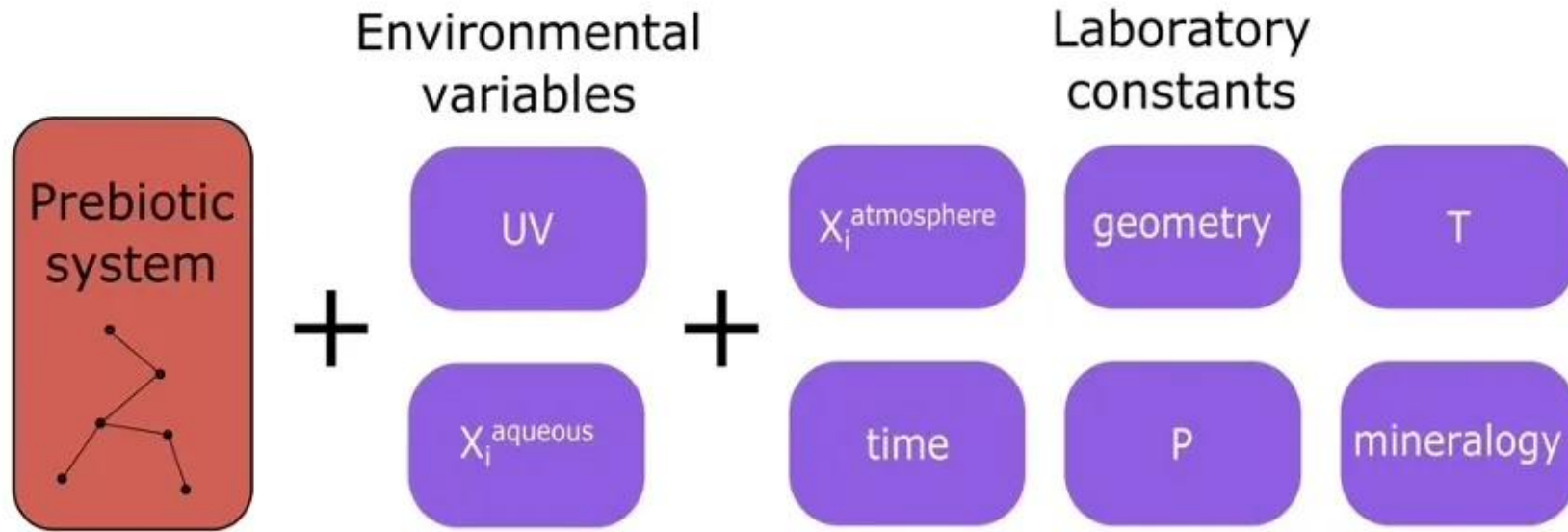


**Systems chemistry:** experimentally demonstrable set of reactions driven by reagents and conditions that may have co-occured on early Earth



# PREBIOTIC SYSTEMS

a series of connected reactions, the reactants for which may plausibly have co-occurred on early Earth in the required abundances / under requisite reaction conditions

