AbSciCon 2019

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

2
00:00:13,140 --> 00:00:09,230
[Applause]

3
00:00:14,609 --> 00:00:13,150
firstly just wanna thank dr. de mer and

4
00:00:17,909 --> 00:00:14,619
the rest of the conveners of the session

5
00:00:19,800 --> 00:00:17,919
for inviting me to give this talk which

6
00:00:22,230 --> 00:00:19,810
is going to be as Bruce mentioned on the

7
00:00:24,689 --> 00:00:22,240
fates of nucleobases in warm little

8
00:00:26,640 --> 00:00:24,699
ponds delivered by meteorites and

9
00:00:30,839 --> 00:00:26,650
interplanetary dust particles so the so

10
00:00:35,100 --> 00:00:30,849
called exogenous delivery hypothesis can

11
00:00:37,799 --> 00:00:35,110
I use to change this thing okay okay so

12
00:00:39,720 --> 00:00:37,809
let's motivate this why pons why we want

13
00:00:42,450 --> 00:00:39,730

to deliver to pons why not deliver to

14
00:00:44,789 --> 00:00:42,460
the desert why not deliver to the ocean

15
00:00:46,500 --> 00:00:44,799
well there's really two main reasons the

16
00:00:48,320 --> 00:00:46,510
first being that these are actual

17
00:00:51,780 --> 00:00:48,330
locations where you might be able to do

18
00:00:52,649 --> 00:00:51,790
concentrated prebiotic chemistry the

19
00:00:54,049 --> 00:00:52,659
chemists in the room could probably

20
00:00:55,979 --> 00:00:54,059
attest that you can't really do

21
00:00:57,719 --> 00:00:55,989
prebiotic chemistry with parts per

22
00:01:00,299 --> 00:00:57,729
trillion level concentrations you need

23
00:01:01,859 --> 00:01:00,309
something more substantial and these are

24
00:01:03,929 --> 00:01:01,869
some locations where you could possibly

25
00:01:06,810 --> 00:01:03,939
get them just due to the lower volume

26
00:01:08,700 --> 00:01:06,820
within ponds and the second and most

27
00:01:11,880 --> 00:01:08,710
important is that these are locations

28
00:01:15,960 --> 00:01:11,890
that have wet and dry cycles which is

29
00:01:17,700 --> 00:01:15,970
key for polymerizing RNA and dr. Paul

30
00:01:20,490 --> 00:01:17,710
Brocker told us this morning about the

31
00:01:22,230 --> 00:01:20,500
condensation reaction and how in order

32
00:01:24,420 --> 00:01:22,240
to make photo diaster bonds you need to

33
00:01:26,640 --> 00:01:24,430
remove water so unless you have these

34
00:01:28,440 --> 00:01:26,650
alternating wet and dry environments

35
00:01:35,970 --> 00:01:28,450
then it's hard for you to make those

36
00:01:37,920 --> 00:01:35,980
bonds okay so the driving question of my

37
00:01:40,440 --> 00:01:37,930
research for a long time has been you

38
00:01:44,130 --> 00:01:40,450

know how did nucleobases arise in ponds

39
00:01:46,260 --> 00:01:44,140
on the prebiotic earth why why are we

40
00:01:47,730 --> 00:01:46,270
interested this question well in the RNA

41
00:01:50,670 --> 00:01:47,740
world hypothesis we're really trying to

42
00:01:52,649 --> 00:01:50,680
get to a self-replicating RNA molecule

43
00:01:54,180 --> 00:01:52,659
so maybe one of the most obvious

44
00:01:55,890 --> 00:01:54,190
questions you could ask is well then

45
00:01:58,850 --> 00:01:55,900
where did the building blocks of RNA

46
00:02:01,950 --> 00:01:58,860
come from nuclear bases are these

47
00:02:03,660 --> 00:02:01,960
characteristic molecules in in the

48
00:02:05,550 --> 00:02:03,670
building blocks and nucleotides and

49
00:02:08,850 --> 00:02:05,560
