
AbSciCon
2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:11,170 --> 00:00:09,180
[Applause]

3
00:00:12,790 --> 00:00:11,180
today I'm going to talk to you guys

4
00:00:16,390 --> 00:00:12,800
about some work I did looking at the

5
00:00:19,600 --> 00:00:16,400
roll iron as a cofactor for the ribosome

6
00:00:23,890 --> 00:00:19,610
in vivo and what that what that means

7
00:00:25,269 --> 00:00:23,900
for the origin of life okay so the

8
00:00:28,810 --> 00:00:25,279
ribosome is very ancient and rare

9
00:00:30,609 --> 00:00:28,820
conserved so much so in fact that it

10
00:00:32,770 --> 00:00:30,619
likely predates the last Universal

11
00:00:34,600 --> 00:00:32,780
common ancestor and even cellular life

12
00:00:36,940 --> 00:00:34,610
itself so we think about the origin of

13
00:00:39,370 --> 00:00:36,950

the ribosome that really sort of puts it

14
00:00:41,500 --> 00:00:39,380
at around four billion years ago here at

15
00:00:44,110 --> 00:00:41,510
the beginning of the Archaean and the

16
00:00:46,840 --> 00:00:44,120
ribosome evolved an environment we're on

17
00:00:49,420 --> 00:00:46,850
an earth where the atmosphere was devoid

18
00:00:52,450 --> 00:00:49,430
of oxygen and because of that you had

19
00:00:54,280 --> 00:00:52,460
abundant stable soluble ferrous iron in

20
00:00:56,320 --> 00:00:54,290
the environments on the early Earth and

21
00:00:58,720 --> 00:00:56,330
not only did the ribosome evolve in this

22
00:01:00,670 --> 00:00:58,730
environment it was encapsulated by cells

23
00:01:02,200 --> 00:01:00,680
and used in early life forms for at

24
00:01:04,689 --> 00:01:02,210
least an additional 1 to 2 billion years

25
00:01:05,859 --> 00:01:04,699
before oxygen started to rise during

26
00:01:09,760 --> 00:01:05,869
what's known as the great oxidation

27
00:01:12,520 --> 00:01:09,770
event and precipitate out this iron so

28
00:01:14,290 --> 00:01:12,530
thinking about why the iron content or

29
00:01:16,090 --> 00:01:14,300
the ferrous iron content of the

30
00:01:17,740 --> 00:01:16,100
environment would be important for the

31
00:01:19,570 --> 00:01:17,750
origin of the ribosome is is clear when

32
00:01:21,160 --> 00:01:19,580
we consider that developmental cations

33
00:01:23,140 --> 00:01:21,170
are absolutely essential to the

34
00:01:24,160 --> 00:01:23,150
structure and function of the ribosome

35
00:01:27,550 --> 00:01:24,170
and actually the whole translation

36
00:01:28,930 --> 00:01:27,560
system and historically magnesium has

37
00:01:31,180 --> 00:01:28,940
really been implicated as the sole

38
00:01:33,700 --> 00:01:31,190

divalent cation in this process however

39
00:01:36,399 --> 00:01:33,710
we've recently shown that iron can

40
00:01:39,310 --> 00:01:36,409
actually near totally replace magnesium

41
00:01:42,039 --> 00:01:39,320
in in the entire translation system and

42
00:01:44,860 --> 00:01:42,049
mediate the translation of functional

43
00:01:46,930 --> 00:01:44,870
protein so in these experiments you can

44
00:01:50,140 --> 00:01:46,940
see that just on in the lower line here

45
00:01:52,600 --> 00:01:50,150
with with iron we very much took the

46
00:01:54,789 --> 00:01:52,610
translation system in and transported it

47
00:01:56,170 --> 00:01:54,799
to the environment of its ancestors and

48
00:01:59,980 --> 00:01:56,180
were able to show that it retains

49
00:02:02,950 --> 00:01:59,990
function in such an environment in vitro

50
00:02:04,719 --> 00:02:02,960
of course and after showing that in

51
