 2.5 but you know

923
00:44:58,039 --> 00:44:55,380
what i'm talking about that break in the

924
00:45:00,410 --> 00:44:58,049
curve where you go from zero mass

925
00:45:02,089 --> 00:45:00,420
independent fractionation to to suddenly

926
00:45:05,599 --> 00:45:02,099
quite dramatic mass independent

927
00:45:06,890 --> 00:45:05,609
signatures I should I explain but how

928
00:45:09,499 --> 00:45:06,900
much how much earlier could this have

929
00:45:12,950 --> 00:45:09,509
been there is there is some evidence

930
00:45:15,170 --> 00:45:12,960
from transition metal abundances

931
00:45:17,930 --> 00:45:15,180
manganese in particular for small

932
00:45:22,059 --> 00:45:17,940
amounts the levels of oxygen at various

933
00:45:25,099 --> 00:45:22,069
times going back to about 2.5 maybe 2.7

934
00:45:28,970 --> 00:45:25,109
and you know it's possible that oxygenic

935
00:45:33,309 --> 00:45:28,980
photosynthesis was actively going on for

936
00:45:36,289 --> 00:45:33,319
quite some time but the oxygen was being

937
00:45:39,259 --> 00:45:36,299
titrated out by the ferrous iron in the

938
00:45:41,539 --> 00:45:39,269

ocean and did not have a chance to

939
00:45:44,150 --> 00:45:41,549
appear until a good chunk of that

940
00:45:46,249 --> 00:45:44,160
Sarah's iron was removed and in fact

941
00:45:48,620 --> 00:45:46,259
much of it is removed by to all of it

942
00:45:52,009 --> 00:45:48,630
but much of it is removed by by about 4

943
00:45:54,079 --> 00:45:52,019
2.5 or was it simply the case that there

944
00:45:58,819 --> 00:45:54,089
was no oxygen occurrences at that time

945
00:46:03,109 --> 00:45:58,829
from prior to point a 2.5 2.6 again we

946
00:46:05,299 --> 00:46:03,119
don't know oh and this this something

947
00:46:06,680 --> 00:46:05,309
that I originally once I mean many of us

948
00:46:08,960 --> 00:46:06,690
were very hopeful for these organic

949
00:46:13,700 --> 00:46:08,970
chemical markers of the hope and lloyds

950
00:46:17,029 --> 00:46:13,710
and things that sort of a representative

951
00:46:22,599 --> 00:46:17,039
of various membrane-bound of sterols and

952
00:46:26,720 --> 00:46:22,609
other fairly good-sized stable molecules

953
00:46:30,109 --> 00:46:26,730
these would be useful as markers of an

954
00:46:32,450 --> 00:46:30,119
oxygen and oxygen photosynthesis going

955
00:46:34,940 --> 00:46:32,460
back in time into early proterozoic into

956
00:46:36,529 --> 00:46:34,950
the archaean and that was indeed the

957
00:46:39,019 --> 00:46:36,539
case for a while or at least we thought

958
00:46:40,729 --> 00:46:39,029
so but the has been an issue of

959
00:46:42,530 --> 00:46:40,739
contamination regarding the

960
00:46:44,360 --> 00:46:42,540
interpretation of all of these organic

961
00:46:47,750 --> 00:46:44,370
since they've all but many of these

962
00:46:49,940 --> 00:46:47,760
organic to chemical markers and so the

963
00:46:51,680 --> 00:46:49,950

field that whole field is in a bit of a

964
00:46:52,790 --> 00:46:51,690
state of flux at the moment and I don't

965
00:46:55,340 --> 00:46:52,800
know exactly where that's going to go

966
00:46:58,790 --> 00:46:55,350
but it it certainly is an important

967
00:47:00,920 --> 00:46:58,800
component of all of this okay so what

968
00:47:02,630 --> 00:47:00,930
about prebiotic chemistry now and we're

969
00:47:06,320 --> 00:47:02,640
talking about origin and evolution of

970
00:47:08,810 --> 00:47:06,330
photosynthesis would you do it in a

971
00:47:11,000 --> 00:47:08,820
prebiotic sense at all and certainly it

972
