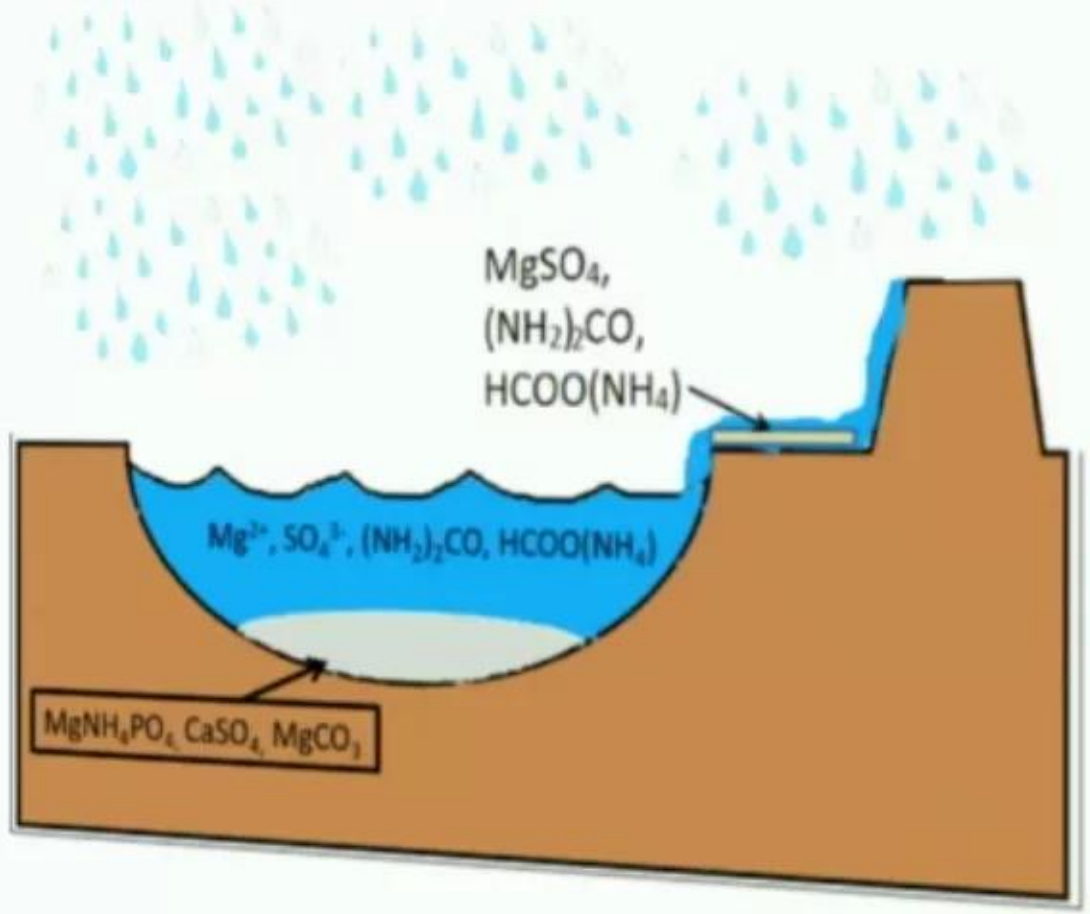
Prebiotic Struvite Formation



1
00:00:12,620 --> 00:00:09,860
radley berker I'm a NASA post doctoral

2
00:00:15,499 --> 00:00:12,630
fellow at Georgia Tech I work at the

3
00:00:18,529 --> 00:00:15,509
Center for chemical evolution where our

4
00:00:21,590 --> 00:00:18,539
main focus is to look at basic prebiotic

5
00:00:25,040 --> 00:00:21,600
chemical systems and see how those can

6
00:00:27,920 --> 00:00:25,050
grow and evolve and develop complexity

7
00:00:29,509 --> 00:00:27,930
over time these view think about it if

8
00:00:31,220 --> 00:00:29,519
you look at biology and you really

9
00:00:35,389 --> 00:00:31,230
tunnel down to its basics it's all just

10
00:00:38,119 --> 00:00:35,399
chemistry at its heart so as a prebiotic

11
00:00:45,549 --> 00:00:38,129
chemist looking at the origins of life I

12
00:00:51,200 --> 00:00:49,100
back when you have a primordial soup

13
00:00:53,000 --> 00:00:51,210

perhaps maybe of hydrothermal vents

14
00:00:55,279 --> 00:00:53,010
maybe have these small little warm

15
00:00:57,290 --> 00:00:55,289
little ponds and lagoons on the surface

16
00:01:00,410 --> 00:00:57,300
the earth where all sorts of interesting

17
00:01:03,590 --> 00:01:00,420
and chemical complexity can happen so

18
00:01:06,440 --> 00:01:03,600
eventually the complexity grows you

19
00:01:08,090 --> 00:01:06,450
develop membranes RNA DNA proteins all

20
00:01:10,520 --> 00:01:08,100
of the fundamental parts of life

21
00:01:13,370 --> 00:01:10,530
eventually transition from this sort of

22
00:01:15,140 --> 00:01:13,380
system to a living system of modern

23
00:01:16,670 --> 00:01:15,150
earth full of life but you have to go

24
00:01:18,649 --> 00:01:16,680
back to the basic fundamentals and

25
00:01:21,620 --> 00:01:18,659
figure out how those systems came to be

26
00:01:26,469 --> 00:01:21,630
in the first place so my current project

27
00:01:30,590 --> 00:01:26,479
is focusing on trying to synthesize a

28
00:01:33,800 --> 00:01:30,600
very basic monomer so for this case you

29
00:01:35,600 --> 00:01:33,810
look at RNA or perhaps DNA and it's

30
00:01:38,480 --> 00:01:35,610
possible that this was not the very

31
00:01:42,080 --> 00:01:38,490
first informational carrying molecule

32
00:01:44,240 --> 00:01:42,090
but its components are quite informative

33
00:01:46,399 --> 00:01:44,250
of what the first informational very

34
00:01:49,719 --> 00:01:46,409
molecule could have been so we don't

35
00:01:53,600 --> 00:01:49,729
necessarily at the CC think that this is

36
00:01:57,200 --> 00:01:53,610
the first monomer but you can look at

37
00:01:58,969 --> 00:01:57,210
the bases and look at that as

38
00:02:01,429 --> 00:01:58,979

information carrying unit and you can

39
00:02:03,260 --> 00:02:01,439
replace with something else like Matt's

40
00:02:07,550 --> 00:02:03,270
talk earlier today with Barbra tarek

41
00:02:09,020 --> 00:02:07,560
acid or other sorts of derivatives but

42
00:02:10,809 --> 00:02:09,030
the main thing is something that does

43
00:02:13,940 --> 00:02:10,819
hydrogen bonding to carry information

44
00:02:17,839 --> 00:02:13,950
you also look at ribose which is

45
00:02:19,190 --> 00:02:17,849
just a component that can tie all of the

46
00:02:21,770 --> 00:02:19,200
different parts of the monomer together

47
00:02:24,050 --> 00:02:21,780
into one system it doesn't have to be

48
00:02:25,690 --> 00:02:24,060
ribose maybe it could be glycerol maybe

49
00:02:28,369 --> 00:02:25,700
it could be something more complex

50
00:02:29,839 --> 00:02:28,379
glucose who knows but as long as it can

51
00:02:31,970 --> 00:02:29,849
branch the different parts of the system

52
00:02:35,839 --> 00:02:31,980
