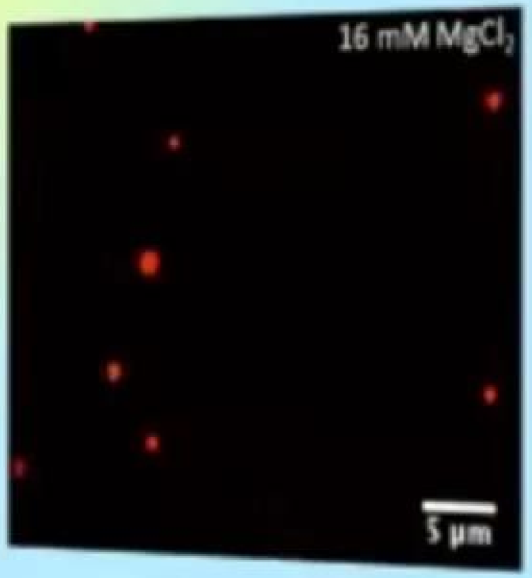
Vesice Stability (Preliminary Results)

Divalent Cations:



Time:

Adapted from: Griffith, E.C., et. al. JACS **2014**, 136, 3784-3787

1
00:00:12,629 --> 00:00:09,589
yeah so we're going to step away from

2
00:00:14,789 --> 00:00:12,639
rocks for a little bit um but i'm going

3
00:00:16,550 --> 00:00:14,799
to be talking about the synthesis of a

4
00:00:19,349 --> 00:00:16,560
potential membrane component

5
00:00:21,990 --> 00:00:19,359
and then the self-assembly of that into

6
00:00:24,390 --> 00:00:22,000
a vesicle or liposome

7
00:00:26,230 --> 00:00:24,400
um so just to place us on the timeline

8
00:00:28,070 --> 00:00:26,240
that we've been talking about um

9
00:00:29,990 --> 00:00:28,080
formation of the earth 4.5 billion years

10
00:00:31,429 --> 00:00:30,000
ago the present

11
00:00:33,670 --> 00:00:31,439
if you like the rna world there's some

12
00:00:35,590 --> 00:00:33,680
other dates in there but if you don't we

13
00:00:37,430 --> 00:00:35,600

still need prebiotic chemistry in order

14
00:00:39,910 --> 00:00:37,440
to make complex

15
00:00:42,069 --> 00:00:39,920
molecules that could potentially go on

16
00:00:43,910 --> 00:00:42,079
to form life and so

17
00:00:46,069 --> 00:00:43,920
here we're talking about a place where

18
00:00:48,950 --> 00:00:46,079
we're existing in the prebiotic soup we

19
00:00:51,430 --> 00:00:48,960
have simple molecules like fatty acids

20
00:00:53,590 --> 00:00:51,440
uh nucleobases that kind of thing but

21
00:00:56,630 --> 00:00:53,600
the question is how we go from those to

22
00:00:59,510 --> 00:00:56,640
sort of the more complex biomolecules

23
00:01:01,029 --> 00:00:59,520
like peptide bonds and in particular

24
00:01:03,349 --> 00:01:01,039
what i'm going to be talking about are

25
00:01:05,590 --> 00:01:03,359
the formation of double-tailed membrane

26
00:01:07,830 --> 00:01:05,600
components so for instance of

27
00:01:10,149 --> 00:01:07,840
phospholipid like we see today or other

28
00:01:13,590 --> 00:01:10,159
membrane components like that

29
00:01:15,670 --> 00:01:13,600
now the reactions that we have to do in

30
00:01:17,109 --> 00:01:15,680
order to make these

31
00:01:20,230 --> 00:01:17,119
compounds

32
00:01:21,590 --> 00:01:20,240
are often in the absence of enzymatic

33
00:01:25,429 --> 00:01:21,600
help

34
00:01:28,789 --> 00:01:25,439
both thermodynamically and kinetically

35
00:01:30,550 --> 00:01:28,799
unfavorable and hard to do and so the

36
00:01:32,149 --> 00:01:30,560
question is how using prebiotic

37
00:01:35,190 --> 00:01:32,159
conditions can we overcome these

38
00:01:37,830 --> 00:01:35,200

reactions in order to make this happen

39
00:01:39,510 --> 00:01:37,840
and so in general you need to have

40
00:01:41,429 --> 00:01:39,520
conditions that are favorable for both

41
00:01:43,270 --> 00:01:41,439
synthesis and the self-assembly so

42
00:01:45,030 --> 00:01:43,280
synthesis to make the molecules but then

43
00:01:46,630 --> 00:01:45,040
the self-assembly either to fold

44
00:01:48,950 --> 00:01:46,640
proteins that kind of thing or

45
00:01:52,310 --> 00:01:48,960
self-assemble from a lipid into

46
00:01:53,990 --> 00:01:52,320
a protocell or membrane of some variety

47
00:01:56,149 --> 00:01:54,000
so there are a lot of different sources

48
00:01:58,469 --> 00:01:56,159
people talk about a lot of them are

49
00:02:00,469 --> 00:01:58,479
hydrothermal vents as an energy source

50
00:02:02,630 --> 00:02:00,479
or clay and mineral surfaces which can

51
00:02:04,469 --> 00:02:02,640