00:47:13,190 --> 00:47:11,010
looks so complicated that that the

973
00:47:15,610 --> 00:47:13,200
answer is almost certainly no but we can

974
00:47:17,990 --> 00:47:15,620
ask some simple questions things like

975
00:47:21,350 --> 00:47:18,000
number one here were provided

976
00:47:23,000 --> 00:47:21,360
chromophore is present in the surface of

977
00:47:26,860 --> 00:47:23,010
the earth meaning for exams or wherever

978
00:47:29,000 --> 00:47:26,870
and that's certainly a plausible thing

979
00:47:31,130 --> 00:47:29,010
some carrots and LEDs are not that

980
00:47:34,250 --> 00:47:31,140
complicated they could be present in

981
00:47:39,790 --> 00:47:34,260
various forms for friends perhaps less

982
00:47:42,230 --> 00:47:39,800
so but even they are not wildly complex

983
00:47:44,740 --> 00:47:42,240
certainly more complicated than methane

984
00:47:47,180 --> 00:47:44,750
or something like that but it's not

985
00:47:49,570 --> 00:47:47,190
implausible to imagine having those some

986
00:47:52,520 --> 00:47:49,580
of those compounds present periodically

987
00:47:54,100 --> 00:47:52,530
we're simple electron chains possible so

988
00:47:57,770 --> 00:47:54,110

imagine now that you have you have

989
00:47:59,720 --> 00:47:57,780
membranes you have cells but you may

990
00:48:02,450 --> 00:47:59,730
still not have living systems would it

991
00:48:04,520 --> 00:48:02,460
be possible if it gets from some

992
00:48:09,680 --> 00:48:04,530
chromophores in those membranes you

993
00:48:13,030 --> 00:48:09,690
could perhaps do some excitation via

994
00:48:16,340 --> 00:48:13,040
photons and transport this is all very

995
00:48:19,070 --> 00:48:16,350
well tuned stuff now when we look at it

996
00:48:22,430 --> 00:48:19,080
all of the excitation transfer and all

997
00:48:24,110 --> 00:48:22,440
that that goes on in picking systems so

998
00:48:26,510 --> 00:48:24,120
to imagine the packages pop up

999
00:48:29,480 --> 00:48:26,520
periodically is perhaps so pushing it

1000
00:48:31,340 --> 00:48:29,490
but simpler forms of that are possible

1001
00:48:33,830 --> 00:48:31,350
unknowns are not that complicated

1002
00:48:36,260 --> 00:48:33,840
iron-sulfur clusters we know form can

1003
00:48:38,930 --> 00:48:36,270
form and plausibly prebiotic scenarios

1004
00:48:42,800 --> 00:48:38,940
so it is a sensible thing to consider I

1005
00:48:46,520 --> 00:48:42,810
would argue it delayed heavy bombardment

1006
00:48:48,800 --> 00:48:46,530
delay the onset of photosynthesis this

1007
00:48:50,450 --> 00:48:48,810
is the late heavy bombardment was just

1008
00:48:54,380 --> 00:48:50,460
to remind everybody you guys and you

1009
00:48:56,359 --> 00:48:54,390
must know was really from about 4.1 to

1010
00:49:01,420 --> 00:48:56,369
say 3.8 billion years

1011
00:49:03,769 --> 00:49:01,430
and in and of itself it would not have

1012
00:49:06,410 --> 00:49:03,779
created a molten earth or anything like

1013
00:49:09,980 --> 00:49:06,420

that it's it would just have created of

1014
00:49:11,440 --> 00:49:09,990
brief spikes of high temperatures and of

1015
00:49:14,539 --> 00:49:11,450
course melting if you're in the area

1016
00:49:16,400 --> 00:49:14,549
nearby where a large asked when he saw

1017
00:49:19,279 --> 00:49:16,410
asteroids asteroidal sized object is in

1018
00:49:21,859 --> 00:49:19,289
fact but if you if you do the later

1019
00:49:23,989 --> 00:49:21,869
bombardment does consider the

1020
00:49:25,099 --> 00:49:23,999
possibility of very large impactors say

1021
00:49:27,499 --> 00:49:25,109
