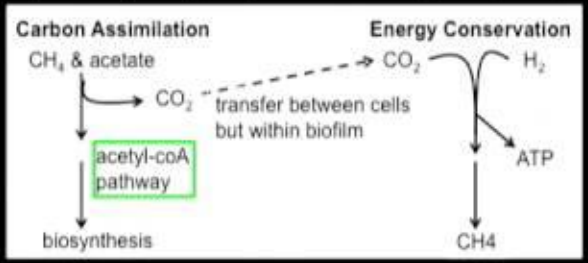
NASA Astrobiology Institute

FAR Seminar Series
10/6/2008

How would the LC Ms biofilm utilize both H_2 and acetate?
(Methanogens typically use acetate *or* H_2, rarely both)



Most methanogens use the acetyl-coA pathway to fix CO_2

But if the acetyl-coA pathway evolved in a serpentinization -driven environment, acetate might have been the original substrate

Nature Reviews Microbiol. 2008

Hydrothermal vents and the origin of life

William Martin*, John Baross‡, Deborah Kelley§ and Michael J. Russell||

1
00:00:05,120 --> 00:00:02,690
hello and welcome to the first far

2
00:00:06,860 --> 00:00:05,130
seminar of the academic year thank you

3
00:00:08,210 --> 00:00:06,870
all for joining us we have a very nice

4
00:00:12,280 --> 00:00:08,220
turnout I just wanted to say a couple

5
00:00:17,450 --> 00:00:12,290
things about the car and this is a

6
00:00:20,750 --> 00:00:17,460
response to graduate students postdocs

7
00:00:22,340 --> 00:00:20,760
and early career astrobiologists chances

8
00:00:24,920 --> 00:00:22,350
to talk about their research share it

9
00:00:27,170 --> 00:00:24,930
with others and get feedback as well so

10
00:00:29,710 --> 00:00:27,180
we are doing this seminar once a month

11
00:00:33,049 --> 00:00:29,720
and in order to make it

12
00:00:35,209 --> 00:00:33,059
interdisciplinary and address the areas

13
00:00:37,639 --> 00:00:35,219

of interest that this community wanted

14
00:00:39,920 --> 00:00:37,649
to hear more about we put together a

15
00:00:43,600 --> 00:00:39,930
whole schedule for the year and that was

16
00:00:45,709 --> 00:00:43,610
done by the science organizing committee

17
00:00:48,139 --> 00:00:45,719
interdisciplinary it covers areas that

18
00:00:51,139 --> 00:00:48,149
they felt was important to be covered

19
00:00:53,299 --> 00:00:51,149
and we have a schedule up through june

20
00:00:54,860 --> 00:00:53,309
four topics we're still lying enough

21
00:00:57,410 --> 00:00:54,870
speakers that we do have our speakers

22
00:00:59,660 --> 00:00:57,420
lined up the next month which is a

23
00:01:04,070 --> 00:00:59,670
believe november third and it's jen

24
00:01:05,750 --> 00:01:04,080
eigenberg and look up the other name but

25
00:01:09,170 --> 00:01:05,760
dumb but you can check the website for

26
00:01:10,940 --> 00:01:09,180
next month and it's on extreme life so

27
00:01:13,310 --> 00:01:10,950
we hope you can join us then you're fat

28
00:01:15,710 --> 00:01:13,320
and I'm now going to turn it over to

29
00:01:18,620 --> 00:01:15,720
Carl culture who will be introducing our

30
00:01:20,929 --> 00:01:18,630
speakers today Thanks well good morning

31
00:01:23,090 --> 00:01:20,939
or afternoon everybody I am really

32
00:01:25,510 --> 00:01:23,100
really glad that the far seminar has

33
00:01:28,340 --> 00:01:25,520
started up again this was something that

34
00:01:31,160 --> 00:01:28,350
we had going until a couple of years ago

35
00:01:34,880 --> 00:01:31,170
and then I think it fell victim to the

36
00:01:37,520 --> 00:01:34,890
big budget cut we took and now I am

37
00:01:39,230 --> 00:01:37,530
really really grateful to Estelle and to

38
00:01:41,359 --> 00:01:39,240

everybody who has served on the

39
00:01:42,859 --> 00:01:41,369
organizing committee for getting it

40
00:01:44,899 --> 00:01:42,869
going again and the fact that you've got

41
00:01:48,980 --> 00:01:44,909
it laid out for most of the next year i

42
00:01:52,569 --> 00:01:48,990
think is really fabulous so giving this

43
00:01:56,090 --> 00:01:52,579
kind of both visibility and and

44
00:01:58,490 --> 00:01:56,100
opportunity to graduate students and

45
