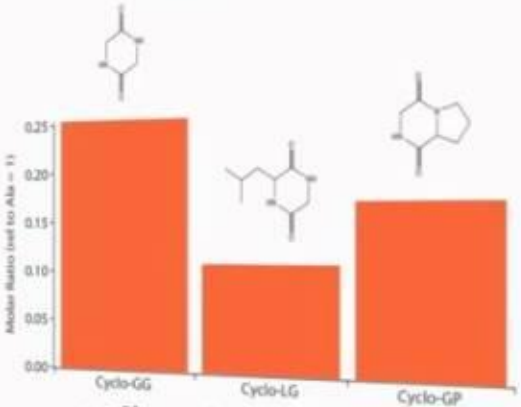
DKP Results



- 3 Gly-containing DKPs
- Dipeptide:DKP ratio ~1:10-20.5
  - Agrees w/dipeptide:DKP equilibrium.

1
00:00:10,870 --> 00:00:09,270
okay thank you uh yes i'll be

2
00:00:13,749 --> 00:00:10,880
discussing some results we've gotten

3
00:00:15,910 --> 00:00:13,759
from analyzing an archive set of samples

4
00:00:18,630 --> 00:00:15,920
that stanley muller produced in 1958

5
00:00:21,029 --> 00:00:18,640
where he used cyanamide which is a

6
00:00:23,349 --> 00:00:21,039
plausible prebiotic condensing agent to

7
00:00:24,790 --> 00:00:23,359
try to evaluate the polymerization of

8
00:00:27,670 --> 00:00:24,800
amino acids

9
00:00:29,509 --> 00:00:27,680
into larger molecules like peptides but

10
00:00:30,390 --> 00:00:29,519
before i do that i'll provide some

11
00:00:32,790 --> 00:00:30,400
context

12
00:00:35,510 --> 00:00:32,800
for this experiment so many of you are

13
00:00:37,830 --> 00:00:35,520

probably aware of the original military

14
00:00:39,750 --> 00:00:37,840
experiment that he published on in 1953

15
00:00:41,510 --> 00:00:39,760
where he used an apparatus

16
00:00:43,430 --> 00:00:41,520
like you see here on the left he put

17
00:00:46,470 --> 00:00:43,440
water in this small flask and he put the

18
00:00:48,389 --> 00:00:46,480
gases methane ammonia and hydrogen in

19
00:00:50,549 --> 00:00:48,399
this large flask over the course of

20
00:00:52,709 --> 00:00:50,559
seven days he sparked the experiment

21
00:00:55,029 --> 00:00:52,719
collected the samples and analyzed them

22
00:00:57,270 --> 00:00:55,039
with what was considered to be

23
00:01:00,229 --> 00:00:57,280
relatively state of the art technology

24
00:01:02,310 --> 00:01:00,239
in 1953 paper chromatography with

25
00:01:04,789 --> 00:01:02,320
hydrogen detection and what that did it

26
00:01:07,030 --> 00:01:04,799
produced these various spots here that

27
00:01:08,469 --> 00:01:07,040
all represent different compounds so in

28
00:01:10,950 --> 00:01:08,479
the case of his analyses they

29
00:01:12,469 --> 00:01:10,960
represented various amino acids so what

30
00:01:14,630 --> 00:01:12,479
this shows us

31
00:01:16,789 --> 00:01:14,640
is that you can simulate a

32
00:01:18,950 --> 00:01:16,799
possible early earth condition using

33
00:01:21,670 --> 00:01:18,960
very simple starting materials adding

34
00:01:24,149 --> 00:01:21,680
energy and you can form amino acids the

35
00:01:25,270 --> 00:01:24,159
building blocks for life

36
00:01:27,190 --> 00:01:25,280
but recently there's been some

37
00:01:29,350 --> 00:01:27,200
rejuvenated interest in some of the work

38
00:01:31,590 --> 00:01:29,360

that he did in the 1950s

39
00:01:33,670 --> 00:01:31,600
particularly with respect to a couple

40
00:01:35,910 --> 00:01:33,680
different experiments one of which was

41
00:01:37,749 --> 00:01:35,920
his volcanic experiment and that was one

42
00:01:39,510 --> 00:01:37,759
where he used an apparatus similar to

43
00:01:41,590 --> 00:01:39,520
the one you saw in the previous slide

44
00:01:43,350 --> 00:01:41,600
except it used an aspirator in it and

45
00:01:46,310 --> 00:01:43,360
what that did was it injected a jet of

46
00:01:48,789 --> 00:01:46,320
steam directly into the spark discharge

47
00:01:50,550 --> 00:01:48,799
simulating a volcanic eruption in the

48
00:01:51,910 --> 00:01:50,560
presence of lightning rich air on the

49
00:01:55,030 --> 00:01:51,920
early earth it's something that's common

50
00:01:57,749 --> 00:01:55,040
today and probably was common uh about

51
00:01:59,910 --> 00:01:57,759