together that's the important part as a

53
00:02:37,520 --> 00:02:35,849
trifunctional connector and my specific

54
00:02:40,699 --> 00:02:37,530
part I working on this project is

55
00:02:44,030 --> 00:02:40,709
looking at this ionized linker and a

56
00:02:45,949 --> 00:02:44,040
modern life uses a phosphate as its

57
00:02:48,589 --> 00:02:45,959
source it makes very energetically

58
00:02:51,380 --> 00:02:48,599
favorable bonds that can be formed and

59
00:02:55,569 --> 00:02:51,390
broken quite reasonably and it provides

60
00:03:00,039 --> 00:02:55,579
a basic amount of celula tea and water

61
00:03:02,960 --> 00:03:00,049
very valuable properties to have for

62
00:03:04,430 --> 00:03:02,970
life as we know it for polymers and

63
00:03:07,720 --> 00:03:04,440

monomers that have to exist in an

64
00:03:11,809 --> 00:03:07,730
aqueous environment so it's not

65
00:03:14,000 --> 00:03:11,819
essential that phosphate was the source

66
00:03:15,410 --> 00:03:14,010
and in my group we look at a lot of

67
00:03:17,750 --> 00:03:15,420
different possibilities for what it

68
00:03:21,530 --> 00:03:17,760
could be for phosphate but phosphate is

69
00:03:22,849 --> 00:03:21,540
so helpful is has such good properties

70
00:03:25,160 --> 00:03:22,859
that would be really great if it could

71
00:03:26,990 --> 00:03:25,170
be the source and so I'm specifically

72
00:03:28,759 --> 00:03:27,000
trying to find reactions that could help

73
00:03:32,629 --> 00:03:28,769
to incorporate phosphate into early

74
00:03:34,610 --> 00:03:32,639
organics but this has been a problem for

75
00:03:36,379 --> 00:03:34,620
a long time the prebiotic

76
00:03:37,729 --> 00:03:36,389
phosphorylation problem which is why

77
00:03:41,569 --> 00:03:37,739
people are even looking for other

78
00:03:46,500 --> 00:03:41,579
informational linkers as it is a hot did

79
00:03:54,070 --> 00:03:52,210
yep alright so the basic fundamental

80
00:03:56,530 --> 00:03:54,080
question is how phosphorylated nucleus

81
00:04:00,039 --> 00:03:56,540
sides or organic phosphates came to be

82
00:04:02,770 --> 00:04:00,049
in the first place there's two

83
00:04:04,720 --> 00:04:02,780
fundamental problems first of all if you

84
00:04:07,330 --> 00:04:04,730
have phosphate it reacts with divalent

85
00:04:08,979 --> 00:04:07,340
cations like magnesium or calcium in

86
00:04:11,860 --> 00:04:08,989
solution and it just precipitates out

87
00:04:13,990 --> 00:04:11,870
you can have a nice bed of appetite so

88
00:04:16,090 --> 00:04:14,000

this makes it largely inaccessible for

89
00:04:18,219 --> 00:04:16,100
prebiotic chemistry which is the main

90
00:04:21,879 --> 00:04:18,229
reason why a lot of prebiotic chemistry

91
00:04:24,700 --> 00:04:21,889
so long also if you're making organic

92
00:04:27,510 --> 00:04:24,710
phosphates it's a condensation reaction

93
00:04:29,740 --> 00:04:27,520
it gives off water it is incredibly

94
00:04:31,930 --> 00:04:29,750
thermodynamically unfavorable to try to

95
00:04:35,230 --> 00:04:31,940
give off water for a chemical reaction

96
00:04:37,570 --> 00:04:35,240
in a water-based environment so these

97
00:04:40,770 --> 00:04:37,580
are two big problems trying to make

98
00:04:43,330 --> 00:04:40,780
phosphate be incorporated into organics

99
00:04:46,029 --> 00:04:43,340
so a lot of research has been done

100
00:04:47,710 --> 00:04:46,039
starting in the late 60s to figure out

101
00:04:50,170 --> 00:04:47,720
what can work how can you incorporate

102
00:04:52,510 --> 00:04:50,180
how can you take a nucleobase or any

103
00:04:55,900 --> 00:04:52,520
organic incorporate phosphate and make

104
00:04:58,240 --> 00:04:55,910
organic phosphates so a lot of work has

105
00:05:01,420 --> 00:04:58,250
