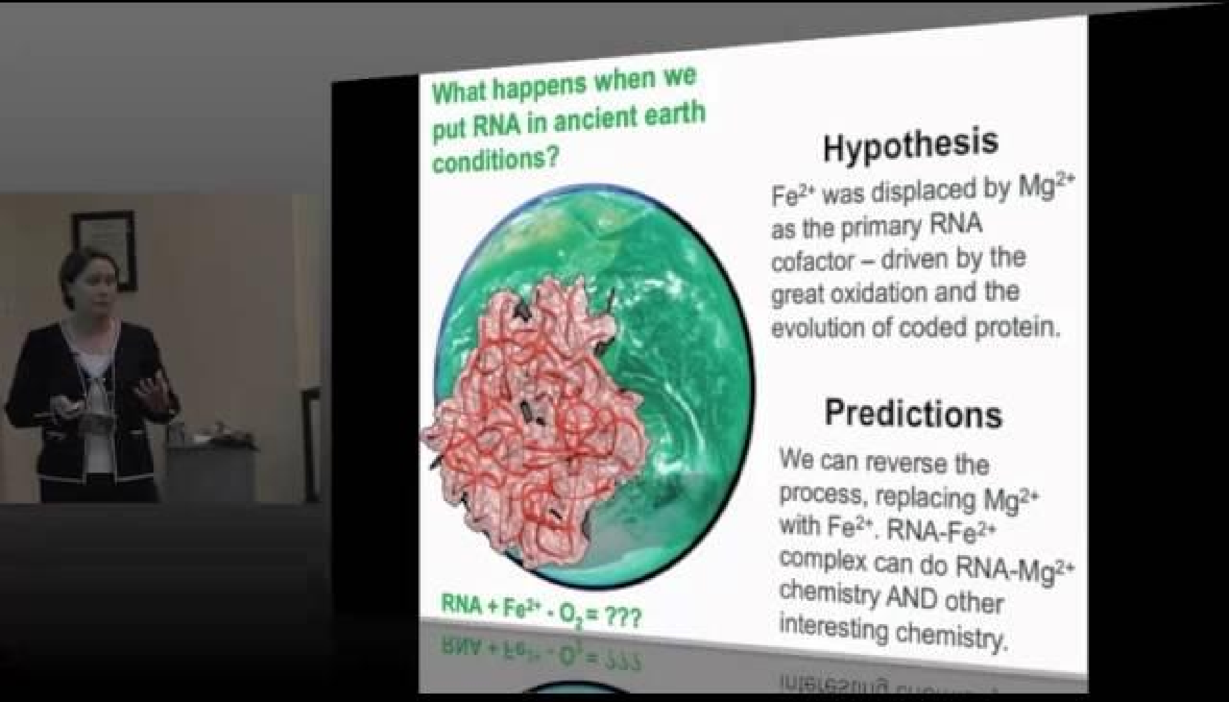
What happens when we put RNA in ancient earth conditions?
RNA + Fe2+ - O2 = ???
Hypothesis
Fe2+ was displaced by Mg2+ as the primary RNA cofactor – driven by the great oxidation and the evolution of coded protein.
Predictions
We can reverse the process, replacing Mg2+ with Fe2+. RNA-Fe2+ complex can do RNA-Mg2+ chemistry AND other interesting chemistry.