1  
00:00:04,870 --> 00:00:03,189  
hi everyone i'm a third year phd student

2  
00:00:05,590 --> 00:00:04,880  
in earth sciences at the university of

3  
00:00:07,670 --> 00:00:05,600  
cambridge

4  
00:00:09,589 --> 00:00:07,680  
i'm really looking forward to appgradcon

5  
00:00:11,110 --> 00:00:09,599  
the lineup seems extremely diverse

6  
00:00:13,350 --> 00:00:11,120  
which is perfect given that the whole

7  
00:00:15,270 --> 00:00:13,360  
point of my talk is to argue in favor of

8  
00:00:17,189 --> 00:00:15,280  
interdisciplinary science

9  
00:00:18,870 --> 00:00:17,199  
specifically the key questions i'm

10  
00:00:20,790 --> 00:00:18,880  
asking today are

11  
00:00:22,790 --> 00:00:20,800  
how can we describe and integrate the

12  
00:00:24,790 --> 00:00:22,800  
complexity of naturally occurring

13  
00:00:26,310 --> 00:00:24,800

geochemical environments into probiotic

14

00:00:28,830 --> 00:00:26,320

chemistry and can

15

00:00:31,109 --> 00:00:28,840

doing this help us to quantify prebiotic

16

00:00:33,270 --> 00:00:31,119

plausibility

17

00:00:34,709 --> 00:00:33,280

prebiotic chemistry as a field is

18

00:00:35,510 --> 00:00:34,719

largely concerned with discovering

19

00:00:37,190 --> 00:00:35,520

synthesis

20

00:00:39,030 --> 00:00:37,200

of those molecules that could have given

21

00:00:40,229 --> 00:00:39,040

rise to life for example

22

00:00:41,910 --> 00:00:40,239

holy grails in the field including

23

00:00:45,430 --> 00:00:41,920

nucleic acids lipid membranes and

24

00:00:47,190 --> 00:00:45,440

proteins which i'm sure you're all aware

25

00:00:49,750 --> 00:00:47,200

i would summarize probiotic chemists as

26  
00:00:52,229 --> 00:00:49,760  
building and testing probiotic pathways

27  
00:00:54,470 --> 00:00:52,239  
a series of steps reactions usually

28  
00:00:56,630 --> 00:00:54,480  
needed to synthesize a given molecule or

29  
00:00:58,869 --> 00:00:56,640  
set of molecules

30  
00:01:00,229 --> 00:00:58,879  
over time these lab assembled pathways

31  
00:01:01,750 --> 00:01:00,239  
have become more complex

32  
00:01:03,510 --> 00:01:01,760  
at first we had merely single step

33  
00:01:04,390 --> 00:01:03,520  
reactions then linear change of

34  
00:01:06,070 --> 00:01:04,400  
reactions

35  
00:01:08,230 --> 00:01:06,080  
and nowadays there are fully fledged

36  
00:01:10,310 --> 00:01:08,240  
systems of chemical reactions that lead

37  
00:01:12,630 --> 00:01:10,320  
to numerous desired products

38  
00:01:14,550 --> 00:01:12,640

a plausible probiotic system must make

39

00:01:17,590 --> 00:01:14,560

use of reagents which co-occurred

40

00:01:19,350 --> 00:01:17,600

in early earth environments

41

00:01:21,350 --> 00:01:19,360

but it's our knowledge of the early

42

00:01:23,109 --> 00:01:21,360

earth where many problems arise

43

00:01:24,630 --> 00:01:23,119

because prebiotic chemists are largely

44

00:01:25,749 --> 00:01:24,640

reliant upon geologists for these

45

00:01:27,590 --> 00:01:25,759

constraints

46

00:01:29,429 --> 00:01:27,600

yet we geologists have a pretty poor

47

00:01:31,109 --> 00:01:29,439

understanding of the early earth

48

00:01:32,550 --> 00:01:31,119

this isn't really our fault the first

49

00:01:34,550 --> 00:01:32,560

half the billion years simply have no

50

00:01:36,310 --> 00:01:34,560

rocks left for us to study

51  
00:01:38,149 --> 00:01:36,320  
we do think that there was an anoxic

52  
00:01:39,910 --> 00:01:38,159  
atmosphere with surface oceans

53  
00:01:41,270 --> 00:01:39,920  
and probably some land but we don't

54  
00:01:42,469 --> 00:01:41,280  
ultimately know how reducing the

55  
00:01:44,069 --> 00:01:42,479  
atmosphere would have been

56  
00:01:46,389 --> 00:01:44,079  
which is very important for many types

57  
00:01:47,749 --> 00:01:46,399  
of proposed prebiotic organic chemistry

58  
00:01:48,550 --> 00:01:47,759  
we don't know if there were continents

59  
00:01:51,510 --> 00:01:48,560  
we don't know what the surface

