
AbSciCon
2019

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

2
00:00:13,589 --> 00:00:09,079
[Applause]

3
00:00:15,869 --> 00:00:13,599
so I've truncated my title down to wet

4
00:00:18,650 --> 00:00:15,879
dry environmental cycles and alternative

5
00:00:22,740 --> 00:00:18,660
building blocks in prebiotic chemistry

6
00:00:24,779 --> 00:00:22,750
and as Bruce said I'm going to talk

7
00:00:26,820 --> 00:00:24,789
about some of the successes we've had in

8
00:00:29,269 --> 00:00:26,830
the Center for chemical evolution I'm

9
00:00:31,499 --> 00:00:29,279
also going to start out with some of our

10
00:00:34,350 --> 00:00:31,509
guiding principles or if you will

11
00:00:36,780 --> 00:00:34,360
truisms and hypotheses that have been

12
00:00:38,430 --> 00:00:36,790
guiding our research you can decide

13
00:00:40,950 --> 00:00:38,440

whether you think something is true or

14
00:00:45,210 --> 00:00:40,960
it's a hypothesis or how quite

15
00:00:47,630 --> 00:00:45,220
questionable I'll say that we follow the

16
00:00:49,950 --> 00:00:47,640
principle life is based on polymers that

17
00:00:52,590 --> 00:00:49,960
the emergence of biopolymers was

18
00:00:55,890 --> 00:00:52,600
essential to the origins of life and

19
00:00:58,429 --> 00:00:55,900
that the synthesis that the first

20
00:01:01,679 --> 00:00:58,439
syntheses of biopolymers was a result of

21
00:01:03,420 --> 00:01:01,689
geophysical geochemical cycles and what

22
00:01:07,530 --> 00:01:03,430
I'd like to just say special organic

23
00:01:12,450 --> 00:01:07,540
molecules specialized in special

24
00:01:14,130 --> 00:01:12,460
properties not necessarily rare and I'll

25
00:01:15,720 --> 00:01:14,140
continue and say that the molecules and

26
00:01:18,810 --> 00:01:15,730
reactions that gave rise to the first

27
00:01:23,010 --> 00:01:18,820
power polymers were simple maybe special

28
00:01:25,649 --> 00:01:23,020
but simple and robust and I'll go on to

29
00:01:29,910 --> 00:01:25,659
say that this is a principle that's been

30
00:01:33,180 --> 00:01:29,920
guiding us for over a decade and we say

31
00:01:34,710 --> 00:01:33,190
that if an experiment the mall model for

32
00:01:39,540 --> 00:01:34,720
a particular step in the origin of life

33
00:01:41,880 --> 00:01:39,550
is correct then we think that the model

34
00:01:43,860 --> 00:01:41,890
should solve more problems than just the

35
00:01:46,140 --> 00:01:43,870
problem that the model is designed to

36
00:01:49,170 --> 00:01:46,150
solve in the very least it should not

37
00:01:50,640 --> 00:01:49,180
generate more but ideally if you're on

38
00:01:53,940 --> 00:01:50,650

the right track it should solve more

39
00:01:55,740 --> 00:01:53,950
problems than you know and if that's

40
00:02:00,289 --> 00:01:55,750
true then you should discover what we

41
00:02:02,160 --> 00:02:00,299
call bonus solutions so I'll start with

42
00:02:05,399 --> 00:02:02,170
inspiration on the design of our

43
00:02:07,469 --> 00:02:05,409
experiments and that's extant

44
00:02:10,740 --> 00:02:07,479
biopolymers then all of these are

45
00:02:13,259 --> 00:02:10,750
synthesized by what are called

46
00:02:15,180 --> 00:02:13,269
condensation bonds such as two amino

47
00:02:17,250 --> 00:02:15,190
acids linked together give off water and

48
00:02:18,130 --> 00:02:17,260
the formation of condensation bond you

49
00:02:20,290 --> 00:02:18,140
keep doing that