1
00:00:10,400 --> 00:00:08,540
okay guys first first thing I want to

2
00:00:13,340 --> 00:00:10,410
make a very large disclaimer that I have

3
00:00:15,290 --> 00:00:13,350
no knowledge of geology whatsoever I'm

4
00:00:17,630 --> 00:00:15,300
not sure why I'm in this session but I'm

5
00:00:19,040 --> 00:00:17,640
assuming it's appropriate and I would

6
00:00:21,620 --> 00:00:19,050
like to request exemption from any

7
00:00:25,010 --> 00:00:21,630
questions regarding Jamie's claims about

8
00:00:26,560 --> 00:00:25,020
iron and having nothing to ferric to

9
00:00:32,120 --> 00:00:26,570
ferrous having nothing to do with

10
00:00:34,490 --> 00:00:32,130
oxidation in the atmosphere okay so what

11
00:00:37,430 --> 00:00:34,500
I wanted to do is to talk about the iron

12
00:00:41,240 --> 00:00:37,440
the soluble form fe 2 plus and its role

13
00:00:43,580 --> 00:00:41,250

of biochemistry and early Earth so if we

14
00:00:45,740 --> 00:00:43,590
look at the history of biology not

15
00:00:48,650 --> 00:00:45,750
geology history of biology as you see

16
00:00:50,390 --> 00:00:48,660
here we see this large tree of life the

17
00:00:52,280 --> 00:00:50,400
tree of life in modern times is

18
00:00:54,560 --> 00:00:52,290
represented by three domains bacteria

19
00:00:57,050 --> 00:00:54,570
archaea and you carry a so if we walk

20
00:00:58,850 --> 00:00:57,060
back in time along that tree of life we

21
00:01:00,590 --> 00:00:58,860
get to what we call Luca last Universal

22
00:01:02,960 --> 00:01:00,600
common ancestor we've all heard of that

23
00:01:06,200 --> 00:01:02,970
by this point which we estimate roughly

24
00:01:08,330 --> 00:01:06,210
is about 3.9 billion years ago if we go

25
00:01:10,910 --> 00:01:08,340
farther back in time we get into this

26
00:01:12,830 --> 00:01:10,920
the squiggly line and the squiggle enos

27
00:01:14,809 --> 00:01:12,840
of this line all that means is that we

28
00:01:16,429 --> 00:01:14,819
are likely to have observed a lot of

29
00:01:18,889 --> 00:01:16,439
horizontal gene transfer during that

30
00:01:21,080 --> 00:01:18,899
time so even though last Universal

31
00:01:22,819 --> 00:01:21,090
common ancestor singular most likely

32
00:01:24,800 --> 00:01:22,829
it's a composite of multiple types of

33
00:01:26,870 --> 00:01:24,810
organisms and what we're really dealing

34
00:01:30,260 --> 00:01:26,880
with this far back in time is more like

35
00:01:32,989 --> 00:01:30,270
a soup or sea of different life-forms so

36
00:01:35,840 --> 00:01:32,999
what I want to talk about is this point

37
00:01:37,999 --> 00:01:35,850
of the RNA world hypothesis essentially

38
00:01:40,699 --> 00:01:38,009

in which we theorize there's some kind

39
00:01:43,370 --> 00:01:40,709
of primitive catalysis and maybe some

40
00:01:46,160 --> 00:01:43,380
metal assisted assembly back in that RNA

41
00:01:48,379 --> 00:01:46,170
world so the RNA world hypothesis

42
00:01:51,050 --> 00:01:48,389
essentially states that before modern

43
00:01:53,300 --> 00:01:51,060
biology which is DNA RNA and proteins of

44
00:01:55,249 --> 00:01:53,310
our modern times we have something

45
00:01:57,559 --> 00:01:55,259
called the RNA world in which RNA

46
00:02:00,019 --> 00:01:57,569
perform the roles of genetic storage and

47
00:02:02,749 --> 00:02:00,029
catalysis essentially all the functions

48
00:02:05,510 --> 00:02:02,759
that protein DNA and RNA do together

49
00:02:08,059 --> 00:02:05,520
today and this world is hypothesized to

50
00:02:12,040 --> 00:02:08,069
have occurred back in the early rkm yawn