00:02:06,640 --> 00:02:04,729
vitro we we then wanted to go and see if

52
00:02:08,949 --> 00:02:06,650
there's anything going on in in vivo

53
00:02:11,080 --> 00:02:08,959
with with iron in the ribosome and more

54
00:02:13,509 --> 00:02:11,090
specifically are there environmental

55
00:02:16,630 --> 00:02:13,519
conditions or growth conditions under

56
00:02:18,430 --> 00:02:16,640
which a bacterial cell we're under you

57
00:02:20,120 --> 00:02:18,440
know sort of canonical normal laboratory

58
00:02:22,450 --> 00:02:20,130
conditions might have most

59
00:02:24,680 --> 00:02:22,460
magnesium associated with its ribosomes

60
00:02:29,060 --> 00:02:24,690
can we impart conditions under which

61
00:02:31,820 --> 00:02:29,070
there are there's it can sort of swap

62
00:02:35,420 --> 00:02:31,830
out either some or all that magnesium in

63
00:02:37,400 --> 00:02:35,430

its ribosomes and so to do that we grew

64
00:02:39,560 --> 00:02:37,410
coli cells under four different growth

65
00:02:42,710 --> 00:02:39,570
conditions we grew them aerobic Li

66
00:02:45,110 --> 00:02:42,720
either in the presence or absence of

67
00:02:47,840 --> 00:02:45,120
added ferrous ion or anaerobically again

68
00:02:49,790 --> 00:02:47,850
in the presence or absence of add added

69
00:02:53,060 --> 00:02:49,800
ferrous iron and in thinking was it was

70
00:02:55,520 --> 00:02:53,070
really this culture that had both no

71
00:02:56,990 --> 00:02:55,530
oxygen because of that allowing for this

72
00:02:59,390 --> 00:02:57,000
ferrous iron high amounts of ferrous

73
00:03:00,410 --> 00:02:59,400
iron to remain stable and solution what

74
00:03:02,770 --> 00:03:00,420
we're going to call our pre great

75
00:03:05,270 --> 00:03:02,780
oxidation event culture pre Joey culture

76
00:03:06,590 --> 00:03:05,280
ribosomes from those cells would we

77
00:03:11,180 --> 00:03:06,600
thought would have the most iron

78
00:03:12,500 --> 00:03:11,190
associated with them so we grew we grew

79
00:03:14,840 --> 00:03:12,510
the cells under those growth conditions

80
00:03:17,000 --> 00:03:14,850
and then in Aleksic chamber to keep

81
00:03:18,920 --> 00:03:17,010
everything nice to know to free I puree

82
00:03:21,410 --> 00:03:18,930
lysis cells purified out the ribosomes

83
00:03:23,060 --> 00:03:21,420
using chromatography based method it

84
00:03:24,770 --> 00:03:23,070
concentrated the ribosomes using ultra

85
00:03:26,420 --> 00:03:24,780
centrifugation and then was able to do

86
00:03:28,250 --> 00:03:26,430
some downstream analysis and so I'll

87
00:03:30,560 --> 00:03:28,260
first look at the iron content analysis

88
00:03:33,410 --> 00:03:30,570

we we measured using a total x-ray

89
00:03:36,080 --> 00:03:33,420
fluorescence spectroscopy and so from

90
00:03:37,790 --> 00:03:36,090
that method we you just get an iron

91
00:03:39,290 --> 00:03:37,800
concentration in in your sample you know

92
00:03:41,360 --> 00:03:39,300
the ribosomal concentration of your

93
00:03:42,830 --> 00:03:41,370
sample and from that we just calculate

94
00:03:44,330 --> 00:03:42,840
an iron per ribosome ratio and that's

95
00:03:47,000 --> 00:03:44,340
what we're showing on the y-axis here

96
00:03:48,500 --> 00:03:47,010
and on the x-axis we have our four

97
00:03:50,030 --> 00:03:48,510
growth conditions so our two aerobic

98
00:03:51,610 --> 00:03:50,040
conditions and then our two anaerobic

99
00:03:54,140 --> 00:03:51,620
conditions and again our pre goe

100
00:03:56,170 --> 00:03:54,150