50
00:02:22,449 --> 00:02:20,300
you know acids each time a water comes

51
00:02:24,880 --> 00:02:22,459
off to make a polypeptide same thing

52
00:02:29,590 --> 00:02:24,890
with polysaccharides nucleic acids and

53
00:02:31,540 --> 00:02:29,600
lipids those type of bonds present what

54
00:02:33,670 --> 00:02:31,550
is the first problem that we had to

55
00:02:36,930 --> 00:02:33,680
address which is the best place to form

56
00:02:39,550 --> 00:02:36,940
condensation ponds is in a hot dry

57
00:02:41,140 --> 00:02:39,560
environment because if you want to drive

58
00:02:43,690 --> 00:02:41,150
this reaction to the right you want to

59
00:02:45,100 --> 00:02:43,700
get rid of water so a surface arid

60
00:02:47,170 --> 00:02:45,110
surface is the best place but

61
00:02:49,000 --> 00:02:47,180
biopolymers they followed they function

62
00:02:53,590 --> 00:02:49,010
and they evolved in water you know

63
00:02:55,240 --> 00:02:53,600

that's a principle of them so we look

64
00:02:56,949 --> 00:02:55,250
for simple solutions that's what we've

65
00:02:59,140 --> 00:02:56,959
been focused on a simple solution to

66
00:03:00,940 --> 00:02:59,150
this is that the polymers of life were

67
00:03:05,020 --> 00:03:00,950
originally formed on the surface of the

68
00:03:06,940 --> 00:03:05,030
earth as a result of wet/dry cycles this

69
00:03:09,610 --> 00:03:06,950
is not a new idea we think that it's

70
00:03:12,040 --> 00:03:09,620
though parsimoniously the most obvious

71
00:03:14,350 --> 00:03:12,050
solution to it fits really well with the

72
00:03:17,890 --> 00:03:14,360
chemistry of the polymers with possible

73
00:03:19,990 --> 00:03:17,900
environments on the earth however early

74
00:03:22,780 --> 00:03:20,000
on we ran into another problem with this

75
00:03:24,850 --> 00:03:22,790
which is that this idea again is not new

76
00:03:26,770 --> 00:03:24,860
and attempts to make polypeptides by

77
00:03:29,860 --> 00:03:26,780
simply drying and heating amino acids

78
00:03:31,979 --> 00:03:29,870
have not provided satisfactory results

79
00:03:34,960 --> 00:03:31,989
we know that some of the earliest

80
00:03:38,050 --> 00:03:34,970
attempts to make vial polymers were from

81
00:03:40,360 --> 00:03:38,060
Sidney Fox and his collaborators and

82
00:03:42,280 --> 00:03:40,370
back in the 50s they had a results are

83
00:03:44,830 --> 00:03:42,290
pretty high temperatures that resulted

84
00:03:47,470 --> 00:03:44,840
in non peptide products there's been

85
00:03:50,920 --> 00:03:47,480
some nice advances in that area again

86
00:03:53,800 --> 00:03:50,930
but we've got some issues still Lahav

87
00:03:56,560 --> 00:03:53,810
Road and others have looked to do this

88
00:03:59,080 --> 00:03:56,570

under lower temperatures where you don't

89
00:04:00,940 --> 00:03:59,090
get those side products they typically

90
00:04:02,740 --> 00:04:00,950
get pretty low yields about one to two

91
00:04:03,670 --> 00:04:02,750
percent of just dipeptides or

92
00:04:06,610 --> 00:04:03,680
tripeptides

93
00:04:09,009 --> 00:04:06,620
so a possible solution to this problem

94
00:04:12,100 --> 00:04:09,019
is that polypeptides are preceded by

95
00:04:13,660 --> 00:04:12,110
what we'll call proto polypeptides with

96
00:04:16,449 --> 00:04:13,670
structures chemical linkages that are

97
00:04:18,550 --> 00:04:16,459
similar but distinct okay and that's

98