3.8 billion years ago as well and what

52
00:02:01,990 --> 00:01:59,920
you can see from the analyses of these

53
00:02:05,190 --> 00:02:02,000
samples that he produced is that you get

54
00:02:08,070 --> 00:02:05,200
a great range and abundance of compounds

55
00:02:10,150 --> 00:02:08,080
that are produced by this experiment

56
00:02:12,229 --> 00:02:10,160
interestingly enough only a handful of

57
00:02:14,630 --> 00:02:12,239
these were actually detected by him when

58
00:02:16,949 --> 00:02:14,640
he first analyzed these samples himself

59
00:02:19,990 --> 00:02:16,959
but over five times as many can be

60
00:02:22,869 --> 00:02:20,000
detected today that speaks to the

61
00:02:25,589 --> 00:02:22,879
analytical achievements of uh

62
00:02:27,350 --> 00:02:25,599
of the past 60 years or so

63
00:02:28,949 --> 00:02:27,360

additionally there was his hydrogen

64
00:02:31,110 --> 00:02:28,959
sulfide experiment where he used a

65
00:02:33,830 --> 00:02:31,120
version of the classic apparatus and he

66
00:02:36,070 --> 00:02:33,840
used a reducing and oxidized gas mixture

67
00:02:38,550 --> 00:02:36,080
that included hydrogen sulfide and he

68
00:02:41,910 --> 00:02:38,560
sparked it for about three days let's go

69
00:02:43,830 --> 00:02:41,920
back sparked it for about three days and

70
00:02:46,390 --> 00:02:43,840
after he collected the samples he stored

71
00:02:48,309 --> 00:02:46,400
them in sealed sterilized vials but he

72
00:02:50,630 --> 00:02:48,319
never looked at them so this is the

73
00:02:52,790 --> 00:02:50,640
first analyses of these particular

74
00:02:54,229 --> 00:02:52,800
samples and you can see a chromatogram

75
00:02:56,470 --> 00:02:54,239
here on the top of the samples a

76
00:02:58,790 --> 00:02:56,480
chromatogram of the standards

77
00:03:01,190 --> 00:02:58,800
below that and even farther below that

78
00:03:03,350 --> 00:03:01,200
is this little line that's a

79
00:03:05,350 --> 00:03:03,360
it's an analysis of a procedural blank

80
00:03:06,949 --> 00:03:05,360
so it shows you that

81
00:03:08,949 --> 00:03:06,959
the sample handling processes

82
00:03:11,270 --> 00:03:08,959
contributed negative or negligibly

83
00:03:13,350 --> 00:03:11,280
excuse me to the presence of these amino

84
00:03:14,949 --> 00:03:13,360
acids that were detected in this sample

85
00:03:17,750 --> 00:03:14,959
set so it shows you that even by adding

86
00:03:20,550 --> 00:03:17,760
a simple gas like hydrogen sulfide

87
00:03:22,630 --> 00:03:20,560
you can have a huge uh effect on the

88
00:03:24,390 --> 00:03:22,640

range of products which included a

89
00:03:26,390 --> 00:03:24,400
number of sulfur bearing organic

90
00:03:28,550 --> 00:03:26,400
molecules like methionine which is

91
00:03:30,710 --> 00:03:28,560
important for eukaryotic protein

92
00:03:32,390 --> 00:03:30,720
synthesis

93
00:03:34,070 --> 00:03:32,400
but despite these

94
00:03:36,070 --> 00:03:34,080
various results that have been produced

95
00:03:38,309 --> 00:03:36,080
from these experiments detractors of the

96
00:03:39,990 --> 00:03:38,319
experiment would say you can take

97
00:03:42,229 --> 00:03:40,000
simulated early earth conditions and

98
00:03:43,589 --> 00:03:42,239
form amino acids but that doesn't mean

99
00:03:45,509 --> 00:03:43,599
that you formed life and that's

100
00:03:46,630 --> 00:03:45,519
absolutely true and in fact that gets

101
00:03:47,990 --> 00:03:46,640
that one of the biggest questions

102
00:03:50,710 --> 00:03:48,000
remaining in the field which is how do

103
00:03:52,789 --> 00:03:50,720
you go from these small monomer

104