51
00:02:15,050 --> 00:02:12,050
about 3.8 billion years ago very roughly

52
00:02:17,030 --> 00:02:15,060
so what do we know about modern RNA well

53
00:02:19,070 --> 00:02:17,040
one thing that we study a lot in our lab

54
00:02:19,490 --> 00:02:19,080
Lauren Williams lab at Georgia Tech is

55
00:02:21,920 --> 00:02:19,500
the relation

56
00:02:25,340 --> 00:02:21,930
between RNA and divalent cations

57
00:02:26,990 --> 00:02:25,350
especially magnesium so we know that our

58
00:02:29,180 --> 00:02:27,000
name magnesium have a very special

59
00:02:31,550 --> 00:02:29,190
relationship and it has to do with this

60
00:02:34,010 --> 00:02:31,560
magnesium being a divalent cation having

61
00:02:38,660 --> 00:02:34,020
two charges and really enjoying the

62
00:02:41,660 --> 00:02:38,670
opportunity whoops what did I do okay

63
00:02:43,580 --> 00:02:41,670

sorry I'm really liking to bond with

64
00:02:45,350 --> 00:02:43,590
those phosphates that form the DNA

65
00:02:50,120 --> 00:02:45,360
backbone of the RNA background in this

66
00:02:52,610 --> 00:02:50,130
case oops I did it again sorry about

67
00:02:54,740 --> 00:02:52,620
that and we know that I that magnesium

68
00:02:57,260 --> 00:02:54,750
also has very special role in the

69
00:02:59,690 --> 00:02:57,270
folding of large RNAs so there are

70
00:03:01,520 --> 00:02:59,700
certain if you have an RNA that's three

71
00:03:02,960 --> 00:03:01,530
thousand bases long such as what you see

72
00:03:05,300 --> 00:03:02,970
in the ribosome there are certain

73
00:03:07,010 --> 00:03:05,310
conformational spaces or certain

74
00:03:09,530 --> 00:03:07,020
three-dimensional shapes that that RNA

75
00:03:11,720 --> 00:03:09,540
cannot reach without the presence of

76
00:03:15,740 --> 00:03:11,730
magnesium in solution just because of

77
00:03:17,630 --> 00:03:15,750
its size and its charge density so we

78
00:03:20,990 --> 00:03:17,640
see this kind of special relationship in

79
00:03:22,850 --> 00:03:21,000
key lated magnesium motifs like those

80
00:03:25,789 --> 00:03:22,860
found in the ribosome believe there are

81
00:03:28,400 --> 00:03:25,799
23 of these magnesium chelation sites in

82
00:03:31,850 --> 00:03:28,410
the 23s ribosomal RNA we'll talk about

83
00:03:33,070 --> 00:03:31,860
biology more tomorrow but just know the

84
00:03:36,530 --> 00:03:33,080
ribosome is the thing that makes

85
00:03:38,750 --> 00:03:36,540
messenger RNA into proteins and all

86
00:03:41,300 --> 00:03:38,760
cells present in all cells completely

87
00:03:43,820 --> 00:03:41,310
ubiquitous but we see these on chelation

88
00:03:46,310 --> 00:03:43,830

complexes where we have two magnesium

89
00:03:48,050 --> 00:03:46,320
and we have multiple phosphates these

90
00:03:50,240 --> 00:03:48,060
are the phosphates on the back room

91
00:03:52,400 --> 00:03:50,250
interacting with the positive charge

92
00:03:54,680 --> 00:03:52,410
from the magnesium and then if we

93
00:03:56,960 --> 00:03:54,690
superimpose ribosomes from across the

94
00:03:59,449 --> 00:03:56,970
phylogenetic tree of modern life what we

95
00:04:02,150 --> 00:03:59,459
see is that these chelation complexes

96
00:04:04,670 --> 00:04:02,160
this geometry is conserved among all of

97
00:04:10,310 --> 00:04:04,680
life especially if the center of the

98
00:04:12,140 --> 00:04:10,320
ribosome from we're going to get the

99
00:04:16,090 --> 00:04:12,150
prize for them good slide changing this

100
00:04:18,860 --> 00:04:16,100
time so one thing we've done we have a

101
00:04:22,130 --> 00:04:18,870