00:04:19,779 --> 00:04:18,560
important just change one atom and it

99
00:04:21,880 --> 00:04:19,789
can totally change the chemical

100
00:04:23,740 --> 00:04:21,890
properties of a molecule so they were

101
00:04:26,529 --> 00:04:23,750
similar but distinct from polypeptides

102
00:04:29,290 --> 00:04:26,539
so an obvious one would be that

103
00:04:31,670 --> 00:04:29,300
polypeptides were preceded by polyesters

104
00:04:33,890 --> 00:04:31,680
again not in not a original

105
00:04:37,939 --> 00:04:33,900
my idea the ester linkage was proposed

106
00:04:40,820 --> 00:04:37,949
back at least 1971 by rich and and then

107
00:04:44,110 --> 00:04:40,830
later or Gail discussed it and we liked

108
00:04:46,730 --> 00:04:44,120
this idea a lot because amino acids have

109
00:04:48,529 --> 00:04:46,740
hydroxy acids as analogues just change

110
00:04:50,659 --> 00:04:48,539
the amino group to hydroxyl group there

111
00:04:52,100 --> 00:04:50,669
and hydroxy acids they're used in life

112
00:04:54,290 --> 00:04:52,110
today they're produced in milli your

113
00:04:57,529 --> 00:04:54,300

experiments are found in meteorites so

114
00:04:59,150 --> 00:04:57,539
it looked like a real possibility that

115
00:05:02,150 --> 00:04:59,160
life would have started with polyesters

116
00:05:05,810 --> 00:05:02,160
so that's a simple solution and what we

117
00:05:08,029 --> 00:05:05,820
did find is that if we dry down these

118
00:05:10,790 --> 00:05:08,039
hydroxy acids what we do make ester

119
00:05:14,659 --> 00:05:10,800
linked oligomers just shown here as a

120
00:05:18,110 --> 00:05:14,669
lactic acid dimer but this is the first

121
00:05:20,839 --> 00:05:18,120
bonus that we found in pursuing this is

122
00:05:23,960 --> 00:05:20,849
that hydroxy acids catalyze peptide bond

123
00:05:26,210 --> 00:05:23,970
formation and what we found is that if

124
00:05:31,100 --> 00:05:26,220
we mix them you know acids in with the

125
00:05:33,080 --> 00:05:31,110
products of hydroxy acid condensation or

126
00:05:35,870 --> 00:05:33,090
even just start at the beginning and mix

127
00:05:37,850 --> 00:05:35,880
them all together that we have a mean

128
00:05:40,850 --> 00:05:37,860
ester exchange that leads to peptide

129
00:05:43,100 --> 00:05:40,860
bond formation so that to us was was a

130
00:05:45,469 --> 00:05:43,110
big bonus and so we thought the idea of

131
00:05:49,189 --> 00:05:45,479
using hydroxy acid looks like a really

132
00:05:50,710 --> 00:05:49,199
good route to polypeptides now there

133
00:05:53,600 --> 00:05:50,720
were some other bonuses that came out

134
00:05:56,270 --> 00:05:53,610
what we found is that if you look in the

135
00:05:57,860 --> 00:05:56,280
literature there was quite a bias on

136
00:05:59,719 --> 00:05:57,870
just drawing down the amino acids on

137
00:06:02,450 --> 00:05:59,729
what the composition is what sequences

138
00:06:06,230 --> 00:06:02,460

were favored and what we found from the

139
00:06:08,149 --> 00:06:06,240
start just mixing glycine and alanine

140
00:06:11,180 --> 00:06:08,159
that we were able to get all the

141
00:06:12,980 --> 00:06:11,190
sequences that were possible this is our

142
00:06:15,529 --> 00:06:12,990
initial results where we're just doing

143
00:06:19,189 --> 00:06:15,539
alanine and glycine and just looking at

144
00:06:21,529 --> 00:06:19,199
these Penta Murs here we're just based

145
00:06:25,040 --> 00:06:21,539