be catalytic and orienting

52
00:02:06,950 --> 00:02:04,479
what we in the vita group choose to look

53
00:02:09,430 --> 00:02:06,960
at instead is another possibility using

54
00:02:12,229 --> 00:02:09,440
the sun which is a high energy low

55
00:02:14,229 --> 00:02:12,239
entropy source and then also air water

56
00:02:17,110 --> 00:02:14,239
interfaces which would have been widely

57
00:02:19,510 --> 00:02:17,120
available on oceans and lakes and

58
00:02:21,589 --> 00:02:19,520
atmospheric aerosols but are also

59
00:02:23,030 --> 00:02:21,599
relatively gentle conditions compared to

60
00:02:24,630 --> 00:02:23,040
say like a hydrothermal vent or

61
00:02:26,790 --> 00:02:24,640
something like that

62
00:02:28,630 --> 00:02:26,800
so with that in mind

63
00:02:30,790 --> 00:02:28,640

just to give brief background on

64
00:02:33,110 --> 00:02:30,800
membrane components membranes are made

65
00:02:33,830 --> 00:02:33,120
out of surfactants or lipids which have

66
00:03:00,790 --> 00:02:33,840
a

67
00:03:02,630 --> 00:03:00,800
of such molecules using

68
00:03:04,470 --> 00:03:02,640
one technique which is a langmuir trough

69
00:03:05,670 --> 00:03:04,480
basically you deposit a monolayer on

70
00:03:09,030 --> 00:03:05,680
this top

71
00:03:10,949 --> 00:03:09,040
and potentially think about

72
00:03:13,350 --> 00:03:10,959
and it partitions to the surface from an

73
00:03:16,229 --> 00:03:13,360
aqueous solution or something

74
00:03:17,350 --> 00:03:16,239
but you can basically move these teflon

75
00:03:18,790 --> 00:03:17,360
barriers

76
00:03:20,149 --> 00:03:18,800
and

77
00:03:22,390 --> 00:03:20,159
look at

78
00:03:24,470 --> 00:03:22,400
the surface tension and get some of the

79
00:03:25,830 --> 00:03:24,480
surface thermodynamics out of that so

80
00:03:28,070 --> 00:03:25,840
that's one of the tools we use to look

81
00:03:29,670 --> 00:03:28,080
at this

82
00:03:31,589 --> 00:03:29,680
and then when we're talking about sort

83
00:03:32,789 --> 00:03:31,599
of prebiotic enclosure types and that

84
00:03:35,030 --> 00:03:32,799
kind of thing

85
00:03:37,910 --> 00:03:35,040
one of the more common prebiotic

86
00:03:39,910 --> 00:03:37,920
protocells that people make are using

87
00:03:41,350 --> 00:03:39,920
fatty acids which are very prebiotically

88
00:03:45,030 --> 00:03:41,360

relevant molecules they would have

89
00:03:46,789 --> 00:03:45,040
existed but they have relatively complex

90
00:03:48,630 --> 00:03:46,799
behavior you require a pretty high

91
00:03:51,110 --> 00:03:48,640
concentration of the molecules in order

92
00:03:53,270 --> 00:03:51,120
to get any 3d structures like micelles

93
00:03:55,910 --> 00:03:53,280
or vesicles and even if you are above

94
00:03:58,630 --> 00:03:55,920
that critical aggregation concentration

95
00:04:00,789 --> 00:03:58,640
there's quite a bit of ph dependence on

96
00:04:03,110 --> 00:04:00,799
what you're going to form you form my

97
00:04:05,910 --> 00:04:03,120
cells when you have fully deprotonated

98
00:04:08,630 --> 00:04:05,920
head groups and so that's at relatively

99
00:04:10,309 --> 00:04:08,640
high phs and then as you lower the ph

100
00:04:12,789 --> 00:04:10,319
until the point where you're about half

101
00:04:13,830 --> 00:04:12,799
protonated and half deprotonated head

102
00:04:16,949 --> 00:04:13,840
groups

103
00:04:18,469 --> 00:04:16,959
you form but vesicles but the vesicles

104
00:04:20,550 --> 00:04:18,479
and the micelles are always in

105
00:04:22,469 --> 00:04:20,560
equilibrium with the monomer in solution

106