00:03:55,190 --> 00:03:52,799
molecules like amino acids into these

105
00:03:56,630 --> 00:03:55,200
bigger molecules like ditri and

106
00:03:58,470 --> 00:03:56,640
polypeptides

107
00:04:00,789 --> 00:03:58,480
eventually working your way up into

108
00:04:03,110 --> 00:04:00,799
small proteins and one possible way to

109
00:04:05,429 --> 00:04:03,120
do that is through the use of condensing

110
00:04:06,869 --> 00:04:05,439
agents so these are simple molecules

111
00:04:09,350 --> 00:04:06,879
that are capable of facilitating

112
00:04:11,350 --> 00:04:09,360
polymerization of amino acids onto one

113
00:04:13,270 --> 00:04:11,360

another to form peptides

114
00:04:14,390 --> 00:04:13,280
and ideally what you could do is you

115
00:04:16,949 --> 00:04:14,400
could demonstrate

116
00:04:19,110 --> 00:04:16,959
a early earth condition and you would

117
00:04:21,270 --> 00:04:19,120
introduce a condensing agent and you

118
00:04:23,590 --> 00:04:21,280
would try to see if you can form both

119
00:04:25,030 --> 00:04:23,600
amino acids and dipeptides which would

120
00:04:27,350 --> 00:04:25,040
be their immediate polymerization

121
00:04:29,830 --> 00:04:27,360
product and show that in fact this

122
00:04:31,830 --> 00:04:29,840
process can happen under simulated early

123
00:04:34,469 --> 00:04:31,840
earth conditions

124
00:04:36,870 --> 00:04:34,479
so to give an overview of what would be

125
00:04:38,310 --> 00:04:36,880
a condensing agent there are a number of

126
00:04:40,070 --> 00:04:38,320
possible condensing agents that could

127
00:04:42,070 --> 00:04:40,080
have been readily

128
00:04:43,350 --> 00:04:42,080
excuse me readily formed on the early

129
00:04:46,070 --> 00:04:43,360
earth one of which would have been

130
00:04:47,670 --> 00:04:46,080
cyanomide uh also it's dimer

131
00:04:49,749 --> 00:04:47,680
diocyandiamide

132
00:04:51,749 --> 00:04:49,759
and then cyan cyanogen and carbonyl

133
00:04:53,670 --> 00:04:51,759
sulfide are also very plausible

134
00:04:55,030 --> 00:04:53,680
prebiotic condensing agents but for the

135
00:04:58,629 --> 00:04:55,040
purposes of this study we're going to

136
00:04:59,430 --> 00:04:58,639
focus on cyanomide and that leads us to

137
00:05:01,270 --> 00:04:59,440
his

138
00:05:03,030 --> 00:05:01,280

most recent set of archive samples that

139
00:05:04,710 --> 00:05:03,040
have been discovered and subsequently

140
00:05:06,950 --> 00:05:04,720
analyzed and that's his cyanomide spark

141
00:05:08,790 --> 00:05:06,960
discharge experiment so if you look here

142
00:05:11,029 --> 00:05:08,800
on the left you can see a photocopy of

143
00:05:12,870 --> 00:05:11,039
his original laboratory notebooks

144
00:05:15,350 --> 00:05:12,880
he was fortunately for us a very

145
00:05:17,670 --> 00:05:15,360
diligent notetaker and from this we can

146
00:05:19,189 --> 00:05:17,680
tell how he did the experiment

147
00:05:21,270 --> 00:05:19,199
we know that he took

148
00:05:23,510 --> 00:05:21,280
a version of the original apparatus and

149
00:05:26,070 --> 00:05:23,520
sparked the gases methane ammonia and

150
00:05:27,670 --> 00:05:26,080
water over the course of seven days and

151
00:05:29,909 --> 00:05:27,680
intermittently throughout the experiment

152
00:05:33,270 --> 00:05:29,919
he stopped the experiment three separate

153
00:05:34,870 --> 00:05:33,280
times to add cyanamide and it's worth

154
00:05:37,270 --> 00:05:34,880
noting that after the first edition of

155
00:05:38,390 --> 00:05:37,280
cyanomide he no longer heeded the

156
00:05:39,749 --> 00:05:38,400
apparatus

157
