



1  
00:00:00,790 --> 00:00:07,320

[Music]

2  
00:00:12,610 --> 00:00:09,480

[Applause]

3  
00:00:14,940 --> 00:00:12,620

okay thank you very much the next talk

4  
00:00:17,650 --> 00:00:14,950

will be about the question on how

5  
00:00:19,870 --> 00:00:17,660

molecular complexity can increase in the

6  
00:00:22,029 --> 00:00:19,880

system which does not know any identical

7  
00:00:24,249 --> 00:00:22,039

reproduction so that's the core question

8  
00:00:26,200 --> 00:00:24,259

here is the depiction of that one we

9  
00:00:28,419 --> 00:00:26,210

start very early times with small

10  
00:00:30,999 --> 00:00:28,429

molecules at the end we will have life

11  
00:00:34,390 --> 00:00:31,009

and in between over the time axis we

12  
00:00:37,000 --> 00:00:34,400

have an increase we have a huge increase

13  
00:00:39,340 --> 00:00:37,010

of complexity we know that Darwinian

14

00:00:41,380 --> 00:00:39,350

evolution can go do a very good job and

15

00:00:43,990 --> 00:00:41,390

that one but this can only start at a

16

00:00:46,140 --> 00:00:44,000

point where we have a system which can

17

00:00:48,430 --> 00:00:46,150

self reproducing

18

00:00:50,380 --> 00:00:48,440

before that period what about this

19

00:00:53,560 --> 00:00:50,390

stretch here what's happening there but

20

00:00:55,600 --> 00:00:53,570

whatever it is it has to obey one very

21

00:00:57,400 --> 00:00:55,610

important principle that's constant

22

00:00:59,620 --> 00:00:57,410

non-equilibrium we definitely need a

23

00:01:02,350 --> 00:00:59,630

constant long long constant

24

00:01:04,420 --> 00:01:02,360

non-equilibrium since otherwise we will

25

00:01:06,340 --> 00:01:04,430

have a situation where the system runs

26

00:01:09,039 --> 00:01:06,350

into equilibrium at a very short time

27

00:01:11,289 --> 00:01:09,049

forms a crystal maybe by a dissipation

28

00:01:14,320 --> 00:01:11,299

of energy when then this will stop in

29

00:01:16,600 --> 00:01:14,330

order to keep this a long going process

30

00:01:19,630 --> 00:01:16,610

we need to do something that keeps it in

31

00:01:23,560 --> 00:01:19,640

a non equilibrium state and made from to

32

00:01:26,050 --> 00:01:23,570

my opinion the most the most efficient

33

00:01:28,960 --> 00:01:26,060

way to do that is to change reaction

34

00:01:32,230 --> 00:01:28,970

conditions in an alternating way for

35

00:01:33,910 --> 00:01:32,240

example by switching some sort of a

36

00:01:36,719 --> 00:01:33,920

reaction condition switching some

37

00:01:40,570 --> 00:01:36,729

parameter which keeps the system

38

00:01:42,969 --> 00:01:40,580

following moving target so the system

39

00:01:45,070 --> 00:01:42,979

will start to run into a liquid then the

40

00:01:48,580 --> 00:01:45,080

parameter will change and then it will

41

00:01:50,500 --> 00:01:48,590

have to start a new and so on so how can

42

00:01:52,420 --> 00:01:50,510

the question now is how could this be

43

00:01:54,430 --> 00:01:52,430

done on early Earth which parameter

44

00:01:57,340 --> 00:01:54,440

would change periodically on early Earth

45

00:01:59,710 --> 00:01:57,350

and of course the first thing that comes

46

00:02:02,950 --> 00:01:59,720

to mind is the day/night cycle for

47

00:02:05,980 --> 00:02:02,960

example changing the dryness and wetness

48

00:02:08,820 --> 00:02:05,990

condition and this leads to dry weight

49

00:02:11,740 --> 00:02:08,830

cycling dry wet cycling we change the

50

00:02:13,839 --> 00:02:11,750

chemical potential of water and this

51  