00:02:01,580 --> 00:01:58,500
young researchers i think is really part

46
00:02:03,889 --> 00:02:01,590
of what the NAI is all about so without

47
00:02:06,740 --> 00:02:03,899
further ado I will just go ahead and

48
00:02:08,600 --> 00:02:06,750
introduce our two speakers this morning

49
00:02:10,820 --> 00:02:08,610
the first speaker is going to be

50
00:02:13,250 --> 00:02:10,830
Catherine ish from the University of

51
00:02:15,770 --> 00:02:13,260
Arizona Catherine is

52
00:02:17,449 --> 00:02:15,780
very close to getting her PhD and she's

53
00:02:21,110 --> 00:02:17,459
been focused on the formation of

54
00:02:23,929 --> 00:02:21,120
biological molecules in liquid water

55
00:02:25,640 --> 00:02:23,939
environments on places like Titan and

56
00:02:28,789 --> 00:02:25,650
what that can tell us about the origin

57
00:02:31,250 --> 00:02:28,799
of life on Earth Catherine is originally

58
00:02:32,930 --> 00:02:31,260
from Canada and has a BS from the

59
00:02:36,860 --> 00:02:32,940
University of British Columbia in

60
00:02:38,869 --> 00:02:36,870
physics and astronomy our second speaker

61
00:02:40,670 --> 00:02:38,879
is going to be Billy brazelton from the

62
00:02:42,890 --> 00:02:40,680
University of Washington he's going to

63
00:02:46,460 --> 00:02:42,900

be speaking about serpentinization and

64
00:02:48,110 --> 00:02:46,470
early life Billy has a bachelor's degree

65
00:02:50,899 --> 00:02:48,120
from the University of Minnesota in

66
00:02:53,379 --> 00:02:50,909
genetics and cell biology and without

67
00:02:56,330 --> 00:02:53,389
further ado Catherine take it away

68
00:02:58,550 --> 00:02:56,340
thanks Carl I hope everyone can hear me

69
00:02:59,960 --> 00:02:58,560
in good morning to everyone on the west

70
00:03:01,879 --> 00:02:59,970
coast and good afternoon to everyone on

71
00:03:03,770 --> 00:03:01,889
the East Coast today I'm going to tell

72
00:03:08,349 --> 00:03:03,780
you a little bit about some work I've

73
00:03:11,210 --> 00:03:08,359
been doing for my PhD dissertation

74
00:03:12,979 --> 00:03:11,220
trying to figure out some of the big

75
00:03:15,229 --> 00:03:12,989
questions about the origin of life and

76
00:03:16,759 --> 00:03:15,239
and how we can use Titan to tell us

77
00:03:19,939 --> 00:03:16,769
about maybe some of the things that

78
00:03:21,680 --> 00:03:19,949
happened on early Earth so I think we're

79
00:03:24,619 --> 00:03:21,690
just getting the screen up excellence

80
00:03:30,319 --> 00:03:24,629
and I'm going to do that on my own

81
00:03:33,260 --> 00:03:30,329
computer get my little pointer out okay

82
00:03:39,500 --> 00:03:35,840
alright so so one of the big questions

83
00:03:41,330 --> 00:03:39,510
that we really want to ask and I guess

84
00:03:48,110 --> 00:03:41,340
I'm you guys see the next slide come up

85
00:03:51,200 --> 00:03:48,120
or we're on your first slide ok I just

86
00:03:52,580 --> 00:03:51,210
moved it and I don't see it moving y'all

87
00:04:00,140 --> 00:03:52,590
know computer are you on the computer

88
00:04:10,890 --> 00:04:00,150

that's logged in as you of h I look the

89
00:04:14,880 --> 00:04:12,899
sorry guys I'm we've been having some

90
00:04:18,870 --> 00:04:14,890
technical difficulties this morning and

91
00:04:22,969 --> 00:04:18,880
now my flies are advancing Oh nothin are

92
00:04:33,540 --> 00:04:30,180
you obey I mean oh yeah minis different

93
00:04:36,710 --> 00:04:33,550
computer now did that work which

94
00:04:41,580 --> 00:04:36,720
computer tell me how your loving din I

95
00:04:44,760 --> 00:04:41,590
don't know ua ua can you see it now yes

96
00:04:46,260 --> 00:04:44,770