upon the molecular weight they have two

146
00:06:26,719 --> 00:06:25,050
lactic acids in and through one alanine

147
00:06:29,749 --> 00:06:26,729
and one and two glycines that we see

148
00:06:32,240 --> 00:06:29,759
that we got all possible sequences we

149
00:06:34,909 --> 00:06:32,250
took this further where we did mixtures

150
00:06:37,730 --> 00:06:34,919
with more amino acids and more hydroxy

151
00:06:40,159 --> 00:06:37,740
acids and what we found is that the

152
00:06:43,439 --> 00:06:40,169
sequence space that we generated is

153
00:06:45,480 --> 00:06:43,449
enormous in fact we we had to develop

154
00:06:48,059 --> 00:06:45,490
new methods that's what's illustrated

155
00:06:50,730 --> 00:06:48,069
here by these 3d plots actually even in

156
00:06:52,619 --> 00:06:50,740
a four dimensional plot to show the

157
00:06:55,920 --> 00:06:52,629
diversity of products that that were

158
00:06:59,549 --> 00:06:55,930
generating so it's again a big bonus

159
00:07:01,499 --> 00:06:59,559
beyond what we had expected there and

160
00:07:04,110 --> 00:07:01,509
I'm going to add one very recent bonus

161
00:07:08,070 --> 00:07:04,120
that's gonna come out very soon which is

162
00:07:09,929 --> 00:07:08,080
that drying these mixtures where we look

163
00:07:12,510 --> 00:07:09,939

at the difference between the

164
00:07:14,399 --> 00:07:12,520
proteinaceous amino acids and non

165
00:07:16,709 --> 00:07:14,409
protease that is those that are found in

166
00:07:18,929 --> 00:07:16,719
the coding of proteins versus those that

167
00:07:21,839 --> 00:07:18,939
are not there seems to be a preference

168
00:07:23,879 --> 00:07:21,849
here for the incorporation at least in

169
00:07:26,519 --> 00:07:23,889
the cationic amino acids for the

170
00:07:30,439 --> 00:07:26,529
proteinaceous woods which may be telling

171
00:07:33,329 --> 00:07:30,449
us something about why and how early

172
00:07:37,200 --> 00:07:33,339
lysine and arginine were selected into

173
00:07:39,779 --> 00:07:37,210
polypeptides so this study here was

174
00:07:41,519 --> 00:07:39,789
headed up by Moran Pinter and Lou

175
00:07:43,739 --> 00:07:41,529
Clayman and Lauren Williams really

176
00:07:45,869 --> 00:07:43,749
acting as the main PI's on this project

177
00:07:48,029 --> 00:07:45,879
and as I said this is coming out very

178
00:07:50,399 --> 00:07:48,039
soon just accepted yesterday and if you

179
00:07:53,760 --> 00:07:50,409
want to hear it talk on this Moran is

180
00:07:57,409 --> 00:07:53,770
giving a talk tomorrow on this so

181
00:08:01,469 --> 00:07:57,419
there's a similar story when it comes to

182
00:08:04,019 --> 00:08:01,479
nucleic acids and I will hopefully admit

183
00:08:06,600 --> 00:08:04,029
nucleic acids are more complex than

184
00:08:09,600 --> 00:08:06,610
polypeptides we know you can make the

185
00:08:11,219 --> 00:08:09,610
building blocks of polypeptides amino

186
00:08:13,619 --> 00:08:11,229
acids and model prebiotic reactions

187
00:08:15,480 --> 00:08:13,629
there's a lot of challenges with sugars

188
00:08:17,429 --> 00:08:15,490

less with bases there's challenges

189
00:08:19,050 --> 00:08:17,439
phosphate but then these all have to be

190
00:08:21,029 --> 00:08:19,060
connected into nucleotides and they're

191
00:08:24,839 --> 00:08:21,039
polymerized so those are additional

192
00:08:27,179 --> 00:08:24,849
challenges so in the CC we've also been