shown that urea is a very key component

106
00:05:03,219 --> 00:05:01,430
for this if you have urea and soluble

107
00:05:06,430 --> 00:05:03,229
phosphate like sodium phosphate in

108
00:05:09,969 --> 00:05:06,440
solution in a dry reaction it can add a

109
00:05:11,500 --> 00:05:09,979
phosphate as low 65 degrees or if you

110
00:05:13,210 --> 00:05:11,510
really ratchet up the temperatures to

111
00:05:15,580 --> 00:05:13,220
100 degrees you can take in soluble

112
00:05:18,730 --> 00:05:15,590
minerals like appetite and also

113
00:05:20,800 --> 00:05:18,740

phosphorylate also if you just remove

114
00:05:24,300 --> 00:05:20,810
water completely from the equation and

115
00:05:26,740 --> 00:05:24,310
use something like toluene or formamide

116
00:05:29,020 --> 00:05:26,750
you can do low temperature reactions

117
00:05:31,029 --> 00:05:29,030
also using soluble phosphate as low as

118
00:05:32,740 --> 00:05:31,039
70 degrees but it's kind of a cheat

119
00:05:34,300 --> 00:05:32,750
because you removed water from the

120
00:05:36,310 --> 00:05:34,310
equation and then you have all sorts of

121
00:05:39,250 --> 00:05:36,320
arguments to make about formamide on a

122
00:05:40,750 --> 00:05:39,260
prebiotic earth also they have

123
00:05:43,360 --> 00:05:40,760
pretreated some of the insoluble

124
00:05:46,390 --> 00:05:43,370
minerals and have used that as a

125
00:05:47,620 --> 00:05:46,400
phosphate source to phosphorylate so

126
00:05:51,370 --> 00:05:47,630
that's one way to deal with the

127
00:05:53,260 --> 00:05:51,380
insoluble mineral problem but these this

128
00:05:55,750 --> 00:05:53,270
pretreatment took place at 150 degrees

129
00:05:59,570 --> 00:05:55,760
Celsius which is very high temperature

130
00:06:01,249 --> 00:05:59,580
and recently

131
00:06:03,740 --> 00:06:01,259
they're novel solvent systems have been

132
00:06:06,529 --> 00:06:03,750
explored particularly this choline

133
00:06:08,619 --> 00:06:06,539
chloride urea eutectic solution so this

134
00:06:10,429 --> 00:06:08,629
is also a water free solution and

135
00:06:12,860 --> 00:06:10,439
eutectics are interesting

136
00:06:15,439 --> 00:06:12,870
multi-component systems in which you can

137
00:06:17,540 --> 00:06:15,449
mix them together and you have a lower

138
00:06:20,749 --> 00:06:17,550

melting point than either the components

139
00:06:22,100 --> 00:06:20,759
so in this case you take two solids at

140
00:06:23,899 --> 00:06:22,110
room temperature mix them together and

141
00:06:26,240 --> 00:06:23,909
you create a liquid this is actually

142
00:06:27,649 --> 00:06:26,250
quite abundant in plants and a lot of

143
00:06:29,890 --> 00:06:27,659
biological life so it has been

144
00:06:33,529 --> 00:06:29,900
investigated a lot in modern

145
00:06:36,020 --> 00:06:33,539
biochemistry and if you use one of these

146
00:06:37,369 --> 00:06:36,030
interesting novel solvent it's been

147
00:06:40,969 --> 00:06:37,379
shown that you can phosphate those those

148
00:06:42,800 --> 00:06:40,979
65 degrees it's problematic because it

149
00:06:47,839 --> 00:06:42,810
reacts with your solvent in this case

150
00:06:50,029 --> 00:06:47,849
which is not great but it works and i'll

151
00:06:52,430 --> 00:06:50,039
reiterate this part here because this is

152
00:06:55,909 --> 00:06:52,440
apparently a very important fundamental

153
00:06:58,760 --> 00:06:55,919
reaction in prebiotic chemistry so this

154
00:07:01,219 --> 00:06:58,770
is the urea catalyzed phosphorylation so

155
00:07:03,439 --> 00:07:01,229
you can take your phosphate group take a

156
00:07:06,589 --> 00:07:03,449
urea and create this high energy

157
00:07:08,570 --> 00:07:06,599
intermediate in a water free solution so

158