there they are attached to the ribose

50
00:02:11,430 --> 00:02:08,860
phosphate backbone I skipped over some

51
00:02:14,220 --> 00:02:11,440
details there it is not trivial to get

52
00:02:16,259 --> 00:02:14,230
to a nucleotide in a pond from just a

53
00:02:17,759 --> 00:02:16,269
nucleobase ribose and phosphorous source

54
00:02:19,709 --> 00:02:17,769
but I want to point your attention to

55
00:02:21,930 --> 00:02:19,719
some recent experiments that many of you

56
00:02:24,750 --> 00:02:21,940
probably know about which may have had

57
00:02:26,670 --> 00:02:24,760
success in this this is namma Dell these

58
00:02:29,070 --> 00:02:26,680
are both PNAS articles where they have

59
00:02:31,590 --> 00:02:29,080
reacted nucleobases ribose and

60
00:02:35,460 --> 00:02:31,600
phosphoric acid in micro droplets in

61
00:02:37,380 --> 00:02:35,470
order to produce nucleosides and then

62
00:02:40,380 --> 00:02:37,390
there has been a wealth of experiments

63
00:02:42,270 --> 00:02:40,390

in the past which have have had some

64
00:02:45,390 --> 00:02:42,280
success in phosphorylating those

65
00:02:49,110 --> 00:02:45,400
nucleosides and i point you to a review

66
00:02:51,630 --> 00:02:49,120
by gullet al 2014 for those results so

67
00:02:53,820 --> 00:02:51,640
back to the main question how did

68
00:02:55,770 --> 00:02:53,830
nuclear bases arise in warm little ponds

69
00:02:57,570 --> 00:02:55,780
what are the sources you can really

70
00:03:00,240 --> 00:02:57,580
break these down into two types of

71
00:03:02,250 --> 00:03:00,250
sources you have your delivery from

72
00:03:03,840 --> 00:03:02,260
space so your exogenously livery

73
00:03:07,410 --> 00:03:03,850
hypothesis and then you can also have

74
00:03:09,090 --> 00:03:07,420
the production on the planet itself for

75
00:03:11,340 --> 00:03:09,100
exhaustion is deliver your two options

76
00:03:13,620 --> 00:03:11,350
are meteorites and interplanetary dust

77
00:03:15,960 --> 00:03:13,630
particles meteorites have been analyzed

78
00:03:18,300 --> 00:03:15,970
to contain nucleobases and IDPs are

79
00:03:20,820 --> 00:03:18,310
thought to also perhaps contain the same

80
00:03:23,220 --> 00:03:20,830
molecules and then for endogenous

81
00:03:25,800 --> 00:03:23,230
production you have photo chemistry in

82
00:03:27,630 --> 00:03:25,810
the atmosphere UV photons can be

83
00:03:30,540 --> 00:03:27,640
absorbed by methane and nitrogen

84
00:03:33,180 --> 00:03:30,550
molecules to break them apart and those

85
00:03:35,760 --> 00:03:33,190
radicals that form from that react form

86
00:03:37,320 --> 00:03:35,770
hydrogen cyanide which once it dissolves

87
00:03:40,010 --> 00:03:37,330
into rainwater and falls into ponds

88
00:03:43,199 --> 00:03:40,020

could possibly through aqueous chemistry

89
00:03:44,790 --> 00:03:43,209
produce nucleobases lightning chemistry

90
00:03:46,170 --> 00:03:44,800
can do the exact same thing the only

91
00:03:48,600 --> 00:03:46,180
difference is you're changing the energy

92
00:03:51,510 --> 00:03:48,610
source which is creating those radicals

93
00:03:53,729 --> 00:03:51,520
which react to form hydrogen cyanide so

94
00:03:56,910 --> 00:03:53,739
this is what I'm working on right now

95
00:03:58,710 --> 00:03:56,920
this is a work in progress we've built a

96
00:04:00,120 --> 00:03:58,720
chemical Network a hydrogen cyanide

97
00:04:02,220 --> 00:04:00,130