60  
00:01:53,510 --> 00:01:51,520  
temperature was and many other things

61  
00:01:54,870 --> 00:01:53,520  
within that global view we have more

62  
00:01:55,830 --> 00:01:54,880  
detailed picture of specific

63  
00:01:57,910 --> 00:01:55,840

environments

64

00:01:59,429 --> 00:01:57,920

an environment being proposed to host a

65

00:02:01,990 --> 00:01:59,439

particular prebiotic system

66

00:02:04,230 --> 00:02:02,000

is called a scenario a testable union of

67

00:02:05,910 --> 00:02:04,240

chemical and geological ideas

68

00:02:07,350 --> 00:02:05,920

whilst we often talk pretty broadly

69

00:02:08,309 --> 00:02:07,360

about plausible environments on the

70

00:02:09,910 --> 00:02:08,319

early earth

71

00:02:11,510 --> 00:02:09,920

probiotic pathways for the origin of

72

00:02:12,630 --> 00:02:11,520

life will have had to contend with what

73

00:02:14,949 --> 00:02:12,640

was actually there

74

00:02:16,869 --> 00:02:14,959

specifically an environment is not just

75

00:02:18,630 --> 00:02:16,879

defined by its most interesting

76

00:02:20,710 --> 00:02:18,640

or useful characteristics for prebiotic

77

00:02:23,030 --> 00:02:20,720

chemistry it is in reality

78

00:02:24,949 --> 00:02:23,040

a hugely diverse and dynamic system

79

00:02:26,150 --> 00:02:24,959

which may pose many more challenges to

80

00:02:29,190 --> 00:02:26,160

the periodic system

81

00:02:31,270 --> 00:02:29,200

than any simplified lab analog so the

82

00:02:32,790 --> 00:02:31,280

challenge facing us is twofold

83

00:02:34,710 --> 00:02:32,800

how to incorporate environmental

84

00:02:36,070 --> 00:02:34,720

complexity into the lab and how to

85

00:02:38,150 --> 00:02:36,080

constrain earlier conditions

86

00:02:40,470 --> 00:02:38,160

sufficiently to properly evaluate

87

00:02:42,790 --> 00:02:40,480

prebiotic plausibility

88

00:02:43,830 --> 00:02:42,800

inter-interference chemistry this is our

89

00:02:45,270 --> 00:02:43,840

proposed term

90

00:02:47,350 --> 00:02:45,280

for describing the response of a

91

00:02:48,869 --> 00:02:47,360

probiotic system to interferences that

92

00:02:50,070 --> 00:02:48,879

are present in the proposed host

93

00:02:53,270 --> 00:02:50,080

environment

94

00:02:54,869 --> 00:02:53,280

defined by many species

95

00:02:56,790 --> 00:02:54,879

and variables external to what is

96

00:02:58,869 --> 00:02:56,800

strictly necessary to execute the

97

00:03:00,869 --> 00:02:58,879

probiotic pathway at hand

98

00:03:02,309 --> 00:03:00,879

these extra species among many other

99

00:03:04,470 --> 00:03:02,319

environmental parameters

100

00:03:06,470 --> 00:03:04,480

may get in the way or indeed assist with

101

00:03:08,790 --> 00:03:06,480

the desired reaction steps

102

00:03:10,869 --> 00:03:08,800

i.e destructively or constructively

103

00:03:12,790 --> 00:03:10,879

interfere with the pathway

104

00:03:15,110 --> 00:03:12,800

therefore by thinking about interference

105

00:03:17,110 --> 00:03:15,120

chemistry we can reformulate the entire

106

00:03:18,550 --> 00:03:17,120

problem in a way that calls upon both

107

00:03:20,390 --> 00:03:18,560

chemists and geologists

108

00:03:22,790 --> 00:03:20,400

to explore a wide reach of parameter

109

00:03:23,910 --> 00:03:22,800

space not only the best conditions for

110

00:03:26,949 --> 00:03:23,920

given synthesis

111

00:03:28,869 --> 00:03:26,959

at the paper at hand that is to say

112

00:03:30,949 --> 00:03:28,879

rather than asking if the chemicals used

113

00:03:32,550 --> 00:03:30,959

in our proposed probiotic pathway

114

00:03:34,309 --> 00:03:32,560

have occurred anywhere on early earth

115

00:03:36,710 --> 00:03:34,319

together we can ask

116

00:03:38,869 --> 00:03:36,720

if a proposed probiotic system would

117

00:03:40,229 --> 00:03:38,879

have survived anywhere on the early

118

00:03:42,390 --> 00:03:40,239

earth

119

00:03:44,390 --> 00:03:42,400

in order to demonstrate our approach we

120