00:07:11,450 --> 00:07:08,580
in fact you're activating the phosphate

159
00:07:13,399 --> 00:07:11,460
if you can create this then you can

160
00:07:17,300 --> 00:07:13,409
bring in any alcohol that we've tested

161
00:07:19,550 --> 00:07:17,310
so far and create an organo phosphate so

162
00:07:22,610 --> 00:07:19,560
it's a great way in urea is a very

163
00:07:24,529 --> 00:07:22,620

powerful chemical for doing this and the

164
00:07:26,930 --> 00:07:24,539
biologists in the group might notice

165
00:07:28,700 --> 00:07:26,940
that this looks like a EDC activated

166
00:07:33,379 --> 00:07:28,710
intermediate which is used for a ton of

167
00:07:35,420 --> 00:07:33,389
modern biochemical reactions so we've

168
00:07:38,059 --> 00:07:35,430
been investigating a phosphorylation can

169
00:07:40,279 --> 00:07:38,069
take place in this in a eutectic made of

170
00:07:43,430 --> 00:07:40,289
urea ammonium wat ammonium formate and

171
00:07:46,430 --> 00:07:43,440
water well this last part is key because

172
00:07:49,129 --> 00:07:46,440
it allows this to be created on a

173
00:07:51,260 --> 00:07:49,139
prebiotic earth in a water-based soluble

174
00:07:54,589 --> 00:07:51,270
system so the great things about this

175
00:07:57,260 --> 00:07:54,599
eutectic all of these components are

176
00:07:58,969 --> 00:07:57,270
very abundant on a prebiotic earth we

177
00:08:01,339 --> 00:07:58,979
saw earlier the serpent in ization

178
00:08:05,659 --> 00:08:01,349
reactions can lead to a lot of ammonium

179
00:08:07,309 --> 00:08:05,669
formate for example and urea can be

180
00:08:09,350 --> 00:08:07,319
abundantly made from miller early type

181
00:08:11,749 --> 00:08:09,360
reactions in fact a lot of prebiotic

182
00:08:12,770 --> 00:08:11,759
scientists think that like the Salt

183
00:08:14,510 --> 00:08:12,780
Flats in Utah

184
00:08:17,570 --> 00:08:14,520
you would have had your reah flats on a

185
00:08:22,970 --> 00:08:17,580
pre-bout occurs so both of these would

186
00:08:25,190 --> 00:08:22,980
have been very available also after some

187
00:08:27,260 --> 00:08:25,200
slight heating driving off the excess

188
00:08:29,780 --> 00:08:27,270

volatile from the solution you have a

189
00:08:32,300 --> 00:08:29,790
fluidic environment that can promote

190
00:08:34,219 --> 00:08:32,310
chemical interactions so you don't have

191
00:08:35,959 --> 00:08:34,229
to have a completely dry system anymore

192
00:08:38,440 --> 00:08:35,969
and a lot of chemistry can take place a

193
00:08:43,730 --> 00:08:38,450
lot more readily in fluidic environments

194
00:08:46,790 --> 00:08:43,740
it's made from urea also upon heating

195
00:08:49,570 --> 00:08:46,800
these chemicals actually do form form ID

196
00:08:52,220 --> 00:08:49,580
which creates a four-part system and

197
00:08:54,380 --> 00:08:52,230
then we have this solvent which has been

198
00:08:57,290 --> 00:08:54,390
shown to do phosphorylation before and

199
00:08:59,930 --> 00:08:57,300
some other prebiotic reactions so it's a

200
00:09:03,680 --> 00:08:59,940
great easy pathway to developing for

201
00:09:07,250 --> 00:09:03,690
moment the high viscosity environment

202
00:09:09,200 --> 00:09:07,260
promotes chemical interactions and it's

203
00:09:10,940 --> 00:09:09,210
a low enough water environment that it

204
00:09:15,740 --> 00:09:10,950
can actually still do dehydration

205
00:09:17,810 --> 00:09:15,750
condensation reactions and one of the

206
00:09:21,710 --> 00:09:17,820
first things that we discovered through

207
00:09:23,750 --> 00:09:21,720
our work with them our collaborators at

208
00:09:26,300 --> 00:09:23,760
USF is just by taking different

209
00:09:28,240 --> 00:09:26,310
phosphate sources struvite which is a