00:05:41,110 --> 00:05:39,759
and the reason for that is likely

158
00:05:43,270 --> 00:05:41,120
because of the risk of thermally

159
00:05:44,950 --> 00:05:43,280
decomposing the cyanomide if you

160
00:05:46,469 --> 00:05:44,960
thermally decompose your condensing

161
00:05:48,790 --> 00:05:46,479
agent you don't have a chemical

162
00:05:50,469 --> 00:05:48,800
mechanism or means by which to induce

163
00:05:52,710 --> 00:05:50,479

the polymerization of the amino acids

164
00:05:55,029 --> 00:05:52,720
you form so one thing we wanted to do is

165
00:05:56,390 --> 00:05:55,039
we wanted to look for not only the amino

166
00:05:59,310 --> 00:05:56,400
acids but also their immediate

167
00:06:01,990 --> 00:05:59,320
polymerization products dipeptides and

168
00:06:04,230 --> 00:06:02,000
diketopirazines or dkps which are the

169
00:06:05,590 --> 00:06:04,240
cyclic dipeptide and the reason why we

170
00:06:07,350 --> 00:06:05,600
want to look for those is because under

171
00:06:09,430 --> 00:06:07,360
equilibrium conditions all three of

172
00:06:12,309 --> 00:06:09,440
those would be predate

173
00:06:13,909 --> 00:06:12,319
present in a polymerization reaction so

174
00:06:15,909 --> 00:06:13,919
we took a targeted approach to look for

175
00:06:18,950 --> 00:06:15,919
amino acids and then a separate targeted

176
00:06:21,350 --> 00:06:18,960
approach to look for dipeptides and dkps

177
00:06:23,110 --> 00:06:21,360
so when we look for amino acids we use

178
00:06:25,029 --> 00:06:23,120
high performance liquor chromatography

179
00:06:27,350 --> 00:06:25,039
with fluorescence detection and triple

180
00:06:29,270 --> 00:06:27,360
quadruple mass spectrometry so the way

181
00:06:31,430 --> 00:06:29,280
this worked is we took our samples and

182
00:06:33,670 --> 00:06:31,440
we derivatized them so we prepared them

183
00:06:36,629 --> 00:06:33,680
for analysis with a chiral adduct known

184
00:06:39,189 --> 00:06:36,639
as othaldialdehyde and acetyl cysteine

185
00:06:41,749 --> 00:06:39,199
or opa nac for short

186
00:06:44,550 --> 00:06:41,759
and what this does is it tags primary

187
00:06:46,830 --> 00:06:44,560
amino groups and provides enantiomeric

188
00:06:49,110 --> 00:06:46,840

separation of amino acids with chiral

189
00:06:51,909 --> 00:06:49,120
centers so we take our samples and we

190
00:06:54,070 --> 00:06:51,919
push them through an hplc column

191
00:06:55,909 --> 00:06:54,080
as the compounds of interest get eluded

192
00:06:58,550 --> 00:06:55,919
off of the column they are either

193
00:07:01,270 --> 00:06:58,560
directed into the fluorescence detector

194
00:07:02,550 --> 00:07:01,280
for detection by one mechanism and

195
00:07:04,870 --> 00:07:02,560
they're also

196
00:07:07,990 --> 00:07:04,880
directed into the triple quad for mass

197
00:07:12,629 --> 00:07:10,150
and if we look at our amino acid data we

198
00:07:14,629 --> 00:07:12,639
can see very clearly that the cyanomide

199
00:07:16,870 --> 00:07:14,639
spark discharge experiment does produce

200
00:07:19,270 --> 00:07:16,880
amino acids and it produces them in good

201
00:07:21,189 --> 00:07:19,280
yields and in fact it compares very well

202
00:07:24,150 --> 00:07:21,199
to the previous spark discharge

203
00:07:26,390 --> 00:07:24,160
experiments that he had conducted

204
00:07:29,110 --> 00:07:26,400
what's worth noting is that you have the

205
00:07:31,430 --> 00:07:29,120
presence here of the amino butyric acids

206
00:07:34,790 --> 00:07:31,440
which are non-protein amino acids and

207
00:07:36,870 --> 00:07:34,800
you also have amino acids that are

208