on the order of several hundred

1022
00:49:30,529 --> 00:49:27,509
kilometers that could have vaporized the

1023
00:49:32,989 --> 00:49:30,539
oceans you vaporize the oceans you may

1024
00:49:36,349 --> 00:49:32,999
have to reset some of the biological

1025
00:49:39,620 --> 00:49:36,359
processes and some of it was present at

1026
00:49:41,509 --> 00:49:39,630
that time of the impact so it is

1027
00:49:43,220 --> 00:49:41,519
possible especially given the photos and

1028
00:49:45,890 --> 00:49:43,230
sizes are right there at the surface and

1029
00:49:51,279 --> 00:49:45,900
see everything going on near the service

1030
00:49:55,420 --> 00:49:51,289
that they could have felt the effects of

1031
00:49:57,440 --> 00:49:55,430
these kind of good sizing factors oh I

1032
00:49:59,599 --> 00:49:57,450
don't know how we're going to dress that

1033
00:50:01,190 --> 00:49:59,609
accepted by because of the early time

1034
00:50:04,549 --> 00:50:01,200
period accepted by those Jack Hills

1035
00:50:08,380 --> 00:50:04,559
zircon sort of measurements looking for

1036
00:50:11,390 --> 00:50:08,390
carbon other prebiotic questions were

1037
00:50:13,160 --> 00:50:11,400
integral membrane proteins as often

1038
00:50:15,890 --> 00:50:13,170

alpha should be alpha helix is produced

1039
00:50:17,660 --> 00:50:15,900
in an RNA DNA protein world certainly

1040
00:50:20,839 --> 00:50:17,670
they they shouldn't be made in our

1041
00:50:23,690 --> 00:50:20,849
anymore but they could be a product of

1042
00:50:26,029 --> 00:50:23,700
an RNA and protein world and even one

1043
00:50:29,180 --> 00:50:26,039
that is the thing on how you define life

1044
00:50:32,569 --> 00:50:29,190
it might still be a prebiotic growth but

1045
00:50:33,890 --> 00:50:32,579
one can convey that but they're not

1046
00:50:36,140 --> 00:50:33,900
alpha equals these are not that

1047
00:50:38,779 --> 00:50:36,150
complicated in there I mean it's a

1048
00:50:41,120 --> 00:50:38,789
certain set it prefers a certain set of

1049
00:50:44,390 --> 00:50:41,130
residues but it's they're fairly

1050
00:50:48,049 --> 00:50:44,400
straightforward and they can in some

1051
00:50:49,910 --> 00:50:48,059
cases pop in the membranes ok so now

1052
00:50:54,890 --> 00:50:49,920
getting into more of the evolution

1053
00:50:57,769 --> 00:50:54,900
questions and again I will my colleagues

1054
00:51:01,220 --> 00:50:57,779
and expand upon any of these that they

1055
00:51:03,259 --> 00:51:01,230
feel they would like to so origin of an

1056
00:51:05,870 --> 00:51:03,269
oxygen occurrences so it's presumably

1057
00:51:08,610 --> 00:51:05,880
from from earlier head of trophic or

1058
00:51:10,590 --> 00:51:08,620
team autotrophic organisms when I

1059
00:51:13,020 --> 00:51:10,600
the photosynthesis was though

1060
00:51:17,570 --> 00:51:13,030
synthesizers were the origin of life

1061
00:51:21,450 --> 00:51:17,580
that would be a bit pushing it but

1062
00:51:24,900 --> 00:51:21,460
indeed they could come from heterotrophs

1063
00:51:28,080 --> 00:51:24,910

and other things so questions related to

1064
00:51:30,120 --> 00:51:28,090
that then what what was the ancestral

1065
00:51:33,360 --> 00:51:30,130
reaction Center and what was its origin

1066
00:51:35,600 --> 00:51:33,370
the reaction centers as we just

1067
00:51:38,160 --> 00:51:35,610
discussed our complicated there remain

1068
00:51:40,320 --> 00:51:38,170
not crazy complicated but they're pretty

1069
00:51:43,050 --> 00:51:40,330
complicated and clearly they are well

1070
00:51:47,030 --> 00:51:43,060