193
00:08:29,519 --> 00:08:27,189
hypothesizing that RNA as a result of

194
00:08:31,829 --> 00:08:29,529
multiple evolutionary steps that the

195
00:08:33,870 --> 00:08:31,839
base sugar connecting molecules have all

196
00:08:36,329 --> 00:08:33,880
changed something that we wrote about in

197
00:08:39,420 --> 00:08:36,339
a paper we called my grandfather's axe a

198
00:08:41,370 --> 00:08:39,430
few years ago and again what are the

199
00:08:44,240 --> 00:08:41,380
problems that we have with nucleic acids

200
00:08:47,069 --> 00:08:44,250
well one of them is that in a simple

201
00:08:50,610 --> 00:08:47,079
model prebiotic reaction where the

202
00:08:53,309 --> 00:08:50,620
extant bases are dried with ribose they

203
00:08:56,040 --> 00:08:53,319
produce nucleosides in either low yield

204
00:08:56,999 --> 00:08:56,050
or in no yield so this has been a big

205
00:09:00,119 --> 00:08:57,009
problem

206
00:09:03,660 --> 00:09:00,129
in the field again a simple solution to

207
00:09:06,869 --> 00:09:03,670
this could be that the nucleobases that

208
00:09:09,569 --> 00:09:06,879
were in proto RNA an ancestor of RNA

209
00:09:11,819 --> 00:09:09,579
were different in this case we've looked

210
00:09:14,400 --> 00:09:11,829
at melamine I'm showing you here and

211
00:09:17,009 --> 00:09:14,410
barbecue rock acid you could see this is

212
00:09:19,199 --> 00:09:17,019
perhaps taking the place of adenine and

213
00:09:21,179 --> 00:09:19,209

this is taking the place of your cell we

214
00:09:24,479 --> 00:09:21,189
tested these molecules and simple dry

215
00:09:26,369 --> 00:09:24,489
down reactions melamine gives us 55

216
00:09:30,150 --> 00:09:26,379
percent yield of both the alpha and beta

217
00:09:33,329 --> 00:09:30,160
anomers of the nucleotides and Barbic

218
00:09:36,539 --> 00:09:33,339
tear gas that gives us 82 so these work

219
00:09:39,419 --> 00:09:36,549
really well we also get bonuses though

220
00:09:42,210 --> 00:09:39,429
these alternative nucleobases those that

221
00:09:45,449 --> 00:09:42,220
form glycosides very easily with rivals

222
00:09:47,970 --> 00:09:45,459
with ribose also form them with many

223
00:09:49,949 --> 00:09:47,980
different sugars basically every sugar

224
00:09:53,009 --> 00:09:49,959
that we tested except for some modified

225
00:09:56,340 --> 00:09:53,019
sugars are showing the formation of

226
00:09:58,289 --> 00:09:56,350
glycosides with our bases so this could

227
00:10:01,799 --> 00:09:58,299
relax the constraints on getting ribose

228
00:10:03,210 --> 00:10:01,809
first david fiallo and Tyler Roach are

229
00:10:05,039 --> 00:10:03,220
working on this so you can talk to them

230
00:10:06,600 --> 00:10:05,049
they're here at this meeting and Tyler

231
00:10:10,439 --> 00:10:06,610
is giving a talk tomorrow

232
00:10:11,340 --> 00:10:10,449
on this topic another bonus that we

233
00:10:14,159 --> 00:10:11,350
found is that these alternative

234
00:10:16,669 --> 00:10:14,169
nucleobases self-assemble in water as

235
00:10:20,220 --> 00:10:16,679
monomers the extant bases don't do that

236
00:10:23,309 --> 00:10:20,230
you could see here this is an AFM image

237
00:10:25,650 --> 00:10:23,319
of non-covalent assemblies yet another

238
00:10:28,350 --> 00:10:25,660

bonus that we found with this is that

239
00:10:31,559 --> 00:10:28,360
they have a very very strong propensity

240
00:10:35,369 --> 00:10:31,569