00:07:39,270 --> 00:07:36,880
present in high abundance that have

209
00:07:41,670 --> 00:07:39,280
chiral centers they are racemic within

210
00:07:44,070 --> 00:07:41,680
experimental measures so that suggests

211
00:07:45,749 --> 00:07:44,080
to us the combination of the two factors

212
00:07:47,830 --> 00:07:45,759
suggests that these amino acids were

213
00:07:50,629 --> 00:07:47,840

formed within the experiment itself and

214
00:07:52,469 --> 00:07:50,639
were not a product of sample handling

215
00:07:54,950 --> 00:07:52,479
processes or other sources of

216
00:07:57,589 --> 00:07:54,960
terrestrial contamination

217
00:07:59,350 --> 00:07:57,599
now if we look at dipeptides and dkp's

218
00:08:00,869 --> 00:07:59,360
our approach for looking at these was to

219
00:08:02,230 --> 00:08:00,879
use ultra high performance liquid

220
00:08:03,029 --> 00:08:02,240
chromatography

221
00:08:05,510 --> 00:08:03,039
with

222
00:08:07,830 --> 00:08:05,520
quadrupole ion mobility separation and

223
00:08:09,670 --> 00:08:07,840
time-of-flight mass spectrometry so when

224
00:08:12,070 --> 00:08:09,680
your compounds of interest come off the

225
00:08:14,230 --> 00:08:12,080
column they come into the instrument

226
00:08:16,070 --> 00:08:14,240
here and they get ionized and that's

227
00:08:17,749 --> 00:08:16,080
when they go through ion mobility

228
00:08:19,430 --> 00:08:17,759
separation

229
00:08:21,029 --> 00:08:19,440
which separates the molecules based on

230
00:08:23,110 --> 00:08:21,039
their cross-sectional area when it

231
00:08:25,110 --> 00:08:23,120
interacts a drift gas acting in the

232
00:08:27,909 --> 00:08:25,120
opposite direction and then they enter

233
00:08:30,950 --> 00:08:27,919
into the mass spectrometer here for high

234
00:08:32,550 --> 00:08:30,960
resolution mass analysis

235
00:08:34,630 --> 00:08:32,560
and when we look at our dipeptide

236
00:08:36,709 --> 00:08:34,640
results we do see a lot of dipeptides

237
00:08:40,310 --> 00:08:36,719
and we see them in good yields as well

238
00:08:43,750 --> 00:08:40,320

and interestingly if you look at your

239
00:08:45,350 --> 00:08:43,760
amino acid to dipeptide ratio the ratio

240
00:08:47,509 --> 00:08:45,360
in the samples is about a thousand to

241
00:08:49,590 --> 00:08:47,519
one or a thousand to ten which agrees

242
00:08:51,509 --> 00:08:49,600
with experimental evidence that shows

243
00:08:54,150 --> 00:08:51,519
that at equilibrium conditions you

244
00:08:56,150 --> 00:08:54,160
should have amino acids in about a

245
00:08:58,470 --> 00:08:56,160
thousand times more abundant than your

246
00:09:00,070 --> 00:08:58,480
dipeptide so that suggests that these

247
00:09:01,750 --> 00:09:00,080
dipeptides were formed within the

248
00:09:03,110 --> 00:09:01,760
experiment and were not a product of

249
00:09:04,630 --> 00:09:03,120
contamination

250
00:09:06,470 --> 00:09:04,640
if you look at the structures down here

251
00:09:08,070 --> 00:09:06,480
at the bottom that shows you the type of

252
00:09:09,590 --> 00:09:08,080
chemical complexity that we're dealing

253
00:09:11,590 --> 00:09:09,600
with the kind the complexity that we're

254
00:09:13,670 --> 00:09:11,600
looking for we're not looking for super

255
00:09:15,670 --> 00:09:13,680
large macromolecules we're looking for

256
00:09:17,110 --> 00:09:15,680
something a little bit larger than amino

257
00:09:19,430 --> 00:09:17,120
acids

258
00:09:21,750 --> 00:09:19,440
so let's look at our dkps we do find

259
00:09:24,230 --> 00:09:21,760
dkps as well and this is very good

260
00:09:25,750 --> 00:09:24,240