00:04:25,189 --> 00:04:22,479
which means you end up creating fairly

107
00:04:27,670 --> 00:04:25,199
leaky vesicles so if we're talking about

108
00:04:29,909 --> 00:04:27,680
enclosures and encapsulating reactions

109
00:04:31,909 --> 00:04:29,919
and things like that you tend to lose a

110
00:04:33,830 --> 00:04:31,919
lot of material out of the center

111
00:04:38,390 --> 00:04:33,840
and even if you don't they tend to be

112
00:04:41,030 --> 00:04:38,400
relatively unstable in terms of

113
00:04:42,629 --> 00:04:41,040

their susceptibility to divalent cations

114
00:04:45,189 --> 00:04:42,639
like magnesium which we've been talking

115
00:04:47,030 --> 00:04:45,199
about as them being quite important

116
00:04:49,110 --> 00:04:47,040
now the other regime is sort of

117
00:04:51,590 --> 00:04:49,120
phospholipids which are modern

118
00:04:53,110 --> 00:04:51,600
biological membrane components and

119
00:04:56,070 --> 00:04:53,120
they're a lot more stable they form

120
00:04:57,590 --> 00:04:56,080
vesicles at lower concentrations and

121
00:04:59,830 --> 00:04:57,600
they're not in equilibrium with the

122
00:05:02,070 --> 00:04:59,840
monomer in solution and so therefore

123
00:05:04,550 --> 00:05:02,080
they're a lot less leaky but in general

124
00:05:06,950 --> 00:05:04,560
there's not a good abiotic synthesis

125
00:05:08,790 --> 00:05:06,960
either of a phospholipid or even a

126
00:05:10,550 --> 00:05:08,800
double tailed surfactant so the big

127
00:05:12,870 --> 00:05:10,560
difference here is difference between a

128
00:05:15,270 --> 00:05:12,880
single tail and a double tail and so the

129
00:05:18,550 --> 00:05:15,280
question is is there a robust abiotic

130
00:05:20,390 --> 00:05:18,560
synthesis of a double-tailed membrane

131
00:05:22,629 --> 00:05:20,400
and so how we choose to try to build

132
00:05:25,909 --> 00:05:22,639
this complexity towards a double-tailed

133
00:05:27,909 --> 00:05:25,919
membrane is by using photochemistry and

134
00:05:30,070 --> 00:05:27,919
so if we look at the early earth

135
00:05:33,029 --> 00:05:30,080
solar spectrum you notice there's a lot

136
00:05:35,670 --> 00:05:33,039
more high-energy material or high-energy

137
00:05:36,870 --> 00:05:35,680
photons available that's due in part

138
00:05:38,950 --> 00:05:36,880

because the

139
00:05:41,670 --> 00:05:38,960
young sun while it was less luminous had

140
00:05:43,189 --> 00:05:41,680
more uv intensity but it's also because

141
00:05:45,830 --> 00:05:43,199
on the surface of the earth there was

142
00:05:49,270 --> 00:05:45,840
less oxygen or no oxygen and no ozone

143
00:05:50,870 --> 00:05:49,280
shield cutting off the high uv energy

144
00:05:52,950 --> 00:05:50,880
and so people usually think about this

145
00:05:56,230 --> 00:05:52,960
in terms of its destructive capabilities

146
00:05:58,469 --> 00:05:56,240
dna mutations and that kind of thing but

147
00:05:59,749 --> 00:05:58,479
it doesn't necessarily have to only be

148
00:06:01,189 --> 00:05:59,759
destructive

149
00:06:03,270 --> 00:06:01,199
there are molecules and one of the

150
00:06:05,990 --> 00:06:03,280
molecules the vital lab has

151
00:06:07,510 --> 00:06:06,000
studied sort of most is pyruvic acid

152
00:06:10,230 --> 00:06:07,520
which is actually an atmospherically

153
00:06:13,270 --> 00:06:10,240
relevant molecule today

154
00:06:15,670 --> 00:06:13,280
whose electronic spectrum overlaps the

155
00:06:17,909 --> 00:06:15,680
solar spectrum and so it can be

156
00:06:21,189 --> 00:06:17,919
energetically excited and go on to do

157