00:02:17,589 --> 00:02:13,849  
change in chemical potential of water

52  
00:02:20,110 --> 00:02:17,599  
will induce such a situation on

53  
00:02:21,729 --> 00:02:20,120  
a long ongoing process this was well

54  
00:02:23,979 --> 00:02:21,739  
described in two papers which I want to

55  
00:02:26,229 --> 00:02:23,989  
cite here but Paul Higgs and David Ross

56  
00:02:28,869 --> 00:02:26,239  
and David Deamer but there are also

57  
00:02:30,670 --> 00:02:28,879  
other situations that we need to take

58  
00:02:33,129 --> 00:02:30,680  
into account for example there are

59  
00:02:35,649 --> 00:02:33,139  
cyclic processes which affect the

60  
00:02:37,599 --> 00:02:35,659  
pressure for example if you look at the

61  
00:02:40,300 --> 00:02:37,609  
tidal phenomena or if we look at

62  
00:02:43,119 --> 00:02:40,310  
periodic geological processes like

63  
00:02:45,280 --> 00:02:43,129

geysers and if this happens then there

64

00:02:47,949 --> 00:02:45,290

are situations there are positions for

65

00:02:50,409 --> 00:02:47,959

example the earth crust one kilometer in

66

00:02:51,879 --> 00:02:50,419

depth where we can induce phase

67

00:02:55,119 --> 00:02:51,889

transitions for example a phase

68

00:02:57,309 --> 00:02:55,129

transition from gaseous carbon dioxide

69

00:03:00,009 --> 00:02:57,319

to supercritical carbon dioxide and we

70

00:03:01,899 --> 00:03:00,019

have that we can switch between two

71

00:03:04,569 --> 00:03:01,909

states of carbon dioxide that were very

72

00:03:06,819 --> 00:03:04,579

different in their thrall vent quality

73

00:03:09,670 --> 00:03:06,829

so we start switching a very good

74

00:03:11,979 --> 00:03:09,680

solvent into a very bad solvent this has

75

00:03:14,589 --> 00:03:11,989

interesting consequences for example we

76

00:03:17,890 --> 00:03:14,599

can run a cycle of condensation and

77

00:03:19,990 --> 00:03:17,900

hydrolysis when the carbon dioxide is

78

00:03:22,960 --> 00:03:20,000

supercritical it takes up a lot of water

79

00:03:25,300 --> 00:03:22,970

due to that the condensation step will

80

00:03:27,369 --> 00:03:25,310

be facilitated water will be taken away

81

00:03:30,249 --> 00:03:27,379

from the chain molecule and we can

82

00:03:32,050 --> 00:03:30,259

polymerize amino acids for example on

83

00:03:34,089 --> 00:03:32,060

the other hand when the carbon dioxide

84

00:03:36,219 --> 00:03:34,099

becomes subcritical again the water is

85

00:03:38,619 --> 00:03:36,229

coming back and the molecule will

86

00:03:41,379 --> 00:03:38,629

hydrolyze and it will be turned down

87

00:03:44,439 --> 00:03:41,389

into amino acids again so every switch

88

00:03:48,129 --> 00:03:44,449

in pressure will induce one cycle of

89

00:03:50,140 --> 00:03:48,139

condensation and hydrolysis but the

90

00:03:53,229 --> 00:03:50,150

cycle can do more for example it can

91

00:03:55,869 --> 00:03:53,239

start a generation of vesicles if we

92

00:03:57,999 --> 00:03:55,879

look at the carbon dioxide in a

93

00:03:59,920 --> 00:03:58,009

supercritical state it's a good solvent

94

00:04:02,110 --> 00:03:59,930

so it will saturate with water it will

95

00:04:04,059 --> 00:04:02,120

take up organic molecules and it will

96

00:04:06,520 --> 00:04:04,069

take up and fulfill acknowledge Jules

97

00:04:08,770 --> 00:04:06,530

when the carbon dioxide turns up

98

00:04:11,399 --> 00:04:08,780

critical again the water will condensate

99

00:04:13,509 --> 00:04:11,409

in small droplets the surfactant

100

00:04:15,279 --> 00:04:13,519