evolved structures can one make of

1071
00:51:49,770 --> 00:51:47,040
reaction center with one or two

1072
00:51:53,100 --> 00:51:49,780
membrane-spanning proteins and can you

1073
00:51:55,530 --> 00:51:53,110
of begin to approach them of course you

1074
00:51:57,420 --> 00:51:55,540
have to find pigments and all that but

1075
00:52:01,560 --> 00:51:57,430
but that's the sort of question that one

1076
00:52:03,450 --> 00:52:01,570
wants to ask how was the ancestor reacts

1077
00:52:05,910 --> 00:52:03,460
under a simple homodimeric photosystem

1078
00:52:07,770 --> 00:52:05,920
okay I think Bob already answered that

1079
00:52:10,560 --> 00:52:07,780
scene saying it's pretty likely that

1080
00:52:12,990 --> 00:52:10,570
these moments home with America's moved

1081
00:52:19,020 --> 00:52:13,000
i'm eric reaction centers are thought to

1082
00:52:21,870 --> 00:52:19,030
be earlier did iron can plus sulfides or

1083
00:52:24,050 --> 00:52:21,880
other easily oxidizable compounds act as

1084
00:52:26,010 --> 00:52:24,060
primary donors in the reaction center

1085
00:52:27,450 --> 00:52:26,020
what we're looking for is evidence of

1086
00:52:31,770 --> 00:52:27,460
that that seems like a logical

1087
00:52:33,360 --> 00:52:31,780
assumption this I stole rate out of one

1088
00:52:36,300 --> 00:52:33,370

of Bob's papers just a marvelous

1089
00:52:37,910 --> 00:52:36,310
question for its directness and

1090
00:52:40,710 --> 00:52:37,920
simplicity with the last common ancestor

1091
00:52:43,770 --> 00:52:40,720
photosynthetic wonderful question I

1092
00:52:47,340 --> 00:52:43,780
don't know it's certainly seem sensible

1093
00:52:50,790 --> 00:52:47,350
but i don't know i think the edward it

1094
00:52:55,950 --> 00:52:50,800
though i think the answer's no yeah the

1095
00:52:57,420 --> 00:52:55,960
last common ancestry luca the reason i

1096
00:52:59,750 --> 00:52:57,430
say that is if you look at the

1097
00:53:04,020 --> 00:52:59,760
distribution of at least four co-based

1098
00:53:06,810 --> 00:53:04,030
photosynthesis in the tree you find it

1099
00:53:08,850 --> 00:53:06,820
all in the bacterial domain and then of

1100
00:53:12,680 --> 00:53:08,860
course the endosymbionts in the Eukarya

1101
00:53:15,450 --> 00:53:12,690
no virus single case of our keel

1102
00:53:20,160 --> 00:53:15,460
chlorophyll based photosynthesis but to

1103
00:53:22,430 --> 00:53:20,170
me that suggests that that the coracle

1104
00:53:25,700 --> 00:53:22,440
based photosynthesis was invented

1105
00:53:29,030 --> 00:53:25,710
within the bacterial domain and then

1106
00:53:32,359 --> 00:53:29,040
spread to the eukaryotes but you know

1107
00:53:34,069 --> 00:53:32,369
you you could get out of that if you

1108
00:53:36,430 --> 00:53:34,079
really wanted to but that's that's what

1109
00:53:40,849 --> 00:53:36,440
that distribution industry says to me

1110
00:53:42,140 --> 00:53:40,859
right right all right I rhodopsins more

1111
00:53:49,790 --> 00:53:42,150
ancient than photosynthetic reaction

1112
00:53:51,589 --> 00:53:49,800
centers I again the basis for the

1113
00:53:56,510 --> 00:53:51,599

question is because weird options and

1114
00:53:58,010 --> 00:53:56,520
their capability of generating a person

1115
00:54:00,440 --> 00:53:58,020
ingredients like driven both ingredients

1116
00:54:02,089 --> 00:54:00,450
are so so much simpler than

1117
00:54:05,870 --> 00:54:02,099
photosynthetic reaction centers one has

1118
00:54:08,690 --> 00:54:05,880
to ask are they in fact more ancestral

1119
00:54:11,359 --> 00:54:08,700