to adopt homo chiral domains

241
00:10:37,590 --> 00:10:35,379
dr. Shanice Caro and karna is here and

242
00:10:40,460 --> 00:10:37,600
he will be giving a poster tonight and a

243
00:10:44,090 --> 00:10:40,470
lightning talk on Friday about how these

244
00:10:47,789 --> 00:10:44,100
plausible prebiotic bases make these

245
00:10:50,189 --> 00:10:47,799
homo chiral domains which we are quite

246
00:10:52,949 --> 00:10:50,199
excited about yet another bonus is that

247
00:10:56,249 --> 00:10:52,959
if we take what we've learned from our

248
00:10:58,679 --> 00:10:56,259
polypeptide work and our nucleo base

249
00:11:00,779 --> 00:10:58,689
work our pro to nuclear base work we put

250
00:11:03,539 --> 00:11:00,789
them together and we can now see just

251
00:11:06,569 --> 00:11:03,549
what might be possible structures for

252
00:11:08,750 --> 00:11:06,579
proto RNA these are just theoretical but

253
00:11:10,700 --> 00:11:08,760
I think that these have a lot

254
00:11:12,940 --> 00:11:10,710
the attributes that we would look be

255
00:11:16,400 --> 00:11:12,950
looking for for a very simple system

256
00:11:18,320 --> 00:11:16,410
that could be composed out of plausible

257
00:11:21,080 --> 00:11:18,330
prebiotic building blocks they can

258
00:11:23,480 --> 00:11:21,090
polymerize and start to evolve and again

259
00:11:25,370 --> 00:11:23,490
David and Senesh are here and David will

260
00:11:28,730 --> 00:11:25,380
be giving a poster tonight and the

261
00:11:31,520 --> 00:11:28,740
Lightning talked about this system so

262
00:11:33,440 --> 00:11:31,530
these are not all of the collaborators

263
00:11:35,810 --> 00:11:33,450

in the CCE but I've tried to pick the

264
00:11:37,700 --> 00:11:35,820
ones that I've highlighted the work on

265
00:11:40,550 --> 00:11:37,710
you can see this is a huge team effort

266
00:11:43,100 --> 00:11:40,560
and I feel very fortunate to work with

267
00:11:45,200 --> 00:11:43,110
so many talented people and there's even

268
00:11:47,630 --> 00:11:45,210
more here's the at the last Center

269
00:11:49,880 --> 00:11:47,640
meeting here and so I've got to thank

270
00:11:52,640 --> 00:11:49,890
everyone in the CCE and members of my

271
00:11:56,030 --> 00:11:52,650
lab for contributing to these projects

272
00:12:00,650 --> 00:11:56,040
in such a wonderful insightful way and

273
00:12:09,760 --> 00:12:00,660
also to NSF and NASA Astrobiology for

274
00:12:17,270 --> 00:12:14,060
we have time for a couple of questions

275
00:12:19,400 --> 00:12:17,280
for Nick if if you'd like to line up we

276
00:12:21,020 --> 00:12:19,410
have one here hi I'm Mike Wong from the

277
00:12:23,330 --> 00:12:21,030
University of Washington I'm really

278
00:12:25,250 --> 00:12:23,340
intrigued by the idea that the original

279
00:12:27,080 --> 00:12:25,260
nucleobases could have been different

280
00:12:28,760 --> 00:12:27,090
from the ones that we see today and I

281
00:12:31,340 --> 00:12:28,770
was wondering if you've identified any

282
00:12:33,350 --> 00:12:31,350
plausible reasons why there was a switch

283
00:12:35,960 --> 00:12:33,360
from those original nucleobases that you

284
00:12:39,170 --> 00:12:35,970
suggests to the ones that that we find

285
00:12:41,210 --> 00:12:39,180
in RNA today so one of the principles

286
00:12:43,250 --> 00:12:41,220
we've also been operating on is with

287
00:12:46,640 --> 00:12:43,260