evidence because it shows the full

261
00:09:28,550 --> 00:09:25,760
product of the polymerization of the

262
00:09:29,990 --> 00:09:28,560
amino acids so you see dkps in high

263
00:09:32,310 --> 00:09:30,000

abundance and when you compare your

264
00:09:34,310 --> 00:09:32,320
dipeptide to dkp abundance it's about

265
00:09:36,230 --> 00:09:34,320
one to ten or one to twenty which

266
00:09:38,070 --> 00:09:36,240
generally agrees with experimental

267
00:09:40,790 --> 00:09:38,080
evidence that shows that at equilibrium

268
00:09:42,870 --> 00:09:40,800
conditions your dipeptide dkp ratio

269
00:09:44,710 --> 00:09:42,880
should be about one to ten further

270
00:09:46,630 --> 00:09:44,720
suggesting that these dkps and these

271
00:09:48,710 --> 00:09:46,640
dipeptides were not a product of

272
00:09:50,710 --> 00:09:48,720
contamination

273
00:09:52,470 --> 00:09:50,720
so one question would remain from this

274
00:09:54,389 --> 00:09:52,480
type of study which is how does this

275
00:09:56,470 --> 00:09:54,399
happen what's the mechanism by which

276
00:09:58,070 --> 00:09:56,480
this might occur so to take a step in

277
00:10:00,389 --> 00:09:58,080
the direction of trying to address this

278
00:10:02,630 --> 00:10:00,399
question we're proposing a mechanism and

279
00:10:04,949 --> 00:10:02,640
it starts like this you have cyanomide

280
00:10:07,030 --> 00:10:04,959
and at equilibrium cyanomide would also

281
00:10:09,430 --> 00:10:07,040
be present as carbodynamide this

282
00:10:11,269 --> 00:10:09,440
carbodyamide can be protonated and then

283
00:10:14,550 --> 00:10:11,279
when protonated it can react with an

284
00:10:16,550 --> 00:10:14,560
amino acid like glycine in this case

285
00:10:18,230 --> 00:10:16,560
which would form the activated form of

286
00:10:20,470 --> 00:10:18,240
the amino acid so here would be

287
00:10:21,829 --> 00:10:20,480
activated glycine the activated form of

288
00:10:23,910 --> 00:10:21,839

the amino acid can then react with

289
00:10:25,269 --> 00:10:23,920
another amino acid to yield your

290
00:10:29,990 --> 00:10:25,279
dipeptide

291
00:10:31,590 --> 00:10:30,000
through two different means one of which

292
00:10:33,750 --> 00:10:31,600
would be a dehydration reaction the

293
00:10:36,150 --> 00:10:33,760
other one of which would be direct

294
00:10:38,069 --> 00:10:36,160
reaction with cyanomite itself to yield

295
00:10:39,670 --> 00:10:38,079
your dkp

296
00:10:41,269 --> 00:10:39,680
so from this study there's several

297
00:10:43,590 --> 00:10:41,279
things we can conclude first thing would

298
00:10:45,590 --> 00:10:43,600
be that this was the chronologically the

299
00:10:47,110 --> 00:10:45,600
first attempt to study condensing agents

300
00:10:49,430 --> 00:10:47,120
for their relevance to the origins of

301
00:10:52,230 --> 00:10:49,440
life additionally what we can conclude

302
00:10:53,910 --> 00:10:52,240
is that yes you can form simultaneously

303
00:10:55,750 --> 00:10:53,920
both amino acids and their

304
00:10:58,470 --> 00:10:55,760
polymerization products dipeptides and

305
00:11:00,150 --> 00:10:58,480
dkps under plausible simulated early

306
00:11:02,389 --> 00:11:00,160
earth conditions and that these

307
00:11:04,389 --> 00:11:02,399
condensing agents like cyanamide would

308
00:11:06,790 --> 00:11:04,399
provide us a chemical mechanism by which

309
00:11:08,870 --> 00:11:06,800
we can explain how this polymerization

310
00:11:10,710 --> 00:11:08,880
may take may have taken place on the

311
00:11:12,790 --> 00:11:10,720
early earth and this could have expanded

312