you try to answer that now ray so so the

97
00:04:54,480 --> 00:04:46,270
big questions are we are we at the big

98
00:04:57,659 --> 00:04:54,490
questions right try advancing it it's

99
00:05:01,110 --> 00:04:57,669
not going so are you using the computer

100
00:05:04,110 --> 00:05:01,120
that says you of a i was now i'm using

101
00:05:08,150 --> 00:05:04,120
the one that says you a this is you a

102
00:05:11,010 --> 00:05:08,160
okay hold on let me switch it to their

103
00:05:12,290 --> 00:05:11,020
sorry we are now on the one that says

104
00:05:15,060 --> 00:05:12,300
one of the big questions go ahead

105
00:05:17,219 --> 00:05:15,070
excellent thank you so so the question

106
00:05:19,140 --> 00:05:17,229
is how did life begin on earth and and

107
00:05:21,540 --> 00:05:19,150
so one of the first steps towards making

108
00:05:23,370 --> 00:05:21,550
life is you need to make the building

109
00:05:25,939 --> 00:05:23,380
blocks of life and there are a couple

110
00:05:30,149 --> 00:05:25,949
ways you can get building blocks of life

111
00:05:32,159 --> 00:05:30,159
either through getting it from exogenous

112
00:05:34,200 --> 00:05:32,169
sources coming from comets and

113
00:05:37,140 --> 00:05:34,210

meteorites or the topic i'm going to

114
00:05:39,689 --> 00:05:37,150
focus on in this talk or the Institute

115
00:05:40,680 --> 00:05:39,699
process is happening in say an ocean or

116
00:05:42,570 --> 00:05:40,690
what I'm going to talk about in

117
00:05:49,740 --> 00:05:42,580
atmospheres and that's you can kind of

118
00:05:59,380 --> 00:05:49,750
see that on the left here so so one of

119
00:06:07,590 --> 00:06:02,290
I'm trying to advance the slide and it's

120
00:06:15,990 --> 00:06:10,650
try hitting one more time already I

121
00:06:20,280 --> 00:06:18,480
but so so something that Stanley Miller

122
00:06:25,110 --> 00:06:20,290
did in the 50s kind of starting this

123
00:06:27,720 --> 00:06:25,120
whole field of provided chemistry was to

124
00:06:31,350 --> 00:06:27,730
take an atmosphere and spark it and see

125
00:06:33,750 --> 00:06:31,360
what he could make and what he is was

126
00:06:36,030 --> 00:06:33,760
what's known as a reducing atmosphere it

127
00:06:39,420 --> 00:06:36,040
had a lot of molecules that were willing

128
00:06:41,070 --> 00:06:39,430
to give up electrons and so the topic of

129
00:06:43,500 --> 00:06:41,080
this talk is sort of what can we make

130
00:06:46,500 --> 00:06:43,510
what interesting simple organic

131
00:06:51,060 --> 00:06:46,510
molecules can we make from reducing

132
00:06:55,980 --> 00:06:51,070
atmospheres and my slides still aren't

133
00:06:57,390 --> 00:06:55,990
avenging so that's great are you doing

134
00:07:04,550 --> 00:06:57,400
for you why don't you just say next

135
00:07:08,430 --> 00:07:04,560
slide it's slide please excellent okay

136
00:07:10,170 --> 00:07:08,440
so so we're going to talk about the

137
00:07:12,330 --> 00:07:10,180
chemistry of reducing atmospheres and

138
00:07:14,700 --> 00:07:12,340

Titan is one great example of a reducing

139
00:07:17,880 --> 00:07:14,710
atmosphere it's made up of methane and

140
00:07:21,170 --> 00:07:17,890
nitrogen and if it's constantly being

141
00:07:24,090 --> 00:07:21,180
bombarded by solar UV photons as well as

142
00:07:27,780 --> 00:07:24,100
charged electrons coming from Saturn's

143
00:07:28,950 --> 00:07:27,790
magnetosphere and what happens is it

144
00:07:31,290 --> 00:07:28,960
breaks apart the methane and the

145
00:07:34,020 --> 00:07:31,300
nitrogen and they then recombine to make

146
00:07:37,590 --> 00:07:34,030
a whole suite of new and more complex

147
00:07:42,300 --> 00:07:37,600