respect to the nucleobases we think that

288
00:12:48,830 --> 00:12:46,650

easy to form nucleosides also translates

289
00:12:50,750 --> 00:12:48,840
to easy to have them break apart and so

290
00:12:52,790 --> 00:12:50,760
that's where we see that the the extant

291
00:12:55,190 --> 00:12:52,800
ones are definitely more stable so one

292
00:12:57,770 --> 00:12:55,200
reason could be that a transition took

293
00:13:00,890 --> 00:12:57,780
place to make what is proto RNA one is

294
00:13:03,860 --> 00:13:00,900
becoming RNA a more stable molecule at

295
00:13:05,600 --> 00:13:03,870
the nucleo base level also there are

296
00:13:06,980 --> 00:13:05,610
some reasons if we draw them out that we

297
00:13:08,990 --> 00:13:06,990
could think about in terms of diversity

298
00:13:10,970 --> 00:13:09,000
of structures and baking and breaking

299
00:13:12,410 --> 00:13:10,980
symmetry between the base pairs and the

300
00:13:15,620 --> 00:13:12,420
minor groove for example that really

301
00:13:18,130 --> 00:13:15,630
point to the extant ones being superior

302
00:13:23,200 --> 00:13:18,140
to what we're looking at thank you

303
00:13:30,970 --> 00:13:27,600
can I ask you a question yeah okay this

304
00:13:33,070 --> 00:13:30,980
Steve banner sort of is arguing about

305
00:13:38,710 --> 00:13:33,080
the org that the origin of RNA is a

306
00:13:42,190 --> 00:13:38,720
solved problem and thinks that it was

307
00:13:55,390 --> 00:13:42,200
the first prebiotic polymer and I just

308
00:13:58,650 --> 00:13:55,400
wondering if you could comment I I'm

309
00:14:02,440 --> 00:13:58,660
gonna accept that that the problem is

310
00:14:05,590 --> 00:14:02,450
solved or a plausible prebiotic polymer

311
00:14:07,780 --> 00:14:05,600
when somebody can take ingredients that

312
00:14:09,430 --> 00:14:07,790
yeah you know I'd say at least a quarter

313
00:14:12,670 --> 00:14:09,440

of us in the room would say those are

314
00:14:14,860 --> 00:14:12,680
plausible building blocks and puts it

315
00:14:19,000 --> 00:14:14,870
through a very simple cycle such as

316
00:14:20,980 --> 00:14:19,010
hydration dehydration cycles and we can

317
00:14:23,620 --> 00:14:20,990
do an analysis and we've got oligomers

318
00:14:27,100 --> 00:14:23,630
that are long enough to fold up and

319
00:14:29,710 --> 00:14:27,110
maybe show some signs of rudimentary

320
00:14:32,350 --> 00:14:29,720
evolution when that's done then I'll say

321
00:14:34,780 --> 00:14:32,360
okay I can accept that what I said

322
00:14:38,020 --> 00:14:34,790
Lauren was that several of the key

323
00:14:41,650 --> 00:14:38,030
paradoxes that made it appear as if the

324
00:14:44,290 --> 00:14:41,660
RNA world model was impossible have been

325
00:14:45,640 --> 00:14:44,300
resolved what I have now done and I

326
00:14:47,470 --> 00:14:45,650
mentioned this a couple of minutes ago

327
00:14:49,420 --> 00:14:47,480
is that there are now when you solve a

328
00:14:52,300 --> 00:14:49,430
certain set of these paradoxes you

329
00:14:55,620 --> 00:14:52,310
encounter new ones and so those are the

330
00:14:58,390 --> 00:14:55,630
ones that are now where focus should be

331
00:15:02,080 --> 00:14:58,400
directed if you want to develop that as

332
00:15:08,260 --> 00:15:06,910
I think it were we return hon yeah so

333
00:15:10,910 --> 00:15:08,270
for the sake of staying on schedule

334
00:15:12,030 --> 00:15:10,920
Arne yes