00:11:14,630 --> 00:11:12,800
upon and diversified the prebiotic

313
00:11:16,630 --> 00:11:14,640

chemical inventory from which life may

314
00:11:19,030 --> 00:11:16,640
have originated

315
00:11:21,910 --> 00:11:19,040
so with that i should acknowledge

316
00:11:23,829 --> 00:11:21,920
colleagues collaborators funding and

317
00:11:25,990 --> 00:11:23,839
this resource down here which provided

318
00:11:28,389 --> 00:11:26,000
us with access to stanley's lab

319
00:11:36,790 --> 00:11:28,399
notebooks so we can understand how he

320
00:11:42,949 --> 00:11:38,710
all right thank you very much do we have

321
00:11:42,959 --> 00:11:51,670
all right

322
00:11:54,790 --> 00:11:53,190
hi thanks for your talk i'm just

323
00:11:56,710 --> 00:11:54,800
wondering on these types of experiment

324
00:11:58,470 --> 00:11:56,720
right now what's the level of complexity

325
00:12:00,630 --> 00:11:58,480
we can achieve uh i know you were

326
00:12:04,389 --> 00:12:00,640
looking for a specific level complexity

327
00:12:06,069 --> 00:12:04,399
but how like long time chains can you uh

328
00:12:07,750 --> 00:12:06,079
synthesize abiotically in this type of

329
00:12:09,509 --> 00:12:07,760
experiment it's a good question so the

330
00:12:11,910 --> 00:12:09,519
question was uh what's the type of

331
00:12:14,150 --> 00:12:11,920
complexity that we can reasonably expect

332
00:12:16,150 --> 00:12:14,160
from these types of experiments and a

333
00:12:17,590 --> 00:12:16,160
lot of it depends on the variables that

334
00:12:19,509 --> 00:12:17,600
you introduce into the experiment what

335
00:12:21,269 --> 00:12:19,519
are your starting conditions how long do

336
00:12:22,949 --> 00:12:21,279
you let the experiment go on for so he

337
00:12:24,870 --> 00:12:22,959
would let the experiment run on average

338
00:12:26,710 --> 00:12:24,880

for a week if you let it run for

339
00:12:28,310 --> 00:12:26,720
probably two or three weeks you can

340
00:12:31,670 --> 00:12:28,320
generate even greater amounts of

341
00:12:33,829 --> 00:12:31,680
complexity and it also depends on

342
00:12:35,509 --> 00:12:33,839
subsequent compounds or components that

343
00:12:37,350 --> 00:12:35,519
you may introduce into the reaction

344
00:12:39,350 --> 00:12:37,360
apparatus so in this case he put a

345
00:12:41,110 --> 00:12:39,360
condensing agent if he continued to add

346
00:12:43,190 --> 00:12:41,120
more condensing agents maybe a greater

347
00:12:46,550 --> 00:12:43,200
variety of condensing agents that could

348
00:12:48,870 --> 00:12:46,560
have facilitated polymerization into uh

349
00:12:51,829 --> 00:12:48,880
polypeptides so one thing i didn't

350
00:12:54,550 --> 00:12:51,839
mention in this talk was we focused on

351
00:12:55,350 --> 00:12:54,560
dipeptides but we also did screen for

352
00:12:57,269 --> 00:12:55,360
tri

353
00:12:59,509 --> 00:12:57,279
and polypeptides and we did see

354
00:13:01,350 --> 00:12:59,519
tripeptides and

355
00:13:03,030 --> 00:13:01,360
very small polypeptides but we didn't

356
00:13:05,670 --> 00:13:03,040
quantitate that

357
00:13:07,670 --> 00:13:05,680
so you can reasonably expect

358
00:13:10,310 --> 00:13:07,680
polypeptides i'm confident in saying at

359
00:13:11,829 --> 00:13:10,320
this point and we're also in

360
00:13:13,670 --> 00:13:11,839
in the process of looking for things

361
00:13:16,230 --> 00:13:13,680
like nucleobases

362
00:13:19,269 --> 00:13:16,240
and moving on beyond just the simple

363
00:13:22,629 --> 00:13:19,279

monomer amino acids

364
00:13:22,639 --> 00:13:27,509
okay thanks very much eric yep i lied