00:03:46,229 --> 00:03:44,400

require a toy chemical scenario

121

00:03:47,509 --> 00:03:46,239

that is complex enough to illustrate

122

00:03:49,270 --> 00:03:47,519

both the utility

123

00:03:50,630 --> 00:03:49,280

and present some limitations of

124

00:03:52,070 --> 00:03:50,640

interference chemistry

125

00:03:53,830 --> 00:03:52,080

but it's simple enough to explore

126

00:03:55,910 --> 00:03:53,840

reasonably comprehensively

127

00:03:57,990 --> 00:03:55,920

here we explore interference chemistry

128

00:04:00,309 --> 00:03:58,000

for a simple series of reactions

129

00:04:01,509 --> 00:04:00,319

ribose and nucleobased formation ribose

130

00:04:03,270 --> 00:04:01,519

phosphorylation

131

00:04:05,110 --> 00:04:03,280

ribonucleotide formation and

132

00:04:06,309 --> 00:04:05,120

ribonucleotide polymerization to make

133

00:04:08,309 --> 00:04:06,319

rna

134

00:04:10,229 --> 00:04:08,319

our selected system of reactions is very

135

00:04:12,070 --> 00:04:10,239

close to the traditional retrosynthetic

136

00:04:13,910 --> 00:04:12,080

disconnection of rna

137

00:04:15,350 --> 00:04:13,920

in general search reaction pathways are

138

00:04:17,030 --> 00:04:15,360

not considered to be probiotically

139

00:04:19,110 --> 00:04:17,040

plausible at the present time

140

00:04:20,150 --> 00:04:19,120

we do not consider our minor variation

141

00:04:22,150 --> 00:04:20,160

on the traditional

142

00:04:24,230 --> 00:04:22,160

retrosynthetic disconnection of rna to

143

00:04:25,590 --> 00:04:24,240

be a novel or especially prematurely

144

00:04:27,670 --> 00:04:25,600

plausible approach

145

00:04:29,030 --> 00:04:27,680

however we do choose this example

146

00:04:30,950 --> 00:04:29,040

because the relevant environmental

147

00:04:31,830 --> 00:04:30,960

dependencies have already been widely

148

00:04:34,070 --> 00:04:31,840

explored

149

00:04:35,909 --> 00:04:34,080

which provides a perfect opportunity to

150

00:04:37,110 --> 00:04:35,919

illustrate how combining systems and

151

00:04:39,110 --> 00:04:37,120

interference chemistry

152

00:04:43,189 --> 00:04:39,120

may be able to formalize constraints on

153

00:04:44,710 --> 00:04:43,199

probiotic plausibility so step one

154

00:04:46,629 --> 00:04:44,720

you take some glycoaldehyde and

155

00:04:48,469 --> 00:04:46,639

glyceraldehyde and react them to form

156

00:04:49,990 --> 00:04:48,479

ribose during simultaneous heating and

157

00:04:52,310 --> 00:04:50,000

base catalysis

158

00:04:53,430 --> 00:04:52,320

in general ribose is highly unstable in

159

00:04:54,950 --> 00:04:53,440

aqueous solution

160

00:04:56,790 --> 00:04:54,960

this would be rather restrictive for any

161

00:04:58,230 --> 00:04:56,800

probiotic pathway requiring ribose

162

00:05:00,469 --> 00:04:58,240

and indeed the issue has plagued

163

00:05:02,310 --> 00:05:00,479

probiotic chemists for some time

164

00:05:03,990 --> 00:05:02,320

the presence of a borate ring moiety

165

00:05:06,150 --> 00:05:04,000

does improve resistance of ribose to

166

00:05:07,830 --> 00:05:06,160

nucleophilic attack significantly

167

00:05:09,430 --> 00:05:07,840

bore it can also encourage ribose

168

00:05:11,590 --> 00:05:09,440

selective forward reactions

169

00:05:13,749 --> 00:05:11,600

acting as a desirable constructive

170

00:05:16,230 --> 00:05:13,759

interference in the reaction scheme

171

00:05:18,150 --> 00:05:16,240

however boric acid only speciates mainly

172

00:05:20,150 --> 00:05:18,160

as borate in aqueous solution under

173

00:05:21,670 --> 00:05:20,160

highly alkaline conditions

174

00:05:23,749 --> 00:05:21,680

this requirement is compatible with the

175

00:05:24,710 --> 00:05:23,759

base catalysis we need to drive rivals

176

00:05:27,110 --> 00:05:24,720

formation itself

177

00:05:27,830 --> 00:05:27,120

via the reaction step we describe here

178

00:05:29,189 --> 00:05:27,840

however

179

00:05:30,950 --> 00:05:29,199

we already have some stringent