anaerobic 1 millimolar ferrous chloride

101
00:03:59,570 --> 00:03:56,180
condition and what we can see is that

102
00:04:01,190 --> 00:03:59,580
indeed in the pre juhi conditions we

103
00:04:02,570 --> 00:04:01,200
have significantly more iron associated

104
00:04:03,890 --> 00:04:02,580
with those ribosomes compared to the

105
00:04:06,530 --> 00:04:03,900
other four growth conditions so about

106
00:04:08,750 --> 00:04:06,540
about 10 versus about one for the other

107
00:04:10,400 --> 00:04:08,760
three growth conditions when we looked

108
00:04:13,220 --> 00:04:10,410
at the ribosomal RNAs of these of these

109
00:04:16,400 --> 00:04:13,230
guys so irregardless of growth condition

110
00:04:19,370 --> 00:04:16,410
the 23's of the 16s ribosomal RNA czar

111
00:04:21,320 --> 00:04:19,380
intact and therefore these ribosomes are

112
00:04:23,240 --> 00:04:21,330
also functional in in in in vitro

113
00:04:26,780 --> 00:04:23,250

translation assays regardless of the

114
00:04:28,550 --> 00:04:26,790
iron content or growth condition so then

115
00:04:30,140 --> 00:04:28,560
when we thought sort of more about the

116
00:04:32,030 --> 00:04:30,150
ribosomes and the way we were purifying

117
00:04:33,150 --> 00:04:32,040
them we realized something really

118
00:04:36,030 --> 00:04:33,160
interesting

119
00:04:37,830 --> 00:04:36,040
it if if any of you purified ribosomes

120
00:04:39,930 --> 00:04:37,840
before familiar with this field really

121
00:04:42,240 --> 00:04:39,940
all canonical ribozyme purification

122
00:04:43,860 --> 00:04:42,250
you're just bathing these things in

123
00:04:45,780 --> 00:04:43,870
millimolar amounts of magnesium during

124
00:04:47,280 --> 00:04:45,790
the purification process and and all the

125
00:04:49,320 --> 00:04:47,290
buffers and so what we're thinking

126
00:04:51,210 --> 00:04:49,330
what's happened was happening is that

127
00:04:53,430 --> 00:04:51,220
you know there may be some iron pool

128
00:04:54,990 --> 00:04:53,440
that's associated in vivo that during

129
00:04:56,760 --> 00:04:55,000
the purification process is getting

130
00:04:59,550 --> 00:04:56,770
spontaneously exchanged for with

131
00:05:01,680 --> 00:04:59,560
magnesium from the buffers and what we

132
00:05:03,420 --> 00:05:01,690
might actually be seeing is magnesium's

133
00:05:06,060 --> 00:05:03,430
that are preferentially associated at

134
00:05:08,610 --> 00:05:06,070
least in vitro with magnesium and you

135
00:05:09,570 --> 00:05:08,620
know thinking about if that's happening

136
00:05:11,130 --> 00:05:09,580
well we should be able to do the

137
00:05:13,350 --> 00:05:11,140
opposite we should be able to purify

138
00:05:15,000 --> 00:05:13,360

this stuff and oxic aliy in buffers

139
00:05:19,140 --> 00:05:15,010
containing normal amounts of ferrous

140
00:05:20,400 --> 00:05:19,150
iron and swap in irons and ending up

141
00:05:23,310 --> 00:05:20,410
with with ribosomes that are

142
00:05:25,140 --> 00:05:23,320
preferentially enriched for iron and

143
00:05:26,640 --> 00:05:25,150
that's what we did and so that is the

144
00:05:29,250 --> 00:05:26,650
duct these dots on the top of the graph

145
00:05:30,870 --> 00:05:29,260
here and we can see is that you know

146
00:05:33,810 --> 00:05:30,880
regardless regardless of growth

147
00:05:37,140 --> 00:05:33,820
condition these ribosomes are all able

148
00:05:38,550 --> 00:05:37,150
to soak up about 500 to 600 irons per

149
00:05:41,250 --> 00:05:38,560
ribosome during the purification process