tomorrow did they appear earlier in an

1120
00:54:12,800 --> 00:54:11,369
evolutionary sense and I don't know that

1121
00:54:14,930 --> 00:54:12,810
we have any evidence one way or the

1122
00:54:16,370 --> 00:54:14,940
other for it but it sort of begs the

1123
00:54:19,730 --> 00:54:16,380
simplicity of the rhodopsin begs the

1124
00:54:21,530 --> 00:54:19,740
question did reaction center complex is

1125
00:54:23,510 --> 00:54:21,540
originated from a concatenation of one

1126
00:54:25,760 --> 00:54:23,520
helix proteins with pigment pigment

1127
00:54:29,210 --> 00:54:25,770
binding sites oh that's really one of

1128
00:54:31,430 --> 00:54:29,220
the figures from vin ver mas paper of it

1129
00:54:33,650 --> 00:54:31,440
certainly sounds plausible I I could not

1130
00:54:35,809 --> 00:54:33,660
really address this in detail but if

1131
00:54:40,630 --> 00:54:35,819
anyone bobrick doesn't want to add to

1132
00:54:44,599 --> 00:54:40,640
that expand upon them feel free to do so

1133
00:54:46,819 --> 00:54:44,609
sounds like a sensible thing this is

1134
00:54:50,030 --> 00:54:46,829
just a basic question about environment

1135
00:54:51,770 --> 00:54:50,040
really did oceanic photo zones before

1136
00:54:54,050 --> 00:54:51,780
2.4 in other words before we had an

1137
00:54:55,880 --> 00:54:54,060
oxygen atmosphere provide enough you've

1138
00:54:58,640 --> 00:54:55,890

each yielding to allow proteins nucleic

1139
00:54:59,960 --> 00:54:58,650
acids to avoid UV damage while

1140
00:55:01,730 --> 00:54:59,970
maintaining high in the physical folks

1141
00:55:04,309 --> 00:55:01,740
and maybe you can get around this with

1142
00:55:06,829 --> 00:55:04,319
you know some some pigment uv-absorbing

1143
00:55:09,559 --> 00:55:06,839
pigment things that can protect the

1144
00:55:11,120 --> 00:55:09,569
organism but if you did not have those

1145
00:55:13,160 --> 00:55:11,130
then you would have to be deep enough in

1146
00:55:19,370 --> 00:55:13,170
the ocean in the water column to avoid

1147
00:55:21,349 --> 00:55:19,380
significant UV damage all right origin

1148
00:55:23,329 --> 00:55:21,359
box Janek photosynthesis we're on we're

1149
00:55:25,730 --> 00:55:23,339
almost done yet Rome's down here from

1150
00:55:28,370 --> 00:55:25,740
and oxygen in photosynthesis oxygen

1151
00:55:30,770 --> 00:55:28,380
acromion oxygenic in seems like a

1152
00:55:33,859 --> 00:55:30,780
reasonable assumption that oxygen Hakeem

1153
00:55:35,329 --> 00:55:33,869
after an toxigenic just a few quick

1154
00:55:36,200 --> 00:55:35,339
questions here what was it selective

1155
00:55:38,530 --> 00:55:36,210
pressure for

1156
00:55:40,790 --> 00:55:38,540
meaning two types of reaction centers

1157
00:55:45,010 --> 00:55:40,800
and on service of it it seems like it's

1158
00:55:47,200 --> 00:55:45,020
simply that if you want to use water

1159
00:55:50,120 --> 00:55:47,210
source of electrons you're going to

1160
00:55:52,700 --> 00:55:50,130
union you're covering us fair span of

1161
00:55:54,920 --> 00:55:52,710
energy there so redox potential so you

1162
00:55:58,460 --> 00:55:54,930
you really do need some way to do that

1163
00:56:00,260 --> 00:55:58,470

but maybe that's a 19 point of view and

1164
00:56:03,650 --> 00:56:00,270
there's something some more so reason

1165
00:56:05,480 --> 00:56:03,660
for it oxygen equipment is arise from

1166
00:56:08,570 --> 00:56:05,490
arise from reaction center with a highly

1167
00:56:10,160 --> 00:56:08,580
oxidizing primary dinner other words

1168
00:56:13,579 --> 00:56:10,170