chemical Network from the ground up

98
00:04:05,160 --> 00:04:02,230
using quantum computational chemistry

99
00:04:07,890 --> 00:04:05,170
methods and we found many reactions

100
00:04:10,410 --> 00:04:07,900
which have not been which have not been

101
00:04:12,210 --> 00:04:10,420
seen in literature literature before so

102
00:04:14,510 --> 00:04:12,220
I'm hoping to show you some results from

103
00:04:17,070 --> 00:04:14,520
that sometime in the very near future

104
00:04:18,420 --> 00:04:17,080
but for today let's focus just on the

105
00:04:23,700 --> 00:04:18,430
meteorites and interplanetary dust

106
00:04:25,080 --> 00:04:23,710
particles so why are these sources why

107
00:04:26,520 --> 00:04:25,090
think about nuclear bases being

108
00:04:28,260 --> 00:04:26,530
delivered by these sources well as I

109
00:04:30,180 --> 00:04:28,270
mentioned before many works have

110
00:04:32,070 --> 00:04:30,190
analyzed them for nuclear bases and we

111
00:04:35,010 --> 00:04:32,080
know they can reach the surface intact

112
00:04:37,050 --> 00:04:35,020
the most obvious reason is because in

113
00:04:39,210 --> 00:04:37,060

two people literally go and search for

114
00:04:41,610 --> 00:04:39,220
them and pick them up so we know that

115
00:04:43,950 --> 00:04:41,620
they landed there intact but other

116
00:04:45,779 --> 00:04:43,960
hypothetical models have found that if

117
00:04:48,360 --> 00:04:45,789
you're a meteoroid entering the

118
00:04:50,040 --> 00:04:48,370
atmosphere and you're about 80 40 to 80

119
00:04:52,710 --> 00:04:50,050
meters in diameter you're kind of the

120
00:04:54,570 --> 00:04:52,720
key size for you to break up into

121
00:04:58,230 --> 00:04:54,580
fragments and actually reach terminal

122
00:05:02,369 --> 00:04:58,240
velocity and kind of fall down and ponds

123
00:05:04,409 --> 00:05:02,379
just just intact a major study benchmark

124
00:05:06,629 --> 00:05:04,419
study by Carl Sagan and and Christopher

125
00:05:08,969 --> 00:05:06,639
Kaiba found that IDPs are actually a

126
00:05:10,680 --> 00:05:08,979
major source of organics so it's

127
00:05:14,070 --> 00:05:10,690
important to explore these as possible

128
00:05:15,899 --> 00:05:14,080
sources as well so what do we do well we

129
00:05:18,570 --> 00:05:15,909
built in numerical sources and sinks

130
00:05:21,570 --> 00:05:18,580
model of a warm little pond in order to

131
00:05:23,460 --> 00:05:21,580
ask the question what concentrations of

132
00:05:26,010 --> 00:05:23,470
nucleobases can you actually reach in

133
00:05:29,189 --> 00:05:26,020
ponds you know is it comparable to what

134
00:05:30,629 --> 00:05:29,199
chemistry experiments can actually do so

135
00:05:32,399 --> 00:05:30,639
here we have a schematic on the right

136
00:05:34,559 --> 00:05:32,409
and on the left if you prefer looking at

137
00:05:35,760 --> 00:05:34,569
things in tabular form I'll just walk

138
00:05:38,129 --> 00:05:35,770

you through these source in the sinks

139
00:05:40,490 --> 00:05:38,139
for pond water we we have precipitation

140
00:05:42,540 --> 00:05:40,500
and the sinks or evaporation and seepage

141
00:05:45,330 --> 00:05:42,550
four nucleobases we're comparing

142
00:05:47,459 --> 00:05:45,340
meteorites and IDPs as sources and for

143
00:05:50,040 --> 00:05:47,469
sinks we have hydrolysis seepage and foa

144
00:05:51,360 --> 00:05:50,050