180

00:05:32,710 --> 00:05:30,960

requirements here on the environmental

181

00:05:38,150 --> 00:05:32,720

ph

182

00:05:39,990 --> 00:05:38,160

for this step we begin to have

183

00:05:41,670 --> 00:05:40,000

sufficiently quantitative constraints in

184

00:05:44,230 --> 00:05:41,680

place to begin formulating

185

00:05:45,909 --> 00:05:44,240

a model with experimental knowledge of

186

00:05:47,830 --> 00:05:45,919

the reaction constant  $k$

187

00:05:49,590 --> 00:05:47,840

and some calculations we did to describe

188

00:05:50,950 --> 00:05:49,600

its dependence on water activity

189

00:05:53,350 --> 00:05:50,960

because the forward reaction and

190

00:05:55,270 --> 00:05:53,360

phosphorylation involves condensation

191

00:05:57,189 --> 00:05:55,280

we can plot the parameter space for

192

00:05:59,670 --> 00:05:57,199

expected equilibrium yield of ribose

193

00:06:01,110 --> 00:05:59,680

phosphate under varying conditions

194

00:06:03,270 --> 00:06:01,120

on the y-axis we have our yield of

195

00:06:04,309 --> 00:06:03,280

robust phosphate on the x-axis we have

196

00:06:06,629 --> 00:06:04,319

water activity

197

00:06:07,749 --> 00:06:06,639

map to a range of various environments

198

00:06:09,830 --> 00:06:07,759

if we lose water

199

00:06:11,350 --> 00:06:09,840

and maintain reactant concentrations we

200

00:06:12,390 --> 00:06:11,360

move along either the top or the bottom

201  
00:06:14,230 --> 00:06:12,400  
pink lane

202  
00:06:16,390 --> 00:06:14,240  
for the bottom condition which is micro

203  
00:06:17,990 --> 00:06:16,400  
molar initial ribose and phosphate

204  
00:06:19,590 --> 00:06:18,000  
if we residually concentrate those

205  
00:06:21,110 --> 00:06:19,600  
reactants as we lose water

206  
00:06:22,710 --> 00:06:21,120  
we will move more steeply along the

207  
00:06:24,230 --> 00:06:22,720  
central pink line

208  
00:06:25,749 --> 00:06:24,240  
if we account for the fact that the

209  
00:06:27,189 --> 00:06:25,759  
equilibrium constant itself

210  
00:06:29,270 --> 00:06:27,199  
actually depends on the activity of

211  
00:06:31,189 --> 00:06:29,280  
water to some extent then equilibrium

212  
00:06:32,309 --> 00:06:31,199  
ribose phosphate increases slightly more

213  
00:06:34,870 --> 00:06:32,319

steeply

214

00:06:36,230 --> 00:06:34,880

that's the top pink line overall in

215

00:06:37,909 --> 00:06:36,240

order to obtain greater than one

216

00:06:38,629 --> 00:06:37,919

millimolar concentrations of ribose

217

00:06:40,230 --> 00:06:38,639

phosphate

218

00:06:42,629 --> 00:06:40,240

we are looking at some combination of

219

00:06:45,029 --> 00:06:42,639

reasonably high reactant concentrations

220

00:06:47,270 --> 00:06:45,039

and low water activity which has more

221

00:06:48,950 --> 00:06:47,280

environmental implications from nature

222

00:06:50,469 --> 00:06:48,960

various combinations of equilibrium

223

00:06:53,430 --> 00:06:50,479

reacting concentrations are also

224

00:06:56,070 --> 00:06:53,440

indicated on the right hand side

225

00:06:56,790 --> 00:06:56,080

next step in the constellation the

226  
00:06:58,710 --> 00:06:56,800  
reaction

227  
00:07:00,550 --> 00:06:58,720  
of nuclear base and ribose phosphate to

228  
00:07:02,070 --> 00:07:00,560  
form a nucleotide

229  
00:07:04,309 --> 00:07:02,080  
now in order to stop things becoming

230  
00:07:06,390 --> 00:07:04,319  
prohibitively complex at this stage

231  
00:07:08,150 --> 00:07:06,400  
we arbitrarily restricted sources of

232  
00:07:10,070 --> 00:07:08,160  
nuclear bases in this scenario to

233  
00:07:11,749 --> 00:07:10,080  
delivery by meteorites

234  
00:07:13,589 --> 00:07:11,759  
this imposition means we are

235  
00:07:14,150 --> 00:07:13,599  
environmentally restricted to shallow

236  
00:07:16,150 --> 00:07:14,160  
surface

237  
00:07:17,749 --> 00:07:16,160  
environments we followed on with our

238  
00:07:18,390 --> 00:07:17,759

work from a model for this delivery

239