150
00:05:42,630 --> 00:05:41,260
from that buffer and so that was really

151
00:05:45,210 --> 00:05:42,640
interesting and it tells us that there's

152
00:05:47,760 --> 00:05:45,220
a huge capacity at least in vitro for

153
00:05:49,860 --> 00:05:47,770
the ribosome to to associate extensively

154
00:05:51,330 --> 00:05:49,870
with ferrous iron molecules it also

155
00:05:53,370 --> 00:05:51,340
tells us something kind of really cool

156
00:05:55,260 --> 00:05:53,380
about about these data from the ions

157
00:05:56,670 --> 00:05:55,270
that are left over left over if you will

158
00:05:59,070 --> 00:05:56,680
after your purification with magnesium

159
00:06:01,050 --> 00:05:59,080
these are the these are ions basically

160
00:06:03,780 --> 00:06:01,060
we couldn't wash out and sort of suggest

161
00:06:06,150 --> 00:06:03,790
at their sort of binding nature with the

162
00:06:07,830 --> 00:06:06,160
ribosome being either tightly very

163
00:06:10,380 --> 00:06:07,840

tightly associated with the ribosomal

164
00:06:12,060 --> 00:06:10,390
RNA and or tightly that are deeply

165
00:06:15,570 --> 00:06:12,070
buried within the ribosomal structure

166
00:06:17,040 --> 00:06:15,580
and really thinking about the behavior

167
00:06:18,990 --> 00:06:17,050
of these these ions and the fact that

168
00:06:22,130 --> 00:06:19,000
we're seeing around ten sort of also

169
00:06:24,240 --> 00:06:22,140
possibly hints at the the exact

170
00:06:26,100 --> 00:06:24,250
mechanism of association with the

171
00:06:27,930 --> 00:06:26,110
ribosome so Lauren Williams and his

172
00:06:29,580 --> 00:06:27,940
group have previously identified these

173
00:06:31,560 --> 00:06:29,590
these interactions called Dyne nuclear

174
00:06:33,720 --> 00:06:31,570
micro clusters these are interactions

175
00:06:36,210 --> 00:06:33,730
that happen in the ribosome RNA where

176
00:06:38,400 --> 00:06:36,220
you have two divalent cations that are

177
00:06:40,950 --> 00:06:38,410
bridged by a common phosphate oxygen on

178
00:06:43,020 --> 00:06:40,960
the backbone of the ribosomal RNA and so

179
00:06:45,180 --> 00:06:43,030
these divalent cations are very tightly

180
00:06:46,949 --> 00:06:45,190
associated and highly coordinated with

181
00:06:49,499 --> 00:06:46,959
with the fought with phosphate

182
00:06:51,179 --> 00:06:49,509
they're also most of them are very

183
00:06:52,799 --> 00:06:51,189
deeply buried within the ribosomal

184
00:06:54,359 --> 00:06:52,809
structure actually many many of them

185
00:06:56,129 --> 00:06:54,369
being very important for framing the

186
00:06:58,079 --> 00:06:56,139
prep the pebble transfer a center and

187
00:06:59,869 --> 00:06:58,089
then when you go to you know see how

188
00:07:02,129 --> 00:06:59,879

many of these things are in the ribosome

189
00:07:03,959 --> 00:07:02,139
we find that there are four on the large

190
00:07:05,999 --> 00:07:03,969
subunit and one in the small subunit and

191
00:07:07,439 --> 00:07:06,009
there should be two divalent cations in

192
00:07:09,600 --> 00:07:07,449
each of these dining clear micro

193
00:07:12,359 --> 00:07:09,610
clusters and so we would expect around

194
00:07:13,859 --> 00:07:12,369
ten divalent cations to be participating

195
00:07:16,529 --> 00:07:13,869
in these sorts of interactions per

196
00:07:19,499 --> 00:07:16,539
ribosome and in fact we've actually

197
00:07:21,869 --> 00:07:19,509
recently got some support for this this

198
00:07:25,909 --> 00:07:21,879
hypothesis a paper came out showing that