sociation we get the rates for these

145
00:05:53,909 --> 00:05:51,370
sources and sinks mostly from

146
00:05:55,249 --> 00:05:53,919
experiments however in the case of

147
00:05:57,510 --> 00:05:55,259
precipitation we use the historical

148
00:05:59,879 --> 00:05:57,520
precipitation record and for the mass

149
00:06:03,899 --> 00:05:59,889
delivery by IDPs and meteorites we use

150
00:06:06,779 --> 00:06:03,909
the lunar crater in record so let's go

151
00:06:09,990 --> 00:06:06,789
through the results on the left here we

152
00:06:11,040 --> 00:06:10,000
have the pond water level and what we

153
00:06:12,959 --> 00:06:11,050
notice is there's actually a lot

154
00:06:15,480 --> 00:06:12,969
degeneracies in our model for instance

155
00:06:18,450 --> 00:06:15,490
if we model as as an analogue for the

156
00:06:20,820 --> 00:06:18,460
early Earth Columbia today at 65 degrees

157
00:06:22,980 --> 00:06:20,830
it actually overlaps with Thailand at 20

158
00:06:24,600 --> 00:06:22,990
degrees so instead of trying to cover

159
00:06:26,420 --> 00:06:24,610
all different temperatures for a

160
00:06:29,129 --> 00:06:26,430
hypothetical early Earth and

161
00:06:30,779 --> 00:06:29,139
precipitation amounts we just modeled

162
00:06:32,279 --> 00:06:30,789
three different environments which have

163
00:06:34,439 --> 00:06:32,289

many redundance which may have many

164
00:06:36,629 --> 00:06:34,449
degeneracies we call them a wet and

165
00:06:38,010 --> 00:06:36,639
intermediate and a dry environment and

166
00:06:39,659 --> 00:06:38,020
notice in the intermediate dry

167
00:06:42,959 --> 00:06:39,669
environments you actually get natural

168
00:06:45,209 --> 00:06:42,969
annual wet and dry cycles so that pops

169
00:06:47,639 --> 00:06:45,219
out just do the data we didn't impose

170
00:06:48,840 --> 00:06:47,649
that that's just due to the changing

171
00:06:50,550 --> 00:06:48,850
precipitation

172
00:06:53,130 --> 00:06:50,560
on the earth everywhere on the earth

173
00:06:55,680 --> 00:06:53,140
today on the right you can see the

174
00:06:58,320 --> 00:06:55,690
adenine concentration from just IDPs

175
00:06:59,640 --> 00:06:58,330
within one little ponds and in red you

176
00:07:01,860 --> 00:06:59,650
can see you can follow there's three

177
00:07:04,530 --> 00:07:01,870
features here and on in blue you have

178
00:07:05,790 --> 00:07:04,540
the the wet/dry cycle so you can see

179
00:07:08,340 --> 00:07:05,800
what's happening in the pond at the same

180
00:07:10,950 --> 00:07:08,350
time what happens is as your pond dries

181
00:07:13,860 --> 00:07:10,960
up you get to your maximum concentration

182
00:07:15,540 --> 00:07:13,870
of adenine and then the pond dries UV

183
00:07:17,640 --> 00:07:15,550
foud sociation is turned on and it

184
00:07:20,100 --> 00:07:17,650
blasts away your adenine to an amount

185
00:07:22,800 --> 00:07:20,110
where your incoming adenine rate matches

186
00:07:25,080 --> 00:07:22,810
your photo destruction rate then your

187
00:07:27,030 --> 00:07:25,090
pond fills up again you dilute and then

188
00:07:30,360 --> 00:07:27,040

this pattern continues on an annual

189
00:07:33,000 --> 00:07:30,370
basis and it never changes it never gets

190
00:07:34,680 --> 00:07:33,010
any more concentrated now notice what it

191
00:07:37,710 --> 00:07:34,690
says on the y-axis there that says

192
00:07:40,380 --> 00:07:37,720