00:07:20,870 --> 00:07:18,400

mechanism

240

00:07:22,070 --> 00:07:20,880

formulated previously by piercetal in

241

00:07:25,270 --> 00:07:22,080

their 2017

242

00:07:27,510 --> 00:07:25,280

pns paper but we made a few so

243

00:07:28,710 --> 00:07:27,520

our results here show adenine

244

00:07:31,189 --> 00:07:28,720

concentration

245

00:07:32,629 --> 00:07:31,199

and pawn volume on the y-axis and time

246

00:07:35,350 --> 00:07:32,639

on the x-axis

247

00:07:36,870 --> 00:07:35,360

in plot a we have totally uv shielded

248

00:07:38,550 --> 00:07:36,880

scenarios for the evaporative

249

00:07:41,270 --> 00:07:38,560

concentration of adenine

250

00:07:42,629 --> 00:07:41,280

in a one meter radius pond solid lines

251  
00:07:44,230 --> 00:07:42,639  
have no outflow

252  
00:07:46,629 --> 00:07:44,240  
dashed lines have an estimated rate of

253  
00:07:47,909 --> 00:07:46,639  
outflow which will remove nuclear bases

254  
00:07:50,629 --> 00:07:47,919  
from the pond

255  
00:07:51,749 --> 00:07:50,639  
in plot b we have only partial uv

256  
00:07:54,230 --> 00:07:51,759  
shielding

257  
00:07:55,589 --> 00:07:54,240  
the orange line in plot b has only uv

258  
00:07:57,749 --> 00:07:55,599  
shielding in the white phase

259  
00:07:59,670 --> 00:07:57,759  
whereas the blue line shows uv shielding

260  
00:08:02,309 --> 00:07:59,680  
only in the dry phase

261  
00:08:04,070 --> 00:08:02,319  
we find that only uv shielded systems

262  
00:08:05,189 --> 00:08:04,080  
can accumulate useful concentrations of

263  
00:08:06,950 --> 00:08:05,199

nuclear bases

264

00:08:08,790 --> 00:08:06,960

peaking during the final evaporation of

265

00:08:10,469 --> 00:08:08,800

the pond uv

266

00:08:12,309 --> 00:08:10,479

radiation in the white phase will

267

00:08:14,070 --> 00:08:12,319

destroy too many nuclear bases

268

00:08:17,670 --> 00:08:14,080

whereas uv irradiation in the dry phase

269

00:08:20,150 --> 00:08:17,680

will destroy all nuclear bases

270

00:08:20,790 --> 00:08:20,160

with respect to the glaciation reaction

271

00:08:22,790 --> 00:08:20,800

itself

272

00:08:24,469 --> 00:08:22,800

the reactant concentrations and water

273

00:08:26,309 --> 00:08:24,479

activity conditions required

274

00:08:28,150 --> 00:08:26,319

for reaction between nuclear base and

275

00:08:29,909 --> 00:08:28,160

ribosomal phosphate are similar to the

276

00:08:32,149 --> 00:08:29,919

previous phosphorylation step

277

00:08:33,829 --> 00:08:32,159

but less favorable however the

278

00:08:35,589 --> 00:08:33,839

experimental constraints on this step

279

00:08:38,070 --> 00:08:35,599

also indicate a requirement for acidic

280

00:08:40,230 --> 00:08:38,080

conditions from suarez merino towel in

281

00:08:41,829 --> 00:08:40,240

chemical communications this is not a

282

00:08:43,509 --> 00:08:41,839

terribly compatible

283

00:08:45,990 --> 00:08:43,519

environmental scenario with previous

284

00:08:47,590 --> 00:08:46,000

steps which required base catalysis

285

00:08:49,430 --> 00:08:47,600

this is the point i'll come back to near

286

00:08:51,750 --> 00:08:49,440

the end of the talk

287

00:08:53,030 --> 00:08:51,760

finally we have the polymerization of

288

00:08:55,110 --> 00:08:53,040

nucleic acids

289

00:08:56,949 --> 00:08:55,120

we use the experimentally informed

290

00:08:58,070 --> 00:08:56,959

parameterization of nucleic acid

291

00:09:01,430 --> 00:08:58,080

polymerization

292

00:09:03,430 --> 00:09:01,440

by mastital in their 2013 pnes paper

293

00:09:04,790 --> 00:09:03,440

to explore the effect of water activity

294

00:09:06,790 --> 00:09:04,800

on this process

295

00:09:08,070 --> 00:09:06,800

we assume that monomer monomer addition

296

00:09:11,030 --> 00:09:08,080

rates depend linearly

297

00:09:13,350 --> 00:09:11,040

on water activity we can only place an

298

00:09:14,949 --> 00:09:13,360

upper limit on polymerization efficiency

299

00:09:16,949 --> 00:09:14,959