research scientist in our lab and named

102
00:04:24,860 --> 00:04:22,140
Anton Petrov he's a quantum physicist

103
00:04:26,870 --> 00:04:24,870
and so he's looked at in silico meaning

104
00:04:28,850 --> 00:04:26,880
on computer in mathematical space the

105
00:04:31,730 --> 00:04:28,860
relationship between magnesium and RNA

106
00:04:34,490 --> 00:04:31,740
you see here calcium and are

107
00:04:37,010 --> 00:04:34,500
a its sodium and RNA trying to identify

108
00:04:40,159 --> 00:04:37,020
what is so special about magnesium that

109
00:04:41,689 --> 00:04:40,169
these other cations don't have and so

110
00:04:43,430 --> 00:04:41,699
what you can see in these quantum

111
00:04:45,260 --> 00:04:43,440
mechanical calculations in mathematical

112
00:04:48,050 --> 00:04:45,270
space is that the interaction energy

113
00:04:49,279 --> 00:04:48,060

between RNA and magnesium the

114
00:04:50,990 --> 00:04:49,289
interaction energy between those

115
00:04:53,689 --> 00:04:51,000
backbone phosphates and magnesium is

116
00:04:55,400 --> 00:04:53,699
much more spontaneous so interaction

117
00:04:57,650 --> 00:04:55,410
energies with very large negative number

118
00:04:59,900 --> 00:04:57,660
or more spontaneous we don't have to

119
00:05:02,719 --> 00:04:59,910
adding energy to them in order to the

120
00:05:04,700 --> 00:05:02,729
fore in order to form that structure but

121
00:05:07,580 --> 00:05:04,710
if we look at calcium or sodium we have

122
00:05:09,620 --> 00:05:07,590
a much lower negative number in the case

123
00:05:11,570 --> 00:05:09,630
of calcium or a positive number in the

124
00:05:13,909 --> 00:05:11,580
case of sodium indicating we need to add

125
00:05:17,300 --> 00:05:13,919
some energy to pour that structure to

126
00:05:18,890 --> 00:05:17,310
form now what we are interested in

127
00:05:20,899 --> 00:05:18,900
looking at is whether some other cations

128
00:05:22,939 --> 00:05:20,909
can play the role of magnesium and we

129
00:05:24,589 --> 00:05:22,949
thought we found one we're pretty sure

130
00:05:26,809 --> 00:05:24,599
we found one at this point so if we look

131
00:05:28,790 --> 00:05:26,819
at iron we put iron in place with

132
00:05:30,950 --> 00:05:28,800
magnesium in the same in the same

133
00:05:34,370 --> 00:05:30,960
mathematical space and then we minimized

134
00:05:37,370 --> 00:05:34,380
structure what we get is the same

135
00:05:39,860 --> 00:05:37,380
geometry in the backbone of the RNA with

136
00:05:41,810 --> 00:05:39,870
iron as we do with magnesium we believe

137
00:05:43,670 --> 00:05:41,820
that's because the charge density and

138
00:05:45,830 --> 00:05:43,680

the size of iron is so similar to

139
00:05:48,290 --> 00:05:45,840
magnesium much more similar than any

140
00:05:50,300 --> 00:05:48,300
other cation that we have biologically

141
00:05:52,550 --> 00:05:50,310
available and in the case of iron

142
00:05:55,249 --> 00:05:52,560
actually the interaction energy is a

143
00:05:56,959 --> 00:05:55,259
little bit more negative so the complex

144
00:06:01,909 --> 00:05:56,969
formation that's a little bit better

145
00:06:03,110 --> 00:06:01,919
with iron than with magnesium so based

146
00:06:04,820 --> 00:06:03,120
on this information what we've

147
00:06:07,100 --> 00:06:04,830
hypothesized is the back in the days

148
00:06:08,510 --> 00:06:07,110
when the earth was very unops Akande i

149
00:06:10,370 --> 00:06:08,520
don't think i have to go much into this

150
00:06:13,990 --> 00:06:10,380
at this point i've had a very good

151
00:06:15,950 --> 00:06:14,000