amphiphilic molecules will cover the

101  
00:04:17,890 --> 00:04:15,289  
surface and the organic molecules will

102  
00:04:19,870 --> 00:04:17,900  
be inside and when these droplets settle

103  
00:04:21,610 --> 00:04:19,880  
onto the surface then there will be an

104  
00:04:23,379 --> 00:04:21,620  
interaction between the amphiphilic

105  
00:04:25,420 --> 00:04:23,389  
layer on the droplet surface and the

106  
00:04:27,490 --> 00:04:25,430  
amplified layer down here and this will

107  
00:04:29,060 --> 00:04:27,500  
lead to the formation of vesicles that's

108  
00:04:30,890 --> 00:04:29,070  
how they look like in the experiment

109  
00:04:33,020 --> 00:04:30,900  
here and of course these vesicles will

110  
00:04:34,970 --> 00:04:33,030  
disintegrate after time especially when

111  
00:04:38,570 --> 00:04:34,980  
the carbon dioxide becomes supercritical

112  
00:04:40,820 --> 00:04:38,580  
again then we follow another cycle here

113  
00:04:44,270 --> 00:04:40,830

so every change in pressure will induce

114

00:04:46,790 --> 00:04:44,280

one generation of vesicles so now we

115

00:04:49,670 --> 00:04:46,800

have a pool of peptides and we have

116

00:04:51,680 --> 00:04:49,680

generations of vesicles of course we

117

00:04:53,480 --> 00:04:51,690

will expect some interaction not of the

118

00:04:56,060 --> 00:04:53,490

hydrophilic ones not out of the

119

00:04:57,170 --> 00:04:56,070

hydrophobic ones but of those peptides

120

00:04:59,390 --> 00:04:57,180

which are amphiphilic

121

00:05:01,490 --> 00:04:59,400

for those peptides the vesicles will be

122

00:05:04,040 --> 00:05:01,500

something like a kinetic trap these

123

00:05:06,050 --> 00:05:04,050

peptides will be able to integrate into

124

00:05:08,270 --> 00:05:06,060

the membrane by integration that will

125

00:05:11,000 --> 00:05:08,280

become protected against hydrolysis so

126

00:05:13,460 --> 00:05:11,010

they will accumulate and they will

127

00:05:16,580 --> 00:05:13,470

increase in numbers I call this the

128

00:05:18,650 --> 00:05:16,590

parasitic step because in this position

129

00:05:21,260 --> 00:05:18,660

we will have an advantage to the peptide

130

00:05:23,450 --> 00:05:21,270

but no advantage to the mythical but

131

00:05:25,040 --> 00:05:23,460

when the peptides keep growing and we

132

00:05:28,400 --> 00:05:25,050

have reached the step in the experiment

133

00:05:30,740 --> 00:05:28,410

to when they are long enough they they

134

00:05:32,780 --> 00:05:30,750

get the capability of stabilizing the

135

00:05:35,360 --> 00:05:32,790

vesicles and if they do that then we

136

00:05:37,760 --> 00:05:35,370

have a mutual advantage to the peptide

137

00:05:40,040 --> 00:05:37,770

as well as the vesicle and the vesicle

138

00:05:41,690 --> 00:05:40,050

will survive several generations at this

139

00:05:43,730 --> 00:05:41,700

point there will be even stronger

140

00:05:48,020 --> 00:05:43,740

selection or advantage for these

141

00:05:50,000 --> 00:05:48,030

peptides and we also have reached this

142

00:05:52,250 --> 00:05:50,010

step here the functional step where the

143

00:05:54,380 --> 00:05:52,260

peptides start to affect for example

144

00:05:56,480 --> 00:05:54,390

permeability when the peptides have been

145

00:05:58,310 --> 00:05:56,490

formed we have a strong concentration

146

00:06:00,830 --> 00:05:58,320

gradient and this concentration gradient

147

00:06:02,960 --> 00:06:00,840

causes osmotic pressure and this

148

00:06:05,270 --> 00:06:02,970

shortens the lifetime of vesicles