199
00:07:29,279 --> 00:07:25,919
these elisa in vitro the RNA responsible

200
00:07:30,809 --> 00:07:29,289
for making these micro clusters looks

201
00:07:32,939 --> 00:07:30,819
like it can fold in the presence of iron

202
00:07:34,739 --> 00:07:32,949
in vitro and so right now we're sort of

203
00:07:38,249 --> 00:07:34,749
thinking about the the next experiment

204
00:07:42,540 --> 00:07:38,259
or good experiments to do to to to

205
00:07:45,739 --> 00:07:42,550
really see you know a where this iron is

206
00:07:48,929 --> 00:07:45,749
and what its binding to in the ribosome

207
00:07:52,529 --> 00:07:48,939
okay so then we went back and we looked

208
00:07:54,089 --> 00:07:52,539
at the the ribosomal RNA of both the

209
00:07:55,979 --> 00:07:54,099
ribosomes that were purified in

210
00:07:58,829 --> 00:07:55,989
magnesium and compared that to the

211
00:08:01,290 --> 00:07:58,839
ribosomal RNA of the ribosomes that were

212
00:08:02,729 --> 00:08:01,300
purified in iron and so again this is

213
00:08:04,709 --> 00:08:02,739

the gel i already showed you so these

214
00:08:06,149 --> 00:08:04,719
these are the intact ribosomal RNAs of

215
00:08:08,549 --> 00:08:06,159
the of the ribosomes that were purified

216
00:08:10,979 --> 00:08:08,559
in buffers containing magnesium and

217
00:08:13,589 --> 00:08:10,989
these are the ribosomal RNAs of the

218
00:08:14,939 --> 00:08:13,599
buffers purified in the presence of iron

219
00:08:17,339 --> 00:08:14,949
and what you can see here is that these

220
00:08:20,129 --> 00:08:17,349
RNAs really seem to be heavily heavily

221
00:08:21,659 --> 00:08:20,139
degraded right after getting them off

222
00:08:24,509 --> 00:08:21,669
the purification process already have

223
00:08:27,629 --> 00:08:24,519
heavily degraded and you know we really

224
00:08:30,149 --> 00:08:27,639
took a lot of great care to not do not

225
00:08:31,739 --> 00:08:30,159
introduce too much oxygen during this

226
00:08:33,299 --> 00:08:31,749
purification process so it's very

227
00:08:35,069 --> 00:08:33,309
unlikely that it's significant amount of

228
00:08:39,179 --> 00:08:35,079
this cleavage is due to any any sort of

229
00:08:41,490 --> 00:08:39,189
iron mediated oxidative damage and so

230
00:08:42,179 --> 00:08:41,500
thinking about other mechanisms of

231
00:08:43,949 --> 00:08:42,189
cleavage

232
00:08:45,720 --> 00:08:43,959
one of the ones we thought about was

233
00:08:49,230 --> 00:08:45,730
in-line cleavage and so this is a

234
00:08:51,420 --> 00:08:49,240
spontaneous cleavage mechanism of RNA

235
00:08:52,980 --> 00:08:51,430
molecules where you basically get

236
00:08:56,699 --> 00:08:52,990
hydrolysis of the phosphate backbone

237
00:08:59,069 --> 00:08:56,709
this this this cleavage mechanism is

238
00:08:59,580 --> 00:08:59,079

also accelerated by the association of

239
00:09:01,440 --> 00:08:59,590
divalent

240
00:09:04,980 --> 00:09:01,450
cations with the phosphate backbone of

241
00:09:08,190 --> 00:09:04,990
the RNA molecule and actually uh Becca

242
00:09:11,460 --> 00:09:08,200
good-good Metzler I another grad student

243
00:09:14,670 --> 00:09:11,470
in Lauren Williams lab and has just

244
00:09:17,070 --> 00:09:14,680
really recently shown that iron can not

245
00:09:18,690 --> 00:09:17,080
only mediate in line cleavage suggesting

246
00:09:21,330 --> 00:09:18,700
that associates with the the backbone of

247
00:09:22,800 --> 00:09:21,340
the RNA but media added orders of

248