overview today so before protosynth

152
00:06:18,230 --> 00:06:15,960
photosynthesis and the great oxidation

153
00:06:21,320 --> 00:06:18,240
what we had as we've already heard is

154
00:06:23,899 --> 00:06:21,330
that the iron in the ocean be

155
00:06:26,659 --> 00:06:23,909
biologically available to plus form is

156
00:06:28,279 --> 00:06:26,669
probably much greater in concentrations

157
00:06:29,839 --> 00:06:28,289
than it is today and would have been

158
00:06:32,740 --> 00:06:29,849
much more biologically available I

159
00:06:36,140 --> 00:06:32,750
didn't want to mention that iron

160
00:06:38,180 --> 00:06:36,150
two-plus in the presence of oxygen gives

161
00:06:43,070 --> 00:06:38,190
rise to Fintan chemistry which can be

162
00:06:45,290 --> 00:06:43,080
toxic to to biology that's I did also

163
00:06:45,500 --> 00:06:45,300

want to show the banded iron formation

164
00:06:47,720 --> 00:06:45,510
that

165
00:06:49,640 --> 00:06:47,730
you've already seen so the theory is

166
00:06:51,530 --> 00:06:49,650
that it's oxygen increased in the

167
00:06:54,140 --> 00:06:51,540
atmosphere we have the interaction with

168
00:06:56,090 --> 00:06:54,150
the surface oceans and the iron

169
00:06:57,770 --> 00:06:56,100
precipitated out and form these banded

170
00:06:59,720 --> 00:06:57,780
iron formations and this one I believe

171
00:07:03,230 --> 00:06:59,730
is in Minnesota courtesy of Clark

172
00:07:05,030 --> 00:07:03,240
Johnson so our hypothesis is that iron

173
00:07:07,880 --> 00:07:05,040
back in the days when the earth was an

174
00:07:09,920 --> 00:07:07,890
optic actually played the role in RNA

175
00:07:13,010 --> 00:07:09,930
and played the role in life that

176
00:07:15,230 --> 00:07:13,020
magnesium plays today so we wondered

177
00:07:17,090 --> 00:07:15,240
whether we could recreate these early

178
00:07:20,090 --> 00:07:17,100
earth conditions remove the magnesium

179
00:07:22,220 --> 00:07:20,100
remove the oxygen so that the iron would

180
00:07:25,640 --> 00:07:22,230
not eat up the RNA and see if we could

181
00:07:27,950 --> 00:07:25,650
find some kind of activity see if RNA

182
00:07:30,590 --> 00:07:27,960
would do something interesting in the

183
00:07:34,430 --> 00:07:30,600
presence of iron so one of the first

184
00:07:37,510 --> 00:07:34,440
things we did is evaluate like I said

185
00:07:40,900 --> 00:07:37,520
before magnesium is required for RNA to

186
00:07:43,760 --> 00:07:40,910
generate certain conformational States

187
00:07:45,560 --> 00:07:43,770
we wanted to see if iron in the presence

188
00:07:47,510 --> 00:07:45,570

of iron the same conformational states

189
00:07:49,490 --> 00:07:47,520
of RNA could be reached so if you look

190
00:07:52,070 --> 00:07:49,500
here along the x-axis this is

191
00:07:53,870 --> 00:07:52,080
essentially if you imagine this the five

192
00:07:56,270 --> 00:07:53,880
prime end of an RNA to the beginning of

193
00:07:57,860 --> 00:07:56,280
one strand of a molecule and you follow

194
00:08:00,170 --> 00:07:57,870
this along this would be the end of the

195
00:08:02,440 --> 00:08:00,180
Strand of the molecule and along the

196
00:08:05,000 --> 00:08:02,450
y-axis we have essentially the

197
00:08:06,800 --> 00:08:05,010
vulnerability of that molecule to some

198
00:08:10,460 --> 00:08:06,810
kind of external chemical modifying

199
00:08:12,890 --> 00:08:10,470
agent so along this chart along this

200
00:08:15,500 --> 00:08:12,900
graph the higher the peak the more

201
00:08:19,130 --> 00:08:15,510
vulnerable the RNA at that position in