could you get away with just one

1169
00:56:17,990 --> 00:56:13,589
reaction Center have no idea answer that

1170
00:56:19,910 --> 00:56:18,000
is unlikely what driving forces led to

1171
00:56:21,380 --> 00:56:19,920
header dynamic reaction centers and this

1172
00:56:26,450 --> 00:56:21,390
gets back to a bit of our earlier

1173
00:56:28,220 --> 00:56:26,460
discussion oh and how did the that

1174
00:56:31,010 --> 00:56:28,230
sorry that should be though not a he how

1175
00:56:34,820 --> 00:56:31,020
did the oxygen-evolving complex evolved

1176
00:56:36,380 --> 00:56:34,830
of them just asking this question and I

1177
00:56:38,720 --> 00:56:36,390
i do not know anything about the

1178
00:56:41,740 --> 00:56:38,730
oxygen-evolving complex so if anyone

1179
00:56:45,230 --> 00:56:41,750
wants to comment on them please do and

1180
00:56:47,030 --> 00:56:45,240
finally again this is this is very

1181
00:56:48,440 --> 00:56:47,040
interesting question i believe i got it

1182
00:56:50,599 --> 00:56:48,450
from one of Bob's papers are there

1183
00:56:52,339 --> 00:56:50,609
undiscovered types of photosynthesis in

1184
00:56:55,250 --> 00:56:52,349
photosynthetic organisms presence on

1185
00:56:58,730 --> 00:56:55,260
earth today well certainly there were

1186
00:57:00,890 --> 00:56:58,740
some presence once upon a time and we

1187
00:57:02,690 --> 00:57:00,900
have long since lost that information

1188
00:57:04,250 --> 00:57:02,700

but are there are there any around today

1189
00:57:09,170 --> 00:57:04,260
I believe that was the point of the

1190
00:57:11,030 --> 00:57:09,180
question no bob is posing in that paper

1191
00:57:15,800 --> 00:57:11,040
but it certainly an interesting

1192
00:57:19,460 --> 00:57:15,810
possibility okay and I believe that that

1193
00:57:20,900 --> 00:57:19,470
is it we've gone for a full hour which

1194
00:57:27,050 --> 00:57:20,910
is a little longer than these usually go

1195
00:57:30,410 --> 00:57:27,060
for so add about the last point about

1196
00:57:33,200 --> 00:57:30,420
oxygen-evolving complex yeah I'm some

1197
00:57:37,790 --> 00:57:33,210
work from Woody Fisher Caltech is you

1198
00:57:39,380 --> 00:57:37,800
can interpret it in light of the idea

1199
00:57:41,420 --> 00:57:39,390
that you might have used manganese as an

1200
00:57:43,760 --> 00:57:41,430
electron donor like some mortgages still

1201
00:57:46,880 --> 00:57:43,770
use iron two electron donor now yes and

1202
00:57:49,910 --> 00:57:46,890
that may have occurred prior to the to

1203
00:57:52,250 --> 00:57:49,920
the horizon oxygen so you might have

1204
00:57:54,260 --> 00:57:52,260
reaction centers in which they were

1205
00:57:57,559 --> 00:57:54,270
using manganese is an electron just as

1206
00:57:59,329 --> 00:57:57,569
an electron donor and from that you know

1207
00:58:01,910 --> 00:57:59,339
if it became oxidizing enough you could

1208
00:58:03,859 --> 00:58:01,920
have involved an auction evolving

1209
00:58:05,690 --> 00:58:03,869
complex as the manganese the oxidized

1210
00:58:08,240 --> 00:58:05,700
making is bound to the reaction center

1211
00:58:10,730 --> 00:58:08,250
so you can gypsum Allen here at ASU is

1212
00:58:12,950 --> 00:58:10,740
doing some work on mutating purple

1213
00:58:15,470 --> 00:58:12,960

bacterial type 2 reaction centers to to

1214
00:58:19,099 --> 00:58:15,480
bind manganese you can actually see them

1215
00:58:20,059 --> 00:58:19,109
get oxidizing manganese okay that

1216
00:58:22,520 --> 00:58:20,069
they're not forming oxygen-evolving

1217