because previous work used enzyme

300

00:09:19,030 --> 00:09:16,959

propagated polymerization

301

00:09:20,630 --> 00:09:19,040

we therefore have to assume that this

302

00:09:22,550 --> 00:09:20,640

would be similar to pre-activated

303

00:09:24,070 --> 00:09:22,560

nucleotide behavior which is certainly a

304

00:09:26,389 --> 00:09:24,080

big assumption

305

00:09:27,990 --> 00:09:26,399

either way given these assumptions the

306

00:09:29,910 --> 00:09:28,000

results place constraints on the

307

00:09:32,389 --> 00:09:29,920

concentration convergence profile

308

00:09:33,030 --> 00:09:32,399

of various rna polymer lengths as you

309

00:09:34,790 --> 00:09:33,040

can see

310

00:09:36,389 --> 00:09:34,800

it is a struggle to achieve long lengths

311

00:09:38,550 --> 00:09:36,399

under most environmentally plausible

312

00:09:41,590 --> 00:09:38,560

conditions

313

00:09:43,190 --> 00:09:41,600

using all this information we created a

314

00:09:45,509 --> 00:09:43,200

simple chemical network and solved for

315

00:09:46,949 --> 00:09:45,519

the equilibrium concentration of rna

316

00:09:49,190 --> 00:09:46,959

that we would expect at different

317

00:09:50,949 --> 00:09:49,200

imposed initial water activities

318

00:09:53,110 --> 00:09:50,959

the system is closed which means the

319

00:09:55,110 --> 00:09:53,120

forward reaction will produce water

320

00:09:56,710 --> 00:09:55,120

due to condensation reactions creating

321

00:09:58,790 --> 00:09:56,720

an inherent limit on the minimum water

322

00:10:00,150 --> 00:09:58,800

activity that could be achieved

323

00:10:01,750 --> 00:10:00,160

even if we adjust the plausible

324

00:10:03,030 --> 00:10:01,760

equilibrium constants to the most

325

00:10:05,829 --> 00:10:03,040

optimum values

326

00:10:07,670 --> 00:10:05,839

we cannot achieve very long terms of rna

327

00:10:09,750 --> 00:10:07,680

these are far too short to cook to code

328

00:10:11,509 --> 00:10:09,760

for any sorts of useful information

329

00:10:13,670 --> 00:10:11,519

implying the need for some sort of open

330

00:10:14,630 --> 00:10:13,680

system water loss without diffusing our

331

00:10:18,870 --> 00:10:14,640

other reactants

332

00:10:21,590 --> 00:10:18,880

to access longer strands

333

00:10:23,350 --> 00:10:21,600

okay so in my final few slides i will

334

00:10:24,710 --> 00:10:23,360

try to crystallize for you

335

00:10:26,630 --> 00:10:24,720

all of that information into a

336

00:10:28,630 --> 00:10:26,640

relatively simple outcome by running

337

00:10:29,990 --> 00:10:28,640

quickly through an overall interference

338

00:10:33,190 --> 00:10:30,000

chemistry analysis

339

00:10:34,150 --> 00:10:33,200

of this particular system we impose an

340

00:10:35,750 --> 00:10:34,160

initial restriction

341

00:10:37,590 --> 00:10:35,760

that all of our nuclear bases should

342

00:10:38,790 --> 00:10:37,600

come from meteoritic deposition

343

00:10:40,949 --> 00:10:38,800

which means we need to look at

344

00:10:44,230 --> 00:10:40,959

restricted basins with uv

345

00:10:49,110 --> 00:10:46,870

within saturation we universally need

346

00:10:50,310 --> 00:10:49,120

some way to access low water activity

347

00:10:53,110 --> 00:10:50,320

in order to drive all of those

348

00:10:55,269 --> 00:10:53,120

condensation reactions this can involve

349

00:10:56,710 --> 00:10:55,279

bulk wet dry cycles or local scale

350

00:10:59,750 --> 00:10:56,720

cycling in bubbles

351  
00:11:00,949 --> 00:10:59,760  
aerosols or protocol membranes etc

352  
00:11:02,790 --> 00:11:00,959  
the key is to be able to maintain

353  
00:11:04,230 --> 00:11:02,800  
reactants in one place and continuously

354  
00:11:06,230 --> 00:11:04,240  
exclude water

355  
00:11:09,269 --> 00:11:06,240  
fully closed systems will be incapable

356  
00:11:11,030 --> 00:11:09,279  
of producing useful results

357  
00:11:12,230 --> 00:11:11,040  
zooming in on these basins we have

358  
00:11:13,590 --> 00:11:12,240  