149

00:06:07,760 --> 00:06:05,280

so by opening these channels many

150

00:06:09,560 --> 00:06:07,770

peptides are capable of doing that we

151  
00:06:12,560 --> 00:06:09,570  
all give them a chance to equilibrate

152  
00:06:16,370 --> 00:06:12,570  
this concentration and to release this

153  
00:06:18,920 --> 00:06:16,380  
pressure okay take the whole thing

154  
00:06:20,720 --> 00:06:18,930  
together we have the pool of peptides

155  
00:06:23,480 --> 00:06:20,730  
which is basically like a box of Lego's

156  
00:06:26,330 --> 00:06:23,490  
we are shaking and expecting random

157  
00:06:28,820 --> 00:06:26,340  
structures to form so there's no

158  
00:06:30,650 --> 00:06:28,830  
specific in that way but they're also

159  
00:06:34,370 --> 00:06:30,660  
the vesicles the vesicles pick out

160  
00:06:36,770 --> 00:06:34,380  
certain peptides and by being selected

161  
00:06:38,990 --> 00:06:36,780  
all the time for this with stability we

162  
00:06:41,280 --> 00:06:39,000  
will get more stable vesicles they will

163  
00:06:45,040 --> 00:06:41,290

get bitter

164

00:06:48,790 --> 00:06:45,050

selecting a specimen and they were also

165

00:06:50,830 --> 00:06:48,800

developed functions so I think based on

166

00:06:53,290 --> 00:06:50,840

that we can say that we have some sort

167

00:06:56,050 --> 00:06:53,300

of a molecular or structural evolution

168

00:06:59,770 --> 00:06:56,060

which is based purely on accumulation

169

00:07:01,540 --> 00:06:59,780

and selection processes of course we

170

00:07:04,510 --> 00:07:01,550

have tried to do that in an experiment

171

00:07:07,000 --> 00:07:04,520

we have non experiment running which

172

00:07:08,980 --> 00:07:07,010

goes over three weeks which means 1000

173

00:07:11,980 --> 00:07:08,990

and 500 generations of vesicles

174

00:07:13,780 --> 00:07:11,990

let me start collecting peptides it's

175

00:07:16,180 --> 00:07:13,790

hundreds of peptides I just picked out a

176

00:07:19,510 --> 00:07:16,190

few ones but what's very common to these

177

00:07:21,730 --> 00:07:19,520

peptides is a positively charged lysine

178

00:07:24,510 --> 00:07:21,740

group in the head and more or less

179

00:07:27,909 --> 00:07:24,520

hydrophobic groups at the end side and

180

00:07:31,540 --> 00:07:27,919

these peptides of course n'e amphiphilic

181

00:07:33,310 --> 00:07:31,550

and will collect in the membrane one of

182

00:07:35,830 --> 00:07:33,320

the early specimen that we got was this

183

00:07:38,440 --> 00:07:35,840

peptide and this peptide we checked for

184

00:07:41,230 --> 00:07:38,450

its we checked out what the reason was

185

00:07:44,250 --> 00:07:41,240

why this peptide was being selected so

186

00:07:47,230 --> 00:07:44,260

we had this peptide synthesized

187

00:07:49,870 --> 00:07:47,240

commercial synthesis and added it to

188

00:07:52,450 --> 00:07:49,880

vesicles and we found three effects we

189

00:07:55,990 --> 00:07:52,460

found first that the size of the

190

00:07:59,590 --> 00:07:56,000

vesicles was reduced by approximately 50

191

00:08:02,170 --> 00:07:59,600

percent we found that the vesicle

192

00:08:04,870 --> 00:08:02,180

permeability was increased by 90 percent

193

00:08:06,640 --> 00:08:04,880

and we found that the peptide increased

194

00:08:09,250 --> 00:08:06,650

the physical stability thermal

195

00:08:11,620 --> 00:08:09,260

instability by a factor of 6 so the half

196

00:08:14,500 --> 00:08:11,630

dive time was increased by a factor of 6

197

00:08:17,020 --> 00:08:14,510