adenine mass fraction ppq that's not a

193
00:07:42,510 --> 00:07:40,390
typo that's parts per quadrillion which

194
00:07:44,430 --> 00:07:42,520
is completely negligible so what this

195
00:07:47,070 --> 00:07:44,440
says is that you're never gonna get a

196
00:07:49,110 --> 00:07:47,080
concentration of nucleobases and warm

197
00:07:51,090 --> 00:07:49,120
little ponds from IDP sources they

198
00:07:53,340 --> 00:07:51,100
simply rain down on to the surface too

199
00:07:55,140 --> 00:07:53,350
slowly and the destructive forces then

200
00:08:00,030 --> 00:07:55,150
the pond are too efficient at removing

201
00:08:02,220 --> 00:08:00,040
them but what about meteorites here we

202
00:08:04,710 --> 00:08:02,230
compare meteorites to IDPs for the pond

203
00:08:07,050 --> 00:08:04,720
concentration IDP curves are on the

204
00:08:08,970 --> 00:08:07,060
lower heart lower half and the meteorite

205
00:08:11,340 --> 00:08:08,980
curves are on the upper half and notice

206
00:08:13,290 --> 00:08:11,350
the stark difference in your maximum

207
00:08:16,110 --> 00:08:13,300
adenine concentration between these two

208
00:08:18,420 --> 00:08:16,120
sources so what's happening here well

209
00:08:20,250 --> 00:08:18,430
meteorites deliver a large sum of

210
00:08:22,890 --> 00:08:20,260
nucleobases on the on the order of

211
00:08:24,900 --> 00:08:22,900
milligrams in one single event those

212
00:08:27,060 --> 00:08:24,910
nuclear bases outflow from the pores of

213
00:08:29,370 --> 00:08:27,070

the meteorite and get up to parts per

214
00:08:31,890 --> 00:08:29,380
million level concentrations and then

215
00:08:34,110 --> 00:08:31,900
begin to dilute from there and parts per

216
00:08:35,280 --> 00:08:34,120
million is still quite low but it's on

217
00:08:38,600 --> 00:08:35,290
the lower end of what you can actually

218
00:08:41,070 --> 00:08:38,610
do perhaps a chemistry experiment with

219
00:08:43,770 --> 00:08:41,080
but there's still some issues notice the

220
00:08:44,940 --> 00:08:43,780
red curve there sharply declines at some

221
00:08:47,580 --> 00:08:44,950
point that's when photodissociation

222
00:08:50,580 --> 00:08:47,590
turns on and it's completely destructive

223
00:08:53,370 --> 00:08:50,590
so you need a solution any surface model

224
00:08:56,250 --> 00:08:53,380
on the early Earth needs a solution for

225
00:08:57,960 --> 00:08:56,260
the photo destruction problem we like to

226
00:09:00,450 --> 00:08:57,970
think of sediments as being a possible

227
00:09:00,920 --> 00:09:00,460
solution sediment is everywhere in the

228
00:09:02,389 --> 00:09:00,930
wind

229
00:09:04,310 --> 00:09:02,399
gonna fall into ponds and it's gonna

230
00:09:06,440 --> 00:09:04,320
create a layer at the base which could

231
00:09:08,090 --> 00:09:06,450
possibly shields nucleobases from faux

232
00:09:10,490 --> 00:09:08,100
destruction it only takes about a

233
00:09:13,490 --> 00:09:10,500
millimeter to completely attenuate UV

234
00:09:15,530 --> 00:09:13,500
lights the second most destructive sink

235
00:09:16,550 --> 00:09:15,540
in the pond is seepage through pores in

236
00:09:18,100 --> 00:09:16,560
the base of the pond and that's what

237
00:09:20,420 --> 00:09:18,110
you're seeing in that blue curve there

238
00:09:23,060 --> 00:09:20,430

so we like to think of a solution for

239
00:09:24,680 --> 00:09:23,070
this as encapsulation something that dr.