00:09:25,730 --> 00:09:22,810
magnitude higher rate than another

249
00:09:27,780 --> 00:09:25,740
divalent cation like magnesium

250
00:09:30,840 --> 00:09:27,790
essentially essentially basically

251
00:09:33,810 --> 00:09:30,850
showing a new pathway of iron mediated

252
00:09:35,430 --> 00:09:33,820
cleavage of ribosomal RNA which is an

253
00:09:36,990 --> 00:09:35,440
extremely exciting result in its own

254
00:09:39,630 --> 00:09:37,000
right and actually she gave a poster

255
00:09:41,520 --> 00:09:39,640
last night but I think it's still up so

256
00:09:44,550 --> 00:09:41,530
I urge any of you haven't already seen

257
00:09:45,660 --> 00:09:44,560
it to to go and look at it but basically

258
00:09:47,340 --> 00:09:45,670
that's what we think is going on here

259
00:09:49,460 --> 00:09:47,350
during the purification in the in the an

260
00:09:52,110 --> 00:09:49,470
toxic chamber over you know multiple our

261
00:09:53,760 --> 00:09:52,120
purification in a anoxic chamber where

262
00:09:56,790 --> 00:09:53,770
it's difficult to keep things very cold

263
00:09:58,410 --> 00:09:56,800

we think the the iron that is soaking

264
00:10:01,320 --> 00:09:58,420
into those ribosomes from the buffer is

265
00:10:03,630 --> 00:10:01,330
is associating with the ribosomal RNA

266
00:10:07,590 --> 00:10:03,640
and therefore mediating this in-line

267
00:10:10,230 --> 00:10:07,600
cleavage so like I just mentioned in the

268
00:10:11,880 --> 00:10:10,240
early part of the talk growing you coli

269
00:10:13,620 --> 00:10:11,890
under these pre jewy conditions these

270
00:10:16,260 --> 00:10:13,630
these conditions conducive to the

271
00:10:18,240 --> 00:10:16,270
Archaean earth leads to elevated levels

272
00:10:21,060 --> 00:10:18,250
of iron within the ribosomes and the

273
00:10:23,130 --> 00:10:21,070
fact these cells retain this is very

274
00:10:25,680 --> 00:10:23,140
suggestive of iron possibly being you

275
00:10:27,140 --> 00:10:25,690
know at least one in may possibly in

276
00:10:30,540 --> 00:10:27,150
tannin with magnesium and others

277
00:10:32,340 --> 00:10:30,550
divalent cofactors for early translation

278
00:10:34,890 --> 00:10:32,350
and that these ribosomes are intact and

279
00:10:37,140 --> 00:10:34,900
functional the in vivo iron we're seeing

280
00:10:40,560 --> 00:10:37,150
is because it can't be washed out is

281
00:10:42,360 --> 00:10:40,570
likely bound to RNA spots where it's

282
00:10:45,530 --> 00:10:42,370
very tightly associated or deeply buried

283
00:10:47,820 --> 00:10:45,540
like those daniel a micro clusters and

284
00:10:49,980 --> 00:10:47,830
also we're seeing iron associated in

285
00:10:52,020 --> 00:10:49,990
vitro extensively with the ribosomal RNA

286
00:10:53,580 --> 00:10:52,030
and mediate that in ninth cleavage and

287
00:10:55,740 --> 00:10:53,590
so given those two points that that

288
00:10:58,290 --> 00:10:55,750

really suggests that possibly the iron

289
00:10:59,870 --> 00:10:58,300
that we're seeing you know here is very

290
00:11:02,250 --> 00:10:59,880
much a muted signal and that

291
00:11:04,560 --> 00:11:02,260
purification under buffers of magnesium

292
00:11:07,350 --> 00:11:04,570
is is washing out possibly significantly

293
00:11:09,030 --> 00:11:07,360
more in vivo associated iron and so

294
00:11:11,370 --> 00:11:09,040
thinking about you know experiments to

295
00:11:13,140 --> 00:11:11,380
to really get at the the true number of

296
00:11:16,440 --> 00:11:13,150
Virant associated

297