organic molecules known as hydrocarbons

148
00:07:43,920 --> 00:07:42,310
and nitriles and hydrocarbon is just

149
00:07:45,990 --> 00:07:43,930
basically any organic molecule both

150
00:07:48,480 --> 00:07:46,000
hydrogen and carbon in it and a nitrile

151
00:07:52,110 --> 00:07:48,490
is an organic molecule containing a CN

152
00:07:54,780 --> 00:07:52,120
functional group such as hydrogen

153
00:07:56,909 --> 00:07:54,790
cyanide and so just to give you a bit of

154
00:07:58,920 --> 00:07:56,919
a schematic about what is going on there

155
00:08:00,840 --> 00:07:58,930
here's a beautiful picture of Titan

156
00:08:04,920 --> 00:08:00,850
taken by the Cassini spacecraft or

157
00:08:07,230 --> 00:08:04,930
they're real and and we start with

158
00:08:08,900 --> 00:08:07,240
methane and nitrogen and then they are

159
00:08:12,050 --> 00:08:08,910
bombarded by you

160
00:08:14,120 --> 00:08:12,060
and electrons and and then we get this

161
00:08:16,310 --> 00:08:14,130
whole great suite of organic molecules

162
00:08:17,990 --> 00:08:16,320
that we've actually observed in Titan's

163
00:08:20,570 --> 00:08:18,000

atmosphere through both the Voyager in

164
00:08:24,470 --> 00:08:20,580
the Cassini spacecraft and right at the

165
00:08:26,510 --> 00:08:24,480
bottom here in addition oh I'm back okay

166
00:08:29,570 --> 00:08:26,520
in addition to these of gaseous

167
00:08:32,570 --> 00:08:29,580
molecules we also have a big hazy

168
00:08:35,390 --> 00:08:32,580
aerosol sort of like what you see in ver

169
00:08:39,650 --> 00:08:35,400
los angeles on a really bad day you get

170
00:08:41,360 --> 00:08:39,660
this haze of heavy heavy organic muck so

171
00:08:42,800 --> 00:08:41,370
that's tight Titan is one example of

172
00:08:44,770 --> 00:08:42,810
this reducing atmosphere where you can

173
00:08:47,000 --> 00:08:44,780
make all these simple building blocks

174
00:08:49,130 --> 00:08:47,010
the early Earth might have been another

175
00:08:51,320 --> 00:08:49,140
example which is sort of how this ties

176
00:08:53,060 --> 00:08:51,330
into the origin of life there's been

177
00:08:54,800 --> 00:08:53,070
some new work that suggests that the

178
00:08:56,450 --> 00:08:54,810
early Earth may have been fairly rich in

179
00:08:58,550 --> 00:08:56,460
hydrogen which is a very reducing

180
00:09:00,380 --> 00:08:58,560
molecule and such an atmosphere might

181
00:09:02,060 --> 00:09:00,390
have been able to produce valla jewels

182
00:09:04,400 --> 00:09:02,070
like hydrogen cyanide which are

183
00:09:08,240 --> 00:09:04,410
considered key to terrestrial prebiotic

184
00:09:10,700 --> 00:09:08,250
chemistry in addition it's possible that

185
00:09:12,590 --> 00:09:10,710
the earlier person there had quite a bit

186
00:09:15,890 --> 00:09:12,600
of methane in it in order to raise the

187
00:09:18,230 --> 00:09:15,900
temperature because that could be any of

188
00:09:19,610 --> 00:09:18,240

the solar system the Sun was a lot

189
00:09:21,680 --> 00:09:19,620
features that the earth was a lot cooler

190
00:09:24,170 --> 00:09:21,690
and you might have needed same methane

191
00:09:26,630 --> 00:09:24,180
and carbon dioxide to increase the

192
00:09:28,730 --> 00:09:26,640
temperature and if you had comfortable

193
00:09:30,440 --> 00:09:28,740
amounts of methane and nitrogen you

194
00:09:32,990 --> 00:09:30,450
might have formed a haze not unlike the

195
00:09:37,790 --> 00:09:33,000
one that we see on Titan today so sort

196
00:09:39,200 --> 00:09:37,800
of a analog there now okay so we've made

197
00:09:42,710 --> 00:09:39,210
we're making some of the building blocks

198
00:09:44,930 --> 00:09