00:06:26,550 --> 00:06:23,830
and this is in fact the aqueous pyruvic

158
00:06:28,950 --> 00:06:26,560
acid photochemistry mechanism a partial

159
00:06:31,350 --> 00:06:28,960
part of it that we've studied but all we

160
00:06:34,309 --> 00:06:31,360
need to focus on right now is this main

161
00:06:36,790 --> 00:06:34,319
section so you take pyruvic acid and you

162
00:06:39,430 --> 00:06:36,800
excite it we use a xenon arc lamp so a

163
00:06:41,749 --> 00:06:39,440

solar spectrum simulator and it gets

164
00:06:44,309 --> 00:06:41,759
excited to the triplet and pi star state

165
00:06:47,110 --> 00:06:44,319
it's not super important but it reacts

166
00:06:49,350 --> 00:06:47,120
with another pyruvic acid molecule

167
00:06:51,510 --> 00:06:49,360
it forms these radicals and then the

168
00:06:53,510 --> 00:06:51,520
radicals can recombine

169
00:06:56,150 --> 00:06:53,520
to form this

170
00:06:57,749 --> 00:06:56,160
dimethyl tartaric acid and so what you

171
00:07:00,390 --> 00:06:57,759
need to see here is that we've gone from

172
00:07:03,670 --> 00:07:00,400
a three carbon molecule to a six carbon

173
00:07:05,510 --> 00:07:03,680
molecule doing photochemistry

174
00:07:07,430 --> 00:07:05,520
then the question is all right how does

175
00:07:09,029 --> 00:07:07,440
this relevant how is this relevant to

176
00:07:11,189 --> 00:07:09,039
lipids and membranes

177
00:07:13,589 --> 00:07:11,199
well if we take a molecule like pyruvic

178
00:07:15,749 --> 00:07:13,599
acid and then a different molecule like

179
00:07:18,550 --> 00:07:15,759
two oxyoctanoic acid which is basically

180
00:07:21,029 --> 00:07:18,560
pyruvic acid but with a hydrophobic tail

181
00:07:23,270 --> 00:07:21,039
it has all the same functionality and so

182
00:07:25,589 --> 00:07:23,280
we could expect that

183
00:07:27,350 --> 00:07:25,599
um this will do the same photochemistry

184
00:07:29,510 --> 00:07:27,360
and this two oxyoctanoic acid is at

185
00:07:31,430 --> 00:07:29,520
least relatively prebiotically relevant

186
00:07:33,189 --> 00:07:31,440
oxoacids have been found in meteorites

187
00:07:35,029 --> 00:07:33,199
and the it's an eight carbon molecule

188
00:07:36,629 --> 00:07:35,039

which is also relevant

189
00:07:38,390 --> 00:07:36,639
and if that's the case and it does do

190
00:07:41,189 --> 00:07:38,400
the same photochemistry then all you

191
00:07:42,309 --> 00:07:41,199
need to make a double tailed lipid are

192
00:07:44,710 --> 00:07:42,319
water

193
00:07:46,550 --> 00:07:44,720
two oxy octanoic acid and the sun in

194
00:07:48,550 --> 00:07:46,560
order to get to this which is a

195
00:07:49,909 --> 00:07:48,560
double-tailed lipid not a phospholipid

196
00:07:52,629 --> 00:07:49,919
but a lipid

197
00:07:54,469 --> 00:07:52,639
and in fact we do see that this happens

198
00:07:55,990 --> 00:07:54,479
we've confirmed it with mass spec and

199
00:07:57,990 --> 00:07:56,000
nmr and a few things like that it

200
00:08:01,029 --> 00:07:58,000
follows exactly the same photochemistry

201
00:08:03,270 --> 00:08:01,039
as pyruvic acid and we make this dihexyl

202
00:08:05,350 --> 00:08:03,280
tartaric acid

203
00:08:08,629 --> 00:08:05,360
so we've synthesized a double-tailed

204
00:08:11,270 --> 00:08:08,639
lipid exciting but what's also exciting

205
00:08:13,430 --> 00:08:11,280
is we do this chemistry we just make a

206
00:08:16,629 --> 00:08:13,440
solution of the two-ox-octanoic acid in

207
00:08:19,510 --> 00:08:16,639
a beaker shine light on it and then as

208
00:08:21,589 --> 00:08:19,520
we see we go from the clear solution