00:11:18,720 --> 00:11:16,450
with the ribosome and with that I just

298
00:11:21,510 --> 00:11:18,730
like to thank my advisor dr. Jen glass

299
00:11:23,730 --> 00:11:21,520
my co advisor dr. Laura Williams

300
00:11:25,410 --> 00:11:23,740
but with members of both labs and NASA

301
00:11:33,000 --> 00:11:25,420
for funding all this and thank you guys

302
00:11:37,800 --> 00:11:33,010
for listening we have time for exactly

303
00:11:45,680 --> 00:11:37,810
do questions okay the ones who anybody

304
00:11:49,980 --> 00:11:47,850
thank you for the nice paper

305
00:11:51,600 --> 00:11:49,990
there's an interesting calculation that

306
00:11:53,790 --> 00:11:51,610
you might want to make I'll just call

307
00:11:56,040 --> 00:11:53,800
this to your attention and that is that

308
00:11:59,310 --> 00:11:56,050
we have a pretty good knowledge of how

309
00:12:02,040 --> 00:11:59,320
much iron ore there is in the Earth's

310
00:12:05,180 --> 00:12:02,050
crust if you dissolve all of that back

311
00:12:08,400 --> 00:12:05,190
into the ocean you only get about five

312
00:12:10,860 --> 00:12:08,410
micromolar iron in the seawater and

313
00:12:13,170 --> 00:12:10,870

right now of course iron has rusted out

314
00:12:15,660 --> 00:12:13,180
and it's way down below it's down the

315
00:12:18,420 --> 00:12:15,670
nano molar range so just keep in mind

316
00:12:20,280 --> 00:12:18,430
that iron might have been very dilute

317
00:12:23,730 --> 00:12:20,290
much more than much less than the

318
00:12:25,110 --> 00:12:23,740
millimolar concentrations yeah yeah yeah

319
00:12:26,520 --> 00:12:25,120
and yeah that's always something that

320
00:12:28,980 --> 00:12:26,530
comes up thinking about sort of the

321
00:12:30,480 --> 00:12:28,990
actual environmental relevance of iron

322
00:12:32,550 --> 00:12:30,490
versus other other dye valence

323
00:12:33,750 --> 00:12:32,560
definitely the the environments on the

324
00:12:35,220 --> 00:12:33,760
earlier earth weren't totally

325
00:12:37,590 --> 00:12:35,230
homogeneous and there could have been

326
00:12:39,510 --> 00:12:37,600
environments where or iron magnesium

327
00:12:42,330 --> 00:12:39,520
could have been possibly competing

328
00:12:43,830 --> 00:12:42,340
levels of concentration yeah I didn't

329
00:12:45,720 --> 00:12:43,840
show this data but even manganese looks

330
00:12:50,190 --> 00:12:45,730
to be able to to to mediate trend

331
00:12:51,960 --> 00:12:50,200
translation function I think really the

332
00:12:54,120 --> 00:12:51,970
most true answer is probably it was some

333
00:12:56,370 --> 00:12:54,130
combination of those three and possibly

334
00:12:58,800 --> 00:12:56,380
even more dive ants especially at the

335
00:13:01,020 --> 00:12:58,810
early origins of the ribosome before you

336
00:13:02,820 --> 00:13:01,030
had other data dedicated systems to go

337
00:13:05,430 --> 00:13:02,830
out and sequester and compartmentalize

338
00:13:06,990 --> 00:13:05,440

and concentrate one divalent over

339
00:13:08,580 --> 00:13:07,000
another but yeah I think it's always

340
00:13:10,650 --> 00:13:08,590
important to very much keep the

341
00:13:12,750 --> 00:13:10,660
environmental relevance of all these

342
00:13:15,000 --> 00:13:12,760
things in mind thank you yeah two

343
00:13:17,040 --> 00:13:15,010
question you showed a plot of the goe in

344
00:13:18,960 --> 00:13:17,050
the higher availability of ferrous iron

345
00:13:21,060 --> 00:13:18,970
ore before the goe what was the

346
00:13:23,190 --> 00:13:21,070