210
00:09:30,770 --> 00:09:28,250
mildly soluble phosphate source

211
00:09:33,230 --> 00:09:30,780
hydroxyapatite which is calcium

212
00:09:35,540 --> 00:09:33,240
phosphate which is a very insoluble

213
00:09:37,190 --> 00:09:35,550

phosphate source in Vivian 8 which is an

214
00:09:40,000 --> 00:09:37,200
iron phosphate which is also Clinton

215
00:09:46,040 --> 00:09:40,010
soluble and mixing it in the eutectic

216
00:09:47,810 --> 00:09:46,050
comparing it at 70 degrees to water we

217
00:09:50,150 --> 00:09:47,820
could see that just initially in the

218
00:09:52,880 --> 00:09:50,160
eutectic there's a marked increase in

219
00:09:56,329 --> 00:09:52,890
solubility of these highly insoluble

220
00:09:58,460 --> 00:09:56,339
phosphate species so one good check for

221
00:10:01,570 --> 00:09:58,470
the eutectic to start with is great you

222
00:10:03,079 --> 00:10:01,580
can now sell you buy some phosphate also

223
00:10:05,600 --> 00:10:03,089
thermodynamically we ran some

224
00:10:07,640 --> 00:10:05,610
calculations and showed in a urea rich

225
00:10:10,040 --> 00:10:07,650
environment that's slightly acidic like

226
00:10:12,140 --> 00:10:10,050
the eutectic is if you have magnesium

227
00:10:14,840 --> 00:10:12,150
and sulfates in there with this in

228
00:10:17,030 --> 00:10:14,850
soluble phosphate source you can just

229
00:10:20,570 --> 00:10:17,040
generate struvite a much more soluble

230
00:10:23,329 --> 00:10:20,580
mineral at a very thermodynamically

231
00:10:25,550 --> 00:10:23,339
favorable rate so you can just mix it

232
00:10:28,100 --> 00:10:25,560
with eutectic and it just can

233
00:10:30,800 --> 00:10:28,110
the phosphate right into solution and

234
00:10:32,720 --> 00:10:30,810
this is shown we've ran some xrd and

235
00:10:35,390 --> 00:10:32,730
some Robin actually testing this

236
00:10:39,620 --> 00:10:35,400
experimentally on some hydroxyapatite

237
00:10:41,690 --> 00:10:39,630
and it's invisible but there's a red

238
00:10:45,620 --> 00:10:41,700

line down here that's for the

239
00:10:47,960 --> 00:10:45,630
hydroxyapatite which is this didn't come

240
00:10:50,450 --> 00:10:47,970
out at all anyway what this shows is

241
00:10:52,700 --> 00:10:50,460
that it works you mix it together and

242
00:10:54,290 --> 00:10:52,710
you create struvite you can separate all

243
00:10:56,600 --> 00:10:54,300
the minerals that you want and see that

244
00:11:01,329 --> 00:10:56,610
it has worked greatly for transferring

245
00:11:04,640 --> 00:11:01,339
hydroxyapatite to other sources Oh max

246
00:11:06,950 --> 00:11:04,650
so this allows allows us to create a

247
00:11:09,260 --> 00:11:06,960
very fundamental prebiotic model so you

248
00:11:11,120 --> 00:11:09,270
could take calcium magnesium and

249
00:11:12,710 --> 00:11:11,130
phosphate on a prebiotic earth which

250
00:11:15,500 --> 00:11:12,720
come together and formed this bed of

251
00:11:18,170 --> 00:11:15,510
insoluble minerals the water can be

252
00:11:20,480 --> 00:11:18,180
removed and then you can get a nearby

253
00:11:23,060 --> 00:11:20,490
hydrothermal sources and volcanoes or

254
00:11:25,220 --> 00:11:23,070
other surface Mets that can create this

255
00:11:28,100 --> 00:11:25,230
interest this suite of organic molecules

256
00:11:30,920 --> 00:11:28,110
and in organics to create the beds of

257
00:11:33,170 --> 00:11:30,930
urea ammonium formate water will come

258
00:11:35,300 --> 00:11:33,180
wash them into solution you now have a

259
00:11:38,960 --> 00:11:35,310
nice warm lagoon rich in magnesium

260
00:11:40,880 --> 00:11:38,970
sulfate urea ammonium formate which will

261
00:11:42,920 --> 00:11:40,890
then convert all of these minerals to

262