constraints from the ribose

359  
00:11:16,389 --> 00:11:13,600  
phosphorylation step

360  
00:11:18,710 --> 00:11:16,399  
for phosphorus rich borate rich ribose

361  
00:11:20,150 --> 00:11:18,720  
rich alkaline restricted basins

362  
00:11:21,750 --> 00:11:20,160  
the raw types that can host such

363  
00:11:23,590 --> 00:11:21,760

environments are different depending on

364

00:11:26,310 --> 00:11:23,600

the atmospheric conditions

365

00:11:28,230 --> 00:11:26,320

specifically under low pco2 alkaline

366

00:11:29,190 --> 00:11:28,240

conditions will be possible in any given

367

00:11:31,430 --> 00:11:29,200

solar lake

368

00:11:33,350 --> 00:11:31,440

but under high pco2 we will need to

369

00:11:35,269 --> 00:11:33,360

drive alkaline conditions

370

00:11:37,430 --> 00:11:35,279

through serpentinizing hydrothermal

371

00:11:39,350 --> 00:11:37,440

systems glycosylation

372

00:11:40,949 --> 00:11:39,360

is only favored in acidic variants of

373

00:11:43,670 --> 00:11:40,959

these restricted basins

374

00:11:45,430 --> 00:11:43,680

which provides a disconnect in the ph of

375

00:11:47,030 --> 00:11:45,440

these environmental scenarios

376

00:11:49,030 --> 00:11:47,040

this is a fairly fundamental challenge

377

00:11:50,710 --> 00:11:49,040

to the scenario from the perspective of

378

00:11:53,110 --> 00:11:50,720

interference chemistry

379

00:11:54,949 --> 00:11:53,120

because in an acidic scenario ribose

380

00:11:57,910 --> 00:11:54,959

accumulation and phosphorylation will be

381

00:12:01,430 --> 00:11:59,910

looking at the overall path analysis we

382

00:12:01,990 --> 00:12:01,440

can see that our interference chemistry

383

00:12:04,069 --> 00:12:02,000

approach

384

00:12:05,030 --> 00:12:04,079

helps to identify favorite scenarios as

385

00:12:07,509 --> 00:12:05,040

well as places

386

00:12:09,590 --> 00:12:07,519

where the scenario breaks down the most

387

00:12:11,350 --> 00:12:09,600

ideal is alkaline closed basins

388

00:12:13,910 --> 00:12:11,360

linked to mechanisms of open system

389

00:12:15,750 --> 00:12:13,920

water loss but overall there is no clear

390

00:12:18,069 --> 00:12:15,760

prebiotically plausible scenario

391

00:12:21,030 --> 00:12:18,079

because even this struggles when you

392

00:12:22,629 --> 00:12:21,040

need acidic conditions for glycosylation

393

00:12:24,069 --> 00:12:22,639

i started the talk by saying that was

394

00:12:25,829 --> 00:12:24,079

our expected outcome

395

00:12:27,269 --> 00:12:25,839

for the probiotic system not to be

396

00:12:28,949 --> 00:12:27,279

plausible however

397

00:12:30,629 --> 00:12:28,959

i hope i have convinced you that putting

398

00:12:32,710 --> 00:12:30,639

the environmental interferences

399

00:12:33,910 --> 00:12:32,720

responsible for rendering the system

400

00:12:36,069 --> 00:12:33,920

implausible

401  
00:12:38,150 --> 00:12:36,079  
at the front and center is a helpful way

402  
00:12:39,670 --> 00:12:38,160  
to think about the challenges we face

403  
00:12:40,870 --> 00:12:39,680  
when i think the limitations that i

404  
00:12:42,470 --> 00:12:40,880  
faced in mapping out with the

405  
00:12:43,990 --> 00:12:42,480  
environmental parameter space

406  
00:12:45,670 --> 00:12:44,000  
for this very well-studied and simple

407  
00:12:47,590 --> 00:12:45,680  
system it seems clear to me

408  
00:12:49,190 --> 00:12:47,600  
that we need to pay closer attention to

409  
00:12:50,470 --> 00:12:49,200  
both probiotic systems

410  
00:12:52,790 --> 00:12:50,480  
and their response to interference

411  
00:12:55,269 --> 00:12:52,800  
chemistry in the coming years

412  
00:12:57,110 --> 00:12:55,279  
many many more variables than i

413  
00:12:58,629 --> 00:12:57,120

considered in this talk for sure

414

00:13:00,310 --> 00:12:58,639

i'm happy to take questions in the time

415

00:13:02,150 --> 00:13:00,320

i have left and i'm very responsive to

416

00:13:04,750 --> 00:13:02,160

email if anybody has any other