we believe that all these changes are

198

00:08:18,880 --> 00:08:17,030

mechanisms of survival so survival

199

00:08:21,280 --> 00:08:18,890

strategies of the vesicle so to speak

200

00:08:24,010 --> 00:08:21,290

with the last one it's obvious since by

201  
00:08:26,500 --> 00:08:24,020  
increasing the terminal now instability

202  
00:08:29,230 --> 00:08:26,510  
they live longer with a second one this

203  
00:08:31,719 --> 00:08:29,240  
means that the vesicle becomes capable

204  
00:08:33,520 --> 00:08:31,729  
of releasing osmotic pressure and with

205  
00:08:36,219 --> 00:08:33,530  
the first one we believe that the size

206  
00:08:39,180 --> 00:08:36,229  
effect means that smaller vesicles are

207  
00:08:44,140 --> 00:08:39,190  
more capable of surviving shear or

208  
00:08:46,390 --> 00:08:44,150  
uplink for example okay so now we

209  
00:08:48,700 --> 00:08:46,400  
believe that we are at this stage here

210  
00:08:51,370 --> 00:08:48,710  
now question is what comes next what

211  
00:08:53,079 --> 00:08:51,380  
will develop of course there's an end

212  
00:08:54,040 --> 00:08:53,089  
point here and this cannot go on forever

213  
00:08:55,480 --> 00:08:54,050

at the

214

00:08:57,670 --> 00:08:55,490

point where the rate of selection is

215

00:09:00,040 --> 00:08:57,680

equal to the rate of degradation then

216

00:09:02,470 --> 00:09:00,050

everything will stop however there is a

217

00:09:04,150 --> 00:09:02,480

potential for a situation like that I

218

00:09:05,620 --> 00:09:04,160

told it in the beginning that there is a

219

00:09:07,390 --> 00:09:05,630

concentration gradient so this

220

00:09:09,760 --> 00:09:07,400

concentration gradient can be regarded

221

00:09:12,760 --> 00:09:09,770

as a source of free energies like a

222

00:09:14,590 --> 00:09:12,770

loaded battery so maybe it's assumed

223

00:09:16,600 --> 00:09:14,600

that the molecules passing through these

224

00:09:19,180 --> 00:09:16,610

channels could induce something like a

225

00:09:21,250 --> 00:09:19,190

high energy conformation to the peptide

226

00:09:25,630 --> 00:09:21,260

and this could be the starting point or

227

00:09:27,430 --> 00:09:25,640

something like a very primitive energy

228

00:09:29,770 --> 00:09:27,440

metabolism of some kind so this is

229

00:09:31,570 --> 00:09:29,780

something we had for right now and this

230

00:09:33,730 --> 00:09:31,580

is something which we want to follow in

231

00:09:35,770 --> 00:09:33,740

the experiment which are being done in

232

00:09:37,900 --> 00:09:35,780

the future ok at this point I want to

233

00:10:28,270 --> 00:09:37,910

leave this as a summary and I thank you

234

00:10:30,880 --> 00:10:28,280

for that's right I have to mention one

235

00:10:32,920 --> 00:10:30,890

thing we need to run this experiment in

236

00:10:34,600 --> 00:10:32,930

a way but it's kind of reproducible

237

00:10:36,070 --> 00:10:34,610

these specimens which have shown right

238

00:10:39,580 --> 00:10:36,080

now and all these changes which are

239

00:10:41,380 --> 00:10:39,590

shown right now one time experiments so

240

00:10:43,300 --> 00:10:41,390

what we need to do is we need to repeat

241

00:10:45,430 --> 00:10:43,310

and repeat this experiment we need to

242

00:10:47,980 --> 00:10:45,440

find which of these changes in which of

243

00:10:52,870 --> 00:10:50,340

progress is that we see here is really

244

00:10:55,870 --> 00:10:52,880

reproducible so I agree with you it

245

00:10:57,670 --> 00:10:55,880

would be already a success but of course

246