00:11:47,030 --> 00:11:42,930
the much more usable struvite and

263
00:11:49,670 --> 00:11:47,040

soluble phosphate i'll go through my

264
00:11:52,790 --> 00:11:49,680
reaction conditions very quickly it's

265
00:11:54,800 --> 00:11:52,800
very simple you mix of adenosine with

266
00:11:59,750 --> 00:11:54,810
the eutectic in a phosphate source in

267
00:12:02,570 --> 00:11:59,760
heated and those are the reactions that

268
00:12:05,210 --> 00:12:02,580
go forth and make phosphorylation so

269
00:12:07,010 --> 00:12:05,220
this is an HPLC trace showing the

270
00:12:09,110 --> 00:12:07,020
different phosphorylated species that

271
00:12:11,329 --> 00:12:09,120
are made five prime a and P some

272
00:12:14,270 --> 00:12:11,339
psychics to prime and three prime and

273
00:12:17,290 --> 00:12:14,280
this these chromatograms down here

274
00:12:20,390 --> 00:12:17,300
compare reactions with soluble phosphate

275
00:12:22,760 --> 00:12:20,400
in the eutectic to soluble phosphate in

276
00:12:25,220 --> 00:12:22,770
just a urea solution alone so you can

277
00:12:26,660 --> 00:12:25,230
see the area of the peak is important

278
00:12:29,000 --> 00:12:26,670
it's related to how much you have in

279
00:12:32,930 --> 00:12:29,010
solution so the eutectic works it makes

280
00:12:36,560 --> 00:12:32,940
great phosphorylated products comparing

281
00:12:38,750 --> 00:12:36,570
it to the urea controls which are up

282
00:12:41,270 --> 00:12:38,760
here we got a total of seven percent

283
00:12:42,830 --> 00:12:41,280
phosphorylation at 65 degrees but

284
00:12:46,160 --> 00:12:42,840
fifty-eight percent running in the

285
00:12:48,710 --> 00:12:46,170
eutectic at a higher temperature of 85

286
00:12:50,090 --> 00:12:48,720
degrees we just see a mild increase so

287
00:12:53,240 --> 00:12:50,100
this works really great at lower

288
00:12:54,770 --> 00:12:53,250

temperatures when you're comparing the

289
00:12:59,080 --> 00:12:54,780
different phosphate sources that you

290
00:13:01,750 --> 00:12:59,090
have we get a up to thirty two percent

291
00:13:03,950 --> 00:13:01,760
phosphorylation with sodium phosphate

292
00:13:06,260 --> 00:13:03,960
struvite in Newberry eight which are

293
00:13:09,920 --> 00:13:06,270
very similar minerals of mildly

294
00:13:11,630 --> 00:13:09,930
phosphate solubility give a little bit

295
00:13:16,250 --> 00:13:11,640
decrease but still a great amount and

296
00:13:18,530 --> 00:13:16,260
then we synthesized some struvite

297
00:13:20,150 --> 00:13:18,540
ourself in the lab and it's a mixture of

298
00:13:22,070 --> 00:13:20,160
Bruce Shannon's through vide and other

299
00:13:23,720 --> 00:13:22,080
mixtures and it still works great if

300
00:13:25,070 --> 00:13:23,730
they very dirty make sure that still

301
00:13:30,020 --> 00:13:25,080
produces a decent amount of

302
00:13:32,210 --> 00:13:30,030
phosphorylation and we process some

303
00:13:34,310 --> 00:13:32,220
hydroxyapatite showing that model that I

304
00:13:36,560 --> 00:13:34,320
had before with the washing and the

305
00:13:39,020 --> 00:13:36,570
magnesium sulfate in the drying and

306
00:13:40,610 --> 00:13:39,030
converting and showed an increase in

307
00:13:45,130 --> 00:13:40,620
phosphorylation compared to just

308
00:13:47,990 --> 00:13:45,140
hydroxyapatite by itself and this is

309
00:13:50,540 --> 00:13:48,000
really emphasized when we do some wet

310
00:13:53,150 --> 00:13:50,550
dry cycles where we continually add in

311
00:13:55,280 --> 00:13:53,160
magnesium sulfate try it added in more

312
00:13:58,580 --> 00:13:55,290
to really drive the equilibrium forward

313
00:14:01,640 --> 00:13:58,590

so this is particularly noticeable at 85

314
00:14:03,320 --> 00:14:01,650