202
00:08:21,740 --> 00:08:19,140
the molecule so if we look at the RNA

203
00:08:23,810 --> 00:08:21,750
and with sodium only we see one

204
00:08:26,330 --> 00:08:23,820
particular pattern of vulnerability

205
00:08:28,040 --> 00:08:26,340
along the bala Kuehl if we add magnesium

206
00:08:31,280 --> 00:08:28,050
we've changed the conformational state

207
00:08:33,409 --> 00:08:31,290
of RNA and we see a different pattern

208
00:08:37,730 --> 00:08:33,419
iron we see almost exactly the same

209
00:08:39,020 --> 00:08:37,740
pattern which is very interesting what

210
00:08:42,200 --> 00:08:39,030
we'd expect based on the in silico

211
00:08:45,290 --> 00:08:42,210
results right so if we look at a

212
00:08:46,790 --> 00:08:45,300
different kinds of enzymatic reaction we

213
00:08:48,140 --> 00:08:46,800

haven't talked about this yet but we

214
00:08:51,140 --> 00:08:48,150
will tomorrow morning ribozymes

215
00:08:54,470 --> 00:08:51,150
ribosomes are like machines like enzymes

216
00:08:56,060 --> 00:08:54,480
like protein machines in this case made

217
00:08:58,820 --> 00:08:56,070
of RNA that can do interesting things

218
00:09:01,280 --> 00:08:58,830
like like eight strands of our

219
00:09:04,300 --> 00:09:01,290
so they can reconnect two strands

220
00:09:07,250 --> 00:09:04,310
together to make one continuous backbone

221
00:09:10,550 --> 00:09:07,260
so what we see in this reaction if we

222
00:09:13,430 --> 00:09:10,560
test the ribozyme with iron in the

223
00:09:17,780 --> 00:09:13,440
absence of oxygen and we subject that to

224
00:09:19,820 --> 00:09:17,790
time what we see is that we get ligation

225
00:09:22,250 --> 00:09:19,830
product with magnesium which is well

226
00:09:23,810 --> 00:09:22,260
documented in the literature but in the

227
00:09:25,700 --> 00:09:23,820
absence of magnesium but the presence of

228
00:09:30,830 --> 00:09:25,710
iron we get a whole lot more like a shin

229
00:09:34,850 --> 00:09:30,840
product which is very cool we can take

230
00:09:38,000 --> 00:09:34,860
also take a ribozyme that does RNA

231
00:09:41,180 --> 00:09:38,010
backbone cleavage so it's separating the

232
00:09:44,000 --> 00:09:41,190
RNA backbone and over time look at the

233
00:09:46,130 --> 00:09:44,010
fraction of cleavage product we see that

234
00:09:50,810 --> 00:09:46,140
in the presence of magnesium the

235
00:09:52,790 --> 00:09:50,820
ribozyme cleaves in the presence of iron

236
00:09:55,640 --> 00:09:52,800
only we get a whole lot more cleavage

237
00:09:59,240 --> 00:09:55,650
project product so overall what this is

238
00:10:00,800 --> 00:09:59,250

telling us is that RNA catalytic RNA can

239
00:10:02,810 --> 00:10:00,810
be much more efficient in the presence

240
00:10:05,570 --> 00:10:02,820
of iron than they can be in magnesium as

241
00:10:07,610 --> 00:10:05,580
long as oxygen is absent as long as

242
00:10:11,630 --> 00:10:07,620
we're recapitulating those early earth

243
00:10:13,850 --> 00:10:11,640
conditions so the very last and most

244
00:10:16,280 --> 00:10:13,860
recent experiment that we performed this

245
00:10:18,380 --> 00:10:16,290
one's done by cha longshaw of our group

246
00:10:20,570 --> 00:10:18,390
please check this out this is a very

247
00:10:23,330 --> 00:10:20,580
very cool paper it was just accepted in

248
00:10:24,860 --> 00:10:23,340
nature chemistry so what we what cha

249
00:10:26,690 --> 00:10:24,870
long did is he took a colourless

250
00:10:33,020 --> 00:10:26,700
solution this is tetramethyl benzidine

251
00:10:35,390 --> 00:10:33,030