00:10:59,019 --> 00:10:57,680

we are curious what will happen right

247

00:11:02,800 --> 00:10:59,029

now we run the experiment for three

248

00:11:04,810 --> 00:11:02,810

weeks and that means 1500 generations of

249

00:11:07,030 --> 00:11:04,820

vesicles we could extend this to three

250

00:11:09,280 --> 00:11:07,040

months and have four times as many

251  
00:11:11,829 --> 00:11:09,290  
generations and of course we still

252  
00:11:13,870 --> 00:11:11,839  
expect a growth we can still see now

253  
00:11:16,480 --> 00:11:13,880  
they've had tides growing to lengths

254  
00:11:18,490 --> 00:11:16,490  
between ten and fourteen something like

255  
00:11:22,570 --> 00:11:18,500  
that and of course by that we would

256  
00:12:15,850 --> 00:11:22,580  
expect something more sophisticated to

257  
00:12:22,879 --> 00:12:21,050  
right that's right exact it's something

258  
00:12:25,129 --> 00:12:22,889  
we do at the moment too we have for

259  
00:12:27,620 --> 00:12:25,139  
example change the conditions like

260  
00:12:29,360 --> 00:12:27,630  
taking away the the vesicles after half

261  
00:12:32,269 --> 00:12:29,370  
of the experimental time I will talk

262  
00:12:33,710 --> 00:12:32,279  
about that on Wednesday it's a somewhat

263  
00:12:36,680 --> 00:12:33,720

more in the detail on the experiment

264

00:12:38,420 --> 00:12:36,690

itself and we see some changes there we

265

00:12:40,670 --> 00:12:38,430

have a hard time to interpret them to be

266

00:12:42,590 --> 00:12:40,680

honest you see changes regarding we have

267

00:12:45,590 --> 00:12:42,600

a full list of peptides which we

268

00:12:47,420 --> 00:12:45,600

observed to develop and we see that they

269

00:12:49,699 --> 00:12:47,430

are significant but you cannot really

270

00:12:52,509 --> 00:12:49,709

interpret what that means but you are

271

00:12:54,980 --> 00:12:52,519

right some hidden information is in the

272

00:13:13,300 --> 00:12:54,990

collection of peptides which we obtained

273

00:13:18,800 --> 00:13:17,630

mm we worked with a long-chain fatty

274

00:13:22,400 --> 00:13:18,810

acid so it's

275

00:13:24,290 --> 00:13:22,410

akhtar Dacula decanoic acid soiree

276

00:13:25,519 --> 00:13:24,300

Octavia dick you'll I mean it's the

277

00:13:28,250 --> 00:13:25,529

mixture of these two

278

00:13:34,400 --> 00:13:28,260

that's the the membrane material so to

279

00:13:37,160 --> 00:13:34,410

speak yes we have strong hints that they

280

00:13:40,310 --> 00:13:37,170

are reaction in between the amphiphiles

281

00:13:42,139 --> 00:13:40,320

and the amino acids so far we have just

282

00:13:44,510 --> 00:13:42,149

ignored them but you're right they are

283

00:13:47,030 --> 00:13:44,520

there and they may take part in this

284

00:13:49,190 --> 00:13:47,040

game somehow so there may be mixed

285

00:13:51,290 --> 00:13:49,200

products in between the amphiphiles and

286

00:13:53,840 --> 00:13:51,300

the amino acids but we have not

287

00:13:55,880 --> 00:13:53,850

characterized them yet because we are

288

00:13:57,980 --> 00:13:55,890

still fighting the very complex

289

00:14:01,040 --> 00:13:57,990

analytical problem that we have to deal

290

00:14:03,370 --> 00:14:01,050

with with all these peptides thousands

291

00:14:06,050 --> 00:14:03,380

hundred thousands of peptides which form

292

00:14:09,680 --> 00:14:06,060

and which need to be sequenced which

293

00:14:11,510 --> 00:14:09,690

need to be identified so we have to do

294

00:14:17,449 --> 00:14:11,520

one step after the other but you're