degrees when we get a decent amount of

315
00:14:05,180 --> 00:14:03,330
phosphorylation as sodium phosphate and

316
00:14:09,170 --> 00:14:05,190
servite hardly any with hydroxyapatite

317
00:14:11,180 --> 00:14:09,180
at 65 and 85 and it really jumps up and

318
00:14:13,940 --> 00:14:11,190
we get fifteen percent phosphorylation

319
00:14:18,170 --> 00:14:13,950
by treating these mixtures with the

320
00:14:20,060 --> 00:14:18,180
magnesium sulfate so we can follow that

321
00:14:22,580 --> 00:14:20,070
one pot scenario to generate that lake

322
00:14:26,210 --> 00:14:22,590
and cellulose phosphate and bring it

323
00:14:28,580 --> 00:14:26,220
into reactions and also it doesn't just

324
00:14:32,200 --> 00:14:28,590
work with the denisita nucleosides we

325
00:14:35,800 --> 00:14:32,210
have done this with a glycerol so we get

326
00:14:38,870 --> 00:14:35,810
phospho glycerol this is a

327
00:14:42,170 --> 00:14:38,880
phosphodiester bond of to glycerol zin

328
00:14:43,790 --> 00:14:42,180
phosphate and two phosphates and to

329
00:14:45,170 --> 00:14:43,800
glycerol so this is showing the mass

330
00:14:47,330 --> 00:14:45,180
spec so we can great higher or

331
00:14:49,670 --> 00:14:47,340
phosphorylated species and create

332
00:14:51,850 --> 00:14:49,680
phosphodiester bonds if you're really

333
00:14:54,100 --> 00:14:51,860
paying attention to a couple talks ago

334
00:14:56,079 --> 00:14:54,110
can think that this might work with

335
00:14:59,980 --> 00:14:56,089
fatty acids and maybe you can make some

336
00:15:04,750 --> 00:14:59,990
lipids and some protocells so all sorts

337
00:15:07,269 --> 00:15:04,760
of interesting possibilities so overall

338
00:15:09,160 --> 00:15:07,279

these results have shown that it that

339
00:15:11,579 --> 00:15:09,170
the eutectic liberate the sequestered

340
00:15:14,560 --> 00:15:11,589
phosphate promotes phosphorylation and

341
00:15:16,329 --> 00:15:14,570
for the future work what other reactions

342
00:15:18,370 --> 00:15:16,339
will work we're taking this off in

343
00:15:20,440 --> 00:15:18,380
different angles and seeing maybe this

344
00:15:23,590 --> 00:15:20,450
is a great solvent to make all sorts of

345
00:15:25,060 --> 00:15:23,600
different prebiotic chemistry can it

346
00:15:27,880 --> 00:15:25,070
make long change polymerization

347
00:15:30,250 --> 00:15:27,890
reactions we saw the to glycerol xin the

348
00:15:32,470 --> 00:15:30,260
two phosphates so that made a polymer

349
00:15:35,949 --> 00:15:32,480
there we've seen up to three informers

350
00:15:38,680 --> 00:15:35,959
with the Deniz een maybe we can make 10

351
00:15:40,449 --> 00:15:38,690
verse 20 MERS maybe there's some magical

352
00:15:43,090 --> 00:15:40,459
chemical equilibrium that can happen in

353
00:15:47,170 --> 00:15:43,100
there to make the information carrier

354
00:15:50,710 --> 00:15:47,180
polymers that we need and this paper has

355
00:15:53,710 --> 00:15:50,720
just been accepted for publication on

356
00:15:55,480 --> 00:15:53,720
Yvonne take mea so you can see a more

357
00:15:56,949 --> 00:15:55,490
detailed version of our work if you

358
00:16:00,790 --> 00:15:56,959
check out that general in the next

359
00:16:03,370 --> 00:16:00,800
couple months here's the group that I

360
00:16:07,090 --> 00:16:03,380
work with and my funding sources from

361
00:16:11,139 --> 00:16:07,100
the nasa astrobiology program I'm

362
00:16:13,630 --> 00:16:11,149
supported by the nasta post doctoral

363
00:16:16,509 --> 00:16:13,640

program and we are funded by a grant

364
00:16:21,380 --> 00:16:16,519
from the ni as well so I'll take any

365
00:16:36,980 --> 00:16:32,090
thank you I'll ask one over I got the

366
00:16:38,270 --> 00:16:36,990