209
00:08:23,670 --> 00:08:21,599
while the photochemist which is before

210
00:08:26,390 --> 00:08:23,680
the photochemistry happens and then as

211
00:08:28,629 --> 00:08:26,400
the photochemistry occurs we see this

212
00:08:31,029 --> 00:08:28,639
cloudiness we see these the solution

213
00:08:32,630 --> 00:08:31,039

turns opalescent and we're in fact just

214
00:08:35,589 --> 00:08:32,640
in the course of photolysis

215
00:08:37,509 --> 00:08:35,599
self-assembling into ordered assemblies

216
00:08:39,670 --> 00:08:37,519
and we started characterizing what these

217
00:08:42,469 --> 00:08:39,680
3d structures are

218
00:08:44,310 --> 00:08:42,479
we've done both confocal and phase

219
00:08:46,470 --> 00:08:44,320
contrast microscopy fluorescence

220
00:08:48,070 --> 00:08:46,480
microscopy and we see that they have a

221
00:08:49,990 --> 00:08:48,080
spherical shape which indicates that

222
00:08:52,389 --> 00:08:50,000
they're an ordered assembly rather than

223
00:08:53,990 --> 00:08:52,399
disordered aggregation

224
00:08:56,150 --> 00:08:54,000
we also have done dynamic light

225
00:08:57,829 --> 00:08:56,160
scattering to look at the size of them

226
00:08:58,870 --> 00:08:57,839
and we see that they're a single type of

227
00:09:00,790 --> 00:08:58,880
structure they're relatively

228
00:09:03,110 --> 00:09:00,800
monodispersed in size

229
00:09:05,509 --> 00:09:03,120
and their radius which is on the order

230
00:09:07,430 --> 00:09:05,519
of 100 nanometers is much more

231
00:09:09,350 --> 00:09:07,440
in keeping with a vesicle rather than a

232
00:09:11,030 --> 00:09:09,360
micelle or something like that so taking

233
00:09:13,829 --> 00:09:11,040
this together we're pretty confident

234
00:09:15,509 --> 00:09:13,839
that we have vesicles and they're not in

235
00:09:17,990 --> 00:09:15,519
equilibrium with micelles as they would

236
00:09:19,750 --> 00:09:18,000
be with say a fatty acid

237
00:09:21,110 --> 00:09:19,760
and we're con currently confirming this

238
00:09:23,990 --> 00:09:21,120

characterization with both dye

239
00:09:25,350 --> 00:09:24,000
encapsulation and cryo-oem experiments

240
00:09:27,350 --> 00:09:25,360
but if you do think that we have

241
00:09:29,590 --> 00:09:27,360
vesicles we need to talk about their

242
00:09:32,550 --> 00:09:29,600
stability and so there's stability to

243
00:09:34,070 --> 00:09:32,560
divide divalent cations like magnesium

244
00:09:35,590 --> 00:09:34,080
these are all preliminary results but

245
00:09:37,110 --> 00:09:35,600
we've seen to some extent that they do

246
00:09:39,910 --> 00:09:37,120
appear to be at least a little bit more

247
00:09:42,310 --> 00:09:39,920
robust than just fatty acid vesicles

248
00:09:45,190 --> 00:09:42,320
in the presence of magnesium and then in

249
00:09:46,870 --> 00:09:45,200
terms of their temporal stability um so

250
00:09:49,190 --> 00:09:46,880
again this is the pre-photolysis and

251
00:09:52,230 --> 00:09:49,200
this the postolysis this

252
00:09:54,550 --> 00:09:52,240
particular picture is from july

253
00:09:55,750 --> 00:09:54,560
31st 2013 which means tomorrow is their

254
00:09:58,389 --> 00:09:55,760
first birthday and they're sitting in

255
00:09:59,269 --> 00:09:58,399
the fridge living happily or not living

256
00:10:01,350 --> 00:09:59,279
but

257
00:10:03,670 --> 00:10:01,360
sitting around so they seem to be quite

258
00:10:05,750 --> 00:10:03,680
stable temporally they don't seem to

259
00:10:07,829 --> 00:10:05,760
make big aggregates and separate out

260
00:10:08,710 --> 00:10:07,839