okay thank you this is a this is

252
00:10:37,310 --> 00:10:35,400
essentially a color eight indicator so

253
00:10:40,490 --> 00:10:37,320
if this tetramethyl benzidine is

254
00:10:42,260 --> 00:10:40,500
oxidized it's going to turn blue very

255
00:10:44,810 --> 00:10:42,270
simple so we take tetramethyl been

256
00:10:48,920 --> 00:10:44,820
setting which is here hydrogen peroxide

257
00:10:50,690 --> 00:10:48,930
which is here here put in the RNA put in

258
00:10:52,880 --> 00:10:50,700
the iron remove the oxygen but not

259
00:10:54,830 --> 00:10:52,890
necessarily in that order and we can

260
00:10:56,380 --> 00:10:54,840
monitor the rate of change of the color

261
00:10:59,260 --> 00:10:56,390
of the solution using a simple

262
00:11:03,470 --> 00:10:59,270
spectrophotometer very simple technique

263
00:11:06,139 --> 00:11:03,480

so we did this or chalam did this not me

264
00:11:08,150 --> 00:11:06,149
so if we monitor this over time 20

265
00:11:12,740 --> 00:11:08,160
minutes here's our solutions 6 micro

266
00:11:14,569 --> 00:11:12,750
molar iron hydrogen peroxide minus this

267
00:11:17,090 --> 00:11:14,579
is supposed to say 02 we can't have

268
00:11:18,889 --> 00:11:17,100
oxygen s reaction if we have no RNA in

269
00:11:23,960 --> 00:11:18,899
the solution we have no color change we

270
00:11:26,569 --> 00:11:23,970
have no electron transfer we add ATP 3

271
00:11:28,160 --> 00:11:26,579
closely spaced phosphate groups which we

272
00:11:33,790 --> 00:11:28,170
would expect to interact with the iron

273
00:11:37,340 --> 00:11:33,800
right we still see no electron transfer

274
00:11:38,960 --> 00:11:37,350
we add single-stranded RNA oligomer no

275
00:11:40,490 --> 00:11:38,970
electron transfer we get electron

276
00:11:41,960 --> 00:11:40,500
transfer we're expecting an increase in

277
00:11:44,710 --> 00:11:41,970
the blue color right which is going to

278
00:11:51,530 --> 00:11:44,720
increase this way double-stranded DNA

279
00:11:54,250 --> 00:11:51,540
nothing large viral genome nothing 23 s

280
00:12:00,110 --> 00:11:54,260
ribosomal RNA from thermus thermophilus

281
00:12:02,210 --> 00:12:00,120
voila we have electron transfer p for p

282
00:12:06,079 --> 00:12:02,220
suit 6 domain RNA which is a

283
00:12:10,610 --> 00:12:06,089
well-characterized RNA small RNA we also

284
00:12:12,259 --> 00:12:10,620
have electron transfer and trna also

285
00:12:15,319 --> 00:12:12,269
very well characterized electron

286
00:12:20,990 --> 00:12:15,329
transfer very cool we should be jumping

287
00:12:22,850 --> 00:12:21,000
up and down right now eh along so what

288
00:12:24,800 --> 00:12:22,860

is common among those three RNAs that

289
00:12:27,350 --> 00:12:24,810
the other the other single-stranded RNA

290
00:12:29,300 --> 00:12:27,360
the double-stranded DNA that showed no

291
00:12:31,340 --> 00:12:29,310
reaction whoa what is so special about

292
00:12:32,840 --> 00:12:31,350
this well one thing we know from looking

293
00:12:35,449 --> 00:12:32,850
at three dimensional crystal structures

294
00:12:38,900 --> 00:12:35,459
is that we have these special magnesium

295
00:12:41,180 --> 00:12:38,910
phosphate geometries going on here mag

296
00:12:43,400 --> 00:12:41,190
tRNA is probably the exception to that I

297
00:12:45,139 --> 00:12:43,410
don't know that one one of the magnesium

298
00:12:47,990 --> 00:12:45,149
phosphate backbone geometries has been

299
00:12:52,610 --> 00:12:48,000
observed in TNA tRNA but we do know that

300
00:12:56,629 --> 00:12:52,620
magnesium is very important to tRNA this