240
00:09:27,260 --> 00:09:24,690
Christine Keating was talking about this

241
00:09:29,600 --> 00:09:27,270
more at this morning's plenary so if you

242
00:09:31,340 --> 00:09:29,610
if you take fatty acids which also

243
00:09:33,019 --> 00:09:31,350
happened to be in meteorites in fact

244
00:09:35,269 --> 00:09:33,029
fatty acids are the most abundant

245
00:09:38,329 --> 00:09:35,279
organic and meteorites you put those

246
00:09:40,460 --> 00:09:38,339
into a pond and all the all the fatty

247
00:09:42,170 --> 00:09:40,470
acids that are 8 carbons in length or

248
00:09:44,150 --> 00:09:42,180
longer are going to create spiracle

249
00:09:46,730 --> 00:09:44,160
compartments called vesicles and the

250
00:09:48,800 --> 00:09:46,740
average diameter of vesicles is larger

251
00:09:50,510 --> 00:09:48,810
than your average pore diameter so this

252
00:09:52,639 --> 00:09:50,520
might be a potential solution for

253
00:09:55,190 --> 00:09:52,649
avoiding seeping through holes in the

254
00:09:56,870 --> 00:09:55,200
base to your pond ok the last thing I'm

255
00:09:59,720 --> 00:09:56,880
going to talk about is actually how

256
00:10:00,860 --> 00:09:59,730
often did meteorites land in ponds on

257
00:10:03,620 --> 00:10:00,870
the early earth just the carbon-rich

258
00:10:05,720 --> 00:10:03,630
ones we ran a probability analysis which

259
00:10:07,820 --> 00:10:05,730
is based on a geophysical model of the

260
00:10:11,449 --> 00:10:07,830
rising continental crust you can see in

261
00:10:13,160 --> 00:10:11,459
the orange line there from 4.5 to 3.7

262
00:10:15,110 --> 00:10:13,170
billion years ago which is the interval

263
00:10:16,910 --> 00:10:15,120

in which we know life emerged and we

264
00:10:18,620 --> 00:10:16,920
used three different mass delivery

265
00:10:21,230 --> 00:10:18,630
models which are all based on the lunar

266
00:10:23,329 --> 00:10:21,240
crater in record now if you're at dr.