that kind of thing

261
00:10:11,750 --> 00:10:08,720
so

262
00:10:13,670 --> 00:10:11,760
what we don't really know exactly is the

263
00:10:16,470 --> 00:10:13,680

importance that the kinetics of this

264
00:10:19,190 --> 00:10:16,480
process may have it looks like the

265
00:10:21,590 --> 00:10:19,200
longer photolysis time that we have for

266
00:10:24,069 --> 00:10:21,600
our particular thing appears to actually

267
00:10:26,069 --> 00:10:24,079
destabilize the vesicles they last less

268
00:10:28,230 --> 00:10:26,079
long if we did a longer photochemical

269
00:10:30,870 --> 00:10:28,240
experiment at the beginning and that may

270
00:10:32,550 --> 00:10:30,880
be in part to this minor product that we

271
00:10:35,269 --> 00:10:32,560
make and i won't go into the mechanism

272
00:10:37,430 --> 00:10:35,279
too much but it's

273
00:10:39,269 --> 00:10:37,440
you take the two oxaloactinoic acid

274
00:10:41,670 --> 00:10:39,279
which is a starting material and you end

275
00:10:43,110 --> 00:10:41,680
up making pyruvic acid and then the two

276
00:10:45,110 --> 00:10:43,120
of them come together to make this

277
00:10:48,710 --> 00:10:45,120
methyl hexyl tartaric acid so it's a

278
00:10:51,590 --> 00:10:48,720
single-tailed molecule and it comes into

279
00:10:53,509 --> 00:10:51,600
play at longer time scales and so

280
00:10:55,030 --> 00:10:53,519
basically

281
00:10:57,590 --> 00:10:55,040
we want to know what the ratio of the

282
00:10:59,269 --> 00:10:57,600
single double tail might be important

283
00:11:02,389 --> 00:10:59,279
and if that's the case then maybe rather

284
00:11:03,990 --> 00:11:02,399
than just having double tailed lipids

285
00:11:06,150 --> 00:11:04,000
we have a mixture of double-tailed and

286
00:11:09,350 --> 00:11:06,160
single-tailed lipids so then what we're

287
00:11:11,350 --> 00:11:09,360
most interested in in terms of

288
00:11:13,269 --> 00:11:11,360

this and being at least reasonably

289
00:11:15,509 --> 00:11:13,279
physical chemists is the role that the

290
00:11:17,829 --> 00:11:15,519
surface is playing so i mentioned that

291
00:11:19,030 --> 00:11:17,839
surfactants partition preferentially to

292
00:11:22,230 --> 00:11:19,040
the surface

293
00:11:24,790 --> 00:11:22,240
well double-tailed surfactants partition

294
00:11:26,069 --> 00:11:24,800
much more preferentially to the surface

295
00:11:27,750 --> 00:11:26,079
and so if we're doing this

296
00:11:29,509 --> 00:11:27,760
photochemistry in an undisturbed

297
00:11:31,750 --> 00:11:29,519
reaction and they're folding up into

298
00:11:33,590 --> 00:11:31,760
these structures it makes sense that the

299
00:11:35,269 --> 00:11:33,600
surface would have some sort of role and

300
00:11:37,509 --> 00:11:35,279
if we can begin to characterize that

301
00:11:40,870 --> 00:11:37,519
mechanism for self-assembly then we

302
00:11:42,870 --> 00:11:40,880
begin to um understand

303
00:11:44,310 --> 00:11:42,880
i guess how this is happening and the

304
00:11:46,389 --> 00:11:44,320
other thing to keep in mind is the role

305
00:11:48,150 --> 00:11:46,399
of ph we're dealing with oxo acids so

306
00:11:49,829 --> 00:11:48,160
we're in relatively acidic environments

307
00:11:52,310 --> 00:11:49,839
and we're starting to look more at the

308
00:11:54,550 --> 00:11:52,320
changing the ph of the photochemistry

309
00:11:56,870 --> 00:11:54,560
but um

310
00:11:58,389 --> 00:11:56,880
if the protonation state is important

311
00:12:01,190 --> 00:11:58,399
you might think that the cell that the

312
00:12:03,269 --> 00:12:01,200