301
00:12:58,309 --> 00:12:56,639
reaction also has the same kinetics as

302
00:13:00,800 --> 00:12:58,319
what we call the michelis minton

303
00:13:03,579 --> 00:13:00,810
formalism so it can essentially complies

304
00:13:06,439 --> 00:13:03,589
with the traditional test for an enzyme

305
00:13:08,509 --> 00:13:06,449
which is cool means it saturates itself

306
00:13:10,490 --> 00:13:08,519
so if we limit the enzyme we have plenty

307
00:13:13,009 --> 00:13:10,500
of substrate at some point we're going

308
00:13:14,720 --> 00:13:13,019
to have so much substrate that we're not

309
00:13:16,050 --> 00:13:14,730
going to get any more catalysis per unit

310
00:13:18,450 --> 00:13:16,060
of substrate at it

311
00:13:21,180 --> 00:13:18,460
so conclusions the critical role of

312
00:13:23,130 --> 00:13:21,190
magnesium in RNA if we put it into a

313
00:13:25,500 --> 00:13:23,140

hypothesized early Earth's environment

314
00:13:28,050 --> 00:13:25,510
in the absence of oxygen can be better

315
00:13:31,170 --> 00:13:28,060
served by iron the relationship with

316
00:13:34,530 --> 00:13:31,180
iron and RNA provides a very needed link

317
00:13:37,560 --> 00:13:34,540
between the RNA world and the geologic

318
00:13:41,130 --> 00:13:37,570
record and that RNA may have originally

319
00:13:42,780 --> 00:13:41,140
served the soul roll them sorry iron may

320
00:13:45,210 --> 00:13:42,790
have originally served the made the

321
00:13:47,280 --> 00:13:45,220
predominant role in the early life and

322
00:13:51,210 --> 00:13:47,290
that was later replaced by the oxidation

323
00:13:54,300 --> 00:13:51,220
and that this new RNA world RNA with

324
00:13:55,560 --> 00:13:54,310
iron opens up a new realm of catalytic

325
00:13:58,530 --> 00:13:55,570
functions that have not been previously

326
00:14:01,080 --> 00:13:58,540
characterized I wanted to thank the real

327
00:14:03,800 --> 00:14:01,090
brains behind this not me shillong Shaw

328
00:14:07,010 --> 00:14:03,810
Anton Petrov dr. shreyas Denise Okafor

329
00:14:10,380 --> 00:14:07,020
graduate student and of course our

330
00:14:12,390 --> 00:14:10,390
wonderful p I Lauren Williams is always

331
00:14:14,340 --> 00:14:12,400
there for us as well as Steve Harvey

332
00:14:16,410 --> 00:14:14,350
Nick HUD dr. worked out and many others

333
00:14:22,610 --> 00:14:16,420
of our lab and this is our lab Lauren

334
00:14:22,620 --> 00:14:33,230
all right we can take one quick question

335
00:14:41,180 --> 00:14:37,080
um I saw that you had the sodium control

336
00:14:44,060 --> 00:14:41,190
for your putting RNA with different

337
00:14:47,070 --> 00:14:44,070
rounds have you tried any other divalent

338
00:14:50,940 --> 00:14:47,080

controls like biologically relevant like

339
00:14:52,530 --> 00:14:50,950
calcium or manganese ore no we have not

340
00:14:54,870 --> 00:14:52,540
one thing we do know is when we add

341
00:14:57,780 --> 00:14:54,880
magnesium to they'll elect the electron

342
00:15:00,030 --> 00:14:57,790
transfer reaction it kills it so even if

343
00:15:01,290 --> 00:15:00,040
we have iron there with RNA if we have

344
00:15:02,850 --> 00:15:01,300
magnesium there it's gone but we have

345
00:15:04,650 --> 00:15:02,860
not tried other cations and we don't

346
00:15:06,540 --> 00:15:04,660
have reason based on our end silico

347
00:15:08,610 --> 00:15:06,550
results to believe that those would

348
00:15:11,100 --> 00:15:08,620
actually support any kind of catalysis

349
00:15:17,449 --> 00:15:11,110
that's a great question manganese would