267
00:10:25,490 --> 00:10:23,339
Nicole's elders talk yesterday you know

268
00:10:28,640 --> 00:10:25,500
that there's now evidence that there's

269
00:10:30,140 --> 00:10:28,650
mass delivered to the moon before 3.9

270
00:10:32,150 --> 00:10:30,150
billion years ago so we can go ahead and

271
00:10:34,100 --> 00:10:32,160
ignore this black curve right there

272
00:10:36,380 --> 00:10:34,110
which is the single Cataclysm model and

273
00:10:38,210 --> 00:10:36,390
just focus on the to sustain declining

274
00:10:40,220 --> 00:10:38,220
bombardment models the red and the blue

275
00:10:42,620 --> 00:10:40,230
with the truth probably being somewhere

276
00:10:44,050 --> 00:10:42,630
between those two models we ran the

277
00:10:46,790 --> 00:10:44,060
probability based on the geometric

278
00:10:51,140 --> 00:10:46,800
probability of landing a meteorite into

279
00:10:53,720 --> 00:10:51,150
a pond and what do we find 15 to 4,000

280
00:10:56,210 --> 00:10:53,730
carbon-rich meteorites landed into warm

281
00:10:59,360 --> 00:10:56,220
little ponds on the early earth from 4.5

282
00:11:01,010 --> 00:10:59,370
to 3.7 billion years ago so this is good

283
00:11:02,180 --> 00:11:01,020
we know that this did happen and the

284
00:11:06,079 --> 00:11:02,190
truth is probably somewhere in between

285
00:11:06,980 --> 00:11:06,089
probably in the thousands regime all

286
00:11:08,660 --> 00:11:06,990
right that's all I should talk about

287
00:11:11,000 --> 00:11:08,670
I'll just summarize my results quickly

288
00:11:12,740 --> 00:11:11,010

we find meteorites or a plausible and

289
00:11:14,759 --> 00:11:12,750
probable source four parts per million

290
00:11:18,269 --> 00:11:14,769
level concentrations of new

291
00:11:19,889 --> 00:11:18,279
Leigha bases and ponds IDPs however the

292
00:11:22,169 --> 00:11:19,899
the nucleobases delivered by these

293
00:11:24,359 --> 00:11:22,179
produce negligible concentrations within

294
00:11:27,569 --> 00:11:24,369
ponds so we can forget about IDPs as

295
00:11:29,429 --> 00:11:27,579
being a source of nucleobases for for

296
00:11:31,739 --> 00:11:29,439
pond environments we get natural

297
00:11:34,199 --> 00:11:31,749
seasonal wet and dry cycles and ponds

298
00:11:37,019 --> 00:11:34,209
just from seasonal precipitation changes

299
00:11:39,179 --> 00:11:37,029
the two main problems with this surface

300
00:11:41,429 --> 00:11:39,189
model are UV foe dissociation and

301
00:11:45,479 --> 00:11:41,439
seepage we think possible solutions for

302
00:11:47,970 --> 00:11:45,489
those are our sediment and encapsulation

303
00:11:50,220 --> 00:11:47,980
and finally we find thousands of

304
00:11:51,600 --> 00:11:50,230
terminal-velocity carbon-rich meteorites

305
00:11:54,059 --> 00:11:51,610
landed in ponds on the early earth

306
00:11:57,030 --> 00:11:54,069
giving life thousands of opportunities

307
00:12:06,059 --> 00:11:57,040
to fail before perhaps succeeding in one

308
00:12:07,799 --> 00:12:06,069
of these ponds okay thank you we have

309
00:12:11,280 --> 00:12:07,809
time for one quick question well dr.

310
00:12:13,379 --> 00:12:11,290
Deemer comes up so I was just wondering

311
00:12:16,289 --> 00:12:13,389
you're showing wet/dry cycles on the

312
00:12:18,329 --> 00:12:16,299
order of years and what we've been

313
00:12:20,389 --> 00:12:18,339

talking about most most people have

314
00:12:23,669 --> 00:12:20,399
shown wet/dry cycle on the order of days

315
00:12:25,919 --> 00:12:23,679
and so if you did have wet/dry cycles

316
00:12:29,699 --> 00:12:25,929
daily how long would it take for

317
00:12:31,859 --> 00:12:29,709
photodissociation to occur so every time

318
00:12:34,049 --> 00:12:31,869
you dry up your pond in our model we

319
00:12:36,329 --> 00:12:34,059
turn on photo station and it only takes

320
00:12:39,030 --> 00:12:36,339
a matter of hours for it to destroy

321
00:12:40,919 --> 00:12:39,040
pretty much everything in your pond so

322
00:12:43,710 --> 00:12:40,929
in the case if you had a daily wet/dry

323
00:12:46,079 --> 00:12:43,720
cycle and you landed a meteorite in that

324
00:12:50,999 --> 00:12:46,089
pond the day before it's gone by the

325
00:12:52,710 --> 00:12:51,009
next day yeah all right we have to close

326
00:12:55,470 --> 00:12:52,720
that up word for time dr. Deemer if you

327
00:12:56,560 --> 00:12:55,480
want to come up Thank You Ben

328
00:12:57,530 --> 00:12:56,570
[Applause]