availability it does magnesium available

347
00:13:23,460 --> 00:13:23,200
yeah that's one quick the other question

348
00:13:25,770 --> 00:13:23,470
is

349
00:13:27,960 --> 00:13:25,780
have you looked at anaerobic iron-rich

350
00:13:30,000 --> 00:13:27,970
conditions today for bacteria that lived

351
00:13:32,340 --> 00:13:30,010
there to see if they have two irons in

352
00:13:33,690 --> 00:13:32,350
these dot in these places yeah so I'll

353
00:13:36,840 --> 00:13:33,700
cover the first question first and that

354
00:13:38,520 --> 00:13:36,850
goes back to the previous answer it

355
00:13:39,840 --> 00:13:38,530
part of it was definitely sort of where

356
00:13:41,880 --> 00:13:39,850
you were on the earth of the time

357
00:13:43,500 --> 00:13:41,890
magnesium was definitely lower due to

358
00:13:44,700 --> 00:13:43,510
the increased hydrothermal activity of

359
00:13:45,780 --> 00:13:44,710
the earth especially because

360
00:13:49,020 --> 00:13:45,790
hydrothermal activity actually

361
00:13:52,260 --> 00:13:49,030
sequester's magnesium in crustal

362
00:13:54,420 --> 00:13:52,270
minerals so definitely more towards the

363
00:13:56,700 --> 00:13:54,430

ocean and the closer you got to any type

364
00:13:58,620 --> 00:13:56,710
of hydrothermal activity actually your

365
00:14:00,270 --> 00:13:58,630
ratio of iron to magnesium would

366
00:14:01,950 --> 00:14:00,280
increase drastically but overall

367
00:14:04,160 --> 00:14:01,960
magnesium was what's probably lower than

368
00:14:06,720 --> 00:14:04,170
it significant lower than it is today

369
00:14:10,110 --> 00:14:06,730
and then part of the second question is

370
00:14:12,270 --> 00:14:10,120
yeah that's sort of that's sort of the

371
00:14:13,710 --> 00:14:12,280
logical as I see the logical next step

372
00:14:15,930 --> 00:14:13,720
of all this but really the biggest

373
00:14:17,760 --> 00:14:15,940
barrier to that is just that nothing

374
00:14:19,620 --> 00:14:17,770
really grows that well that's it that's

375
00:14:22,890 --> 00:14:19,630
an anaerobic now look at anaerobe

376
00:14:25,200 --> 00:14:22,900
possibly to to the the Odie's that you

377
00:14:27,510 --> 00:14:25,210
can get e.coli and just this purifies so

378
00:14:28,890 --> 00:14:27,520
I definitely think it's possible and I

379
00:14:30,360 --> 00:14:28,900
think it's an experiment that needs to

380
00:14:32,640 --> 00:14:30,370
be done because you can think about

381
00:14:34,800 --> 00:14:32,650
obligate anaerobes that possibly haven't

382
00:14:36,480 --> 00:14:34,810
seen oxygen for millions of years or

383
00:14:38,730 --> 00:14:36,490
possibly never in their in their

384
00:14:42,410 --> 00:14:38,740
evolutionary history and and postulate

385
00:14:45,000 --> 00:14:42,420
about you know not not only the

386
00:14:47,370 --> 00:14:45,010
biochemistry of iron versus magnesium

387
00:14:48,990 --> 00:14:47,380
the translation system but but possibly

388
00:14:51,030 --> 00:14:49,000

they don't use magnesium for anything if

389
00:14:52,200 --> 00:14:51,040
if they're in an iron abundant

390
00:14:55,440 --> 00:14:52,210
environment don't have to worry about

391
00:14:56,520 --> 00:14:55,450
oxygen oxidative immediate toxicity but

392
00:14:59,220 --> 00:14:56,530
I think there's a lot of method

393
00:15:01,620 --> 00:14:59,230
methodological challenges to that that

394
00:15:03,270 --> 00:15:01,630
finding that out I have I don't know

395
00:15:07,260 --> 00:15:03,280
billion questions to ask but later or