photochemistry um would happen more

313
00:12:05,190 --> 00:12:03,279

readily in acidic environments but the

314
00:12:07,350 --> 00:12:05,200
self-assembly might happen more readily

315
00:12:09,030 --> 00:12:07,360
in basic environments and if that's the

316
00:12:11,269 --> 00:12:09,040
case we need to look at the various

317
00:12:12,710 --> 00:12:11,279
different water surfaces that would have

318
00:12:14,310 --> 00:12:12,720
been available

319
00:12:16,470 --> 00:12:14,320
um either on

320
00:12:18,310 --> 00:12:16,480
on the early earth and so you have the

321
00:12:20,710 --> 00:12:18,320
ocean ph but you also have all of these

322
00:12:23,430 --> 00:12:20,720
atmospheric aqueous aerosols which have

323
00:12:25,590 --> 00:12:23,440
a lower ph in general and undergo a lot

324
00:12:27,910 --> 00:12:25,600
of reactions and a lot of sort of

325
00:12:29,910 --> 00:12:27,920
processing in the process so you kind of

326
00:12:32,150 --> 00:12:29,920
need to think about this cycle between

327
00:12:34,710 --> 00:12:32,160
the atmospheric aerosols and the water

328
00:12:36,150 --> 00:12:34,720
surface on the ocean

329
00:12:37,750 --> 00:12:36,160
and so

330
00:12:39,030 --> 00:12:37,760
i just want to thank everybody

331
00:12:40,470 --> 00:12:39,040
especially elizabeth griffith who

332
00:12:48,310 --> 00:12:40,480
started off on this

333
00:12:48,320 --> 00:13:00,870
questions

334
00:13:05,430 --> 00:13:02,870
um so i was wondering a lot of the

335
00:13:07,990 --> 00:13:05,440
problems with prebiotic chemistry is a

336
00:13:09,990 --> 00:13:08,000
matter of yields and kind of dilution

337
00:13:11,910 --> 00:13:10,000
and an infinitely large ocean

338
00:13:13,590 --> 00:13:11,920

so i was wondering um what

339
00:13:15,030 --> 00:13:13,600
concentrations you're working at if

340
00:13:16,949 --> 00:13:15,040
they're near the critical micelle

341
00:13:20,069 --> 00:13:16,959
concentration and if that's pretty

342
00:13:23,430 --> 00:13:20,079
radically plausible so we work with

343
00:13:25,509 --> 00:13:23,440
about 6 millimolar 2-oxo octanoic acid

344
00:13:27,910 --> 00:13:25,519
which is at about the solubility limit

345
00:13:30,389 --> 00:13:27,920
of that molecule um

346
00:13:32,069 --> 00:13:30,399
it's nowhere near we don't ever see any

347
00:13:33,269 --> 00:13:32,079
micelles in the precursor so we're not

348
00:13:36,069 --> 00:13:33,279
close to

349
00:13:37,990 --> 00:13:36,079
the critical uh micelle concentration

350
00:13:41,509 --> 00:13:38,000
and for similar acid

351
00:13:43,269 --> 00:13:41,519
of the same length it's a 145 millimolar

352
00:13:44,710 --> 00:13:43,279
or something like that so it does seem

353
00:13:45,910 --> 00:13:44,720
to be that the double tailed is

354
00:13:48,790 --> 00:13:45,920
exceeding the critical vesicle

355
00:13:51,590 --> 00:13:48,800
concentration more than the single tail

356
00:13:53,190 --> 00:13:51,600
in terms of the concentration overall

357
00:13:54,710 --> 00:13:53,200
that's where maybe the atmospheric

358
00:13:56,230 --> 00:13:54,720
aerosols come into play because if

359
00:13:57,189 --> 00:13:56,240
you're partitioning the surface you're

360
00:13:59,430 --> 00:13:57,199
going to get enhancement in

361
00:14:01,590 --> 00:13:59,440
concentration and also if you're in an

362
00:14:04,470 --> 00:14:01,600
aerosol you've got a much higher surface

363
00:14:06,150 --> 00:14:04,480

area to volume ratio in general

364
00:14:08,069 --> 00:14:06,160
and you can evaporate some of the water

365
00:14:09,750 --> 00:14:08,079
off