365
00:13:30,629 --> 00:13:29,110
thanks for a great talk eric um i don't

366
00:13:32,389 --> 00:13:30,639
know much about condensing agents or

367
00:13:33,430 --> 00:13:32,399
cyanomide or other condensing agents

368
00:13:34,949 --> 00:13:33,440
things that you find in the natural

369
00:13:37,350 --> 00:13:34,959
environment and abundance is comparable

370
00:13:40,629 --> 00:13:37,360
to those that you or that stanley miller

371
00:13:45,030 --> 00:13:42,870
say that again

372
00:13:46,550 --> 00:13:45,040
are condensing agents like the ones that

373
00:13:48,310 --> 00:13:46,560
were used in this experiment or other

374
00:13:51,030 --> 00:13:48,320
condensing agents are those things that

375
00:13:53,430 --> 00:13:51,040
are commonly found in the environment

376
00:13:54,790 --> 00:13:53,440
and in concentrations comparable to

377
00:13:57,670 --> 00:13:54,800
those used here

378
00:14:00,710 --> 00:13:57,680
yes they are so these condensing agents

379
00:14:02,949 --> 00:14:00,720
that um that i discussed are readily

380
00:14:04,389 --> 00:14:02,959
formed under simulated early earth

381
00:14:06,150 --> 00:14:04,399
conditions so they're very simple

382
00:14:07,829 --> 00:14:06,160
molecules they're formed from the

383
00:14:10,150 --> 00:14:07,839
starting materials that were likely

384
00:14:11,910 --> 00:14:10,160
present on the early earth and using the

385
00:14:13,829 --> 00:14:11,920
energy sources that were likely present

386
00:14:16,230 --> 00:14:13,839
on the early earth like uv radiation so

387
00:14:18,389 --> 00:14:16,240
for example cyanamide is formed from the

388
00:14:20,870 --> 00:14:18,399

ultraviolet radiation of ammonium

389
00:14:22,470 --> 00:14:20,880
cyanide which is formed fairly readily

390
00:14:24,150 --> 00:14:22,480
on the early earth so these are very

391
00:14:26,710 --> 00:14:24,160
much plausible

392
00:14:28,790 --> 00:14:26,720
molecules and the concentrations he used

393
00:14:31,990 --> 00:14:28,800
in this experiment were on the order of

394
00:14:41,269 --> 00:14:32,000
millimolar to micromolar ranges which is

395
00:14:44,629 --> 00:14:42,790
it's a good question so we're looking

396
00:14:46,389 --> 00:14:44,639
for cyanamide in spark discharge

397
00:14:48,870 --> 00:14:46,399
experiments there's currently no

398
00:14:50,310 --> 00:14:48,880
literature that shows that cyanamide has

399
00:14:52,870 --> 00:14:50,320
been formed in spark discharge

400
00:14:55,189 --> 00:14:52,880
experiments one problem with that is a

401
00:14:57,110 --> 00:14:55,199
lot of the analytical instrumentation is

402
00:15:00,230 --> 00:14:57,120
mass spectrometry based so if you're

403
00:15:01,189 --> 00:15:00,240
looking for a really slow mass molecule

404
00:15:05,910 --> 00:15:01,199
in the

405
00:15:07,990 --> 00:15:05,920
tough to find it using mass spectrometry

406
00:15:10,310 --> 00:15:08,000
because there's certain mass cutoffs a

407
00:15:13,750 --> 00:15:10,320
lot of mass specs will not

408
00:15:17,590 --> 00:15:13,760
have very good accuracy or precision for

409
00:15:19,110 --> 00:15:17,600
masses below 50. so cyanamide is around

410
00:15:21,189 --> 00:15:19,120
42

411
00:15:22,629 --> 00:15:21,199
is their amu so it's difficult to look

412
00:15:24,550 --> 00:15:22,639
for that but you can use other things

413
00:15:25,910 --> 00:15:24,560

you can use chromatographic techniques

414
00:15:27,509 --> 00:15:25,920
but that's something that we're

415
00:15:29,189 --> 00:15:27,519
currently looking for is to see if it

416
00:15:31,910 --> 00:15:29,199
can be formed inherently within the