00:58:24,680 --> 00:58:22,530
complex of course but it's not so

1218
00:58:26,660 --> 00:58:24,690
far-fetched we actually tried to

1219
00:58:28,280 --> 00:58:26,670
determine if there were some modern

1220
00:58:31,400 --> 00:58:28,290
Santa bacteria international environment

1221
00:58:33,170 --> 00:58:31,410
that was oxidizing manganese in a hot

1222
00:58:36,109 --> 00:58:33,180
spring but we didn't really find any

1223
00:58:38,780 --> 00:58:36,119
evidence of that at least in sit you is

1224
00:58:41,870 --> 00:58:38,790
Lindsay work oh no sorry this is Nikki /

1225
00:58:43,970 --> 00:58:41,880
anto okay yep we're could identify yeah

1226
00:58:47,089 --> 00:58:43,980
sorry work with Beth person on that one

1227
00:58:50,059 --> 00:58:47,099
okay and could you say that one more

1228
00:58:51,740 --> 00:58:50,069
time please I oh sorry we were working

1229
00:58:54,829 --> 00:58:51,750
at a hot spring in Yellowstone that has

1230
00:58:59,030 --> 00:58:54,839
very high levels of manganese as well as

1231
00:59:01,700 --> 00:58:59,040
fe 2 and so we were asking you know do

1232
00:59:04,640 --> 00:59:01,710
these Santa bacteria use Fe to directly

1233
00:59:06,650 --> 00:59:04,650
and also do they use manganese and well

1234
00:59:09,289 --> 00:59:06,660
we found evidence that they did use fe 2

1235
00:59:11,569 --> 00:59:09,299
we didn't find any evidence of manganese

1236
00:59:15,410 --> 00:59:11,579
oxidation at least in scituate those

1237
00:59:18,079 --> 00:59:15,420
natural meds did you looked at any

1238
00:59:21,589 --> 00:59:18,089

oxygen excite have had a more of a

1239
00:59:23,720 --> 00:59:21,599
pressure look for electron donors uh

1240
00:59:25,400 --> 00:59:23,730
yeah there's chlorophyll exes and Rosie

1241
00:59:27,380 --> 00:59:25,410
flexus in there as well but they're not

1242
00:59:30,589 --> 00:59:27,390
doing anything you're growing photo

1243
00:59:35,270 --> 00:59:30,599
heterotrophic play usually they are ok

1244
00:59:37,940 --> 00:59:35,280
thanks ok and this is Nikki right yeah

1245
00:59:42,380 --> 00:59:37,950
yeah yes ok I see you I just now noticed

1246
00:59:44,150 --> 00:59:42,390
your comment about the hydraulic

1247
00:59:46,339 --> 00:59:44,160
appropriate pathway for chlorophyll

1248
00:59:49,010 --> 00:59:46,349
excess carbon isotopes about minus 15

1249
00:59:50,690 --> 00:59:49,020
per mil so yeah that is that is about 10

1250
00:59:55,870 --> 00:59:50,700
/ no less than

1251
01:00:02,210 --> 00:59:59,870
all right okay any other questions shall

1252
01:00:03,710 --> 01:00:02,220
we and again I apologize for not having

1253
01:00:04,910 --> 01:00:03,720
I have two cameras sitting here attached

1254
01:00:08,210 --> 01:00:04,920
to my computer and I could not get

1255
01:00:14,839 --> 01:00:08,220
either one working so we just had to do

1256
01:00:19,040 --> 01:00:14,849
this by voice okay if no other questions

1257
01:00:23,420 --> 01:00:19,050
I think we're all set current kids thank

1258
01:00:27,800 --> 01:00:23,430
you very much okay they are very much so

1259
01:00:29,210 --> 01:00:27,810
wrapping up our our series here lindsey

1260
01:00:33,770 --> 01:00:29,220
is going to be sending out an email

1261
01:00:37,160 --> 01:00:33,780
shortly on next steps because we know

1262
01:00:40,010 --> 01:00:37,170
that you will miss us if we didn't so

1263
01:00:41,750 --> 01:00:40,020

expect to hear from the shortly and and

1264
01:00:44,660 --> 01:00:41,760
then we'll be outlining the next steps

1265
01:00:47,240 --> 01:00:44,670
in the process after lap so thank you