mic I got the power yeah so the wet/dry

367
00:16:40,130 --> 00:16:38,280
cycles you were showing where was like

368
00:16:42,080 --> 00:16:40,140
raining off and then refilling and

369
00:16:44,120 --> 00:16:42,090
drying out again yeah so is your

370
00:16:46,220 --> 00:16:44,130
thinking this is like a marginal coastal

371
00:16:49,190 --> 00:16:46,230
type of environment where you're having

372
00:16:50,690 --> 00:16:49,200
some terrestrial exposure yes ok so our

373
00:16:53,000 --> 00:16:50,700
fundamental thing you're looking at

374
00:16:55,100 --> 00:16:53,010
either small islands or very small proto

375
00:16:56,810 --> 00:16:55,110
continents I'm sure yeah and so we're

376
00:16:58,520 --> 00:16:56,820
not looking at both water systems at all

377
00:17:04,130 --> 00:16:58,530
it is very hard to do chemistry in the

378
00:17:06,650 --> 00:17:04,140
bulk water Hey yeah enjoy yeah I'm just

379
00:17:09,290 --> 00:17:06,660
curious can this also work with ammonia

380
00:17:11,000 --> 00:17:09,300
oceans as well as it is over just only

381
00:17:14,840 --> 00:17:11,010
considering just water oceans at this

382
00:17:17,660 --> 00:17:14,850
point so ammonia ammonia is a key

383
00:17:20,180 --> 00:17:17,670
component of it so urea will convert to

384
00:17:22,730 --> 00:17:20,190
you Mona ammonia I'm only a four mate

385
00:17:24,650 --> 00:17:22,740
has ammonia in it so you do need ammonia

386
00:17:26,360 --> 00:17:24,660
to drive these reactions so ammonia

387
00:17:28,670 --> 00:17:26,370
oceans will work ammonia lagoons will

388
00:17:36,910 --> 00:17:28,680

work but you need some source of ammonia

389
00:17:39,050 --> 00:17:36,920
yes in a prebiotic setting could this

390
00:17:40,970 --> 00:17:39,060
phosphorylation should be nonspecific

391
00:17:43,190 --> 00:17:40,980
like you could end up phosphorylating

392
00:17:46,250 --> 00:17:43,200
your amino acids to or would this be

393
00:17:49,190 --> 00:17:46,260
somewhat specific at least so we have

394
00:17:51,680 --> 00:17:49,200
shown a small amount of specific Regis

395
00:17:54,320 --> 00:17:51,690
Rijo specific reactions so if you look

396
00:17:55,820 --> 00:17:54,330
at the adenosine you form far more five

397
00:17:59,270 --> 00:17:55,830
prime than the two prime of the three

398
00:18:01,400 --> 00:17:59,280
prime if you put in glycerol is going to

399
00:18:03,470 --> 00:18:01,410
react with that I don't know how it's

400
00:18:05,390 --> 00:18:03,480
going to react with a whole mixture of

401
00:18:07,820 --> 00:18:05,400
alcohols in there and what will be

402
00:18:09,850 --> 00:18:07,830
specifically phosphorylated over there

403
00:18:16,509 --> 00:18:09,860
it looks like it's a pretty nonspecific

404
00:18:22,029 --> 00:18:19,719
how much water is too much water before

405
00:18:24,489 --> 00:18:22,039
the dehydration doesn't work very well

406
00:18:26,619 --> 00:18:24,499
anymore so I mean that's a good question

407
00:18:30,099 --> 00:18:26,629
this is actually problematic to quantity

408
00:18:31,839 --> 00:18:30,109
to quantify an NMR because in this

409
00:18:33,399 --> 00:18:31,849
eutectic you get so many interactions we

410
00:18:37,839 --> 00:18:33,409
just get a broad peak instead of a nice

411
00:18:40,419 --> 00:18:37,849
sharp water peak it is what it is but

412
00:18:43,029 --> 00:18:40,429
there is still water present in there it

413
00:18:45,699 --> 00:18:43,039

takes three days of heating at 85 before

414
00:18:47,949 --> 00:18:45,709
South passports phosphorylate if I riad

415
00:18:50,440 --> 00:18:47,959
water it stops and then happens like a

416
00:18:54,249 --> 00:18:50,450
day to two days later but I don't know

417
00:18:58,989 --> 00:18:54,259
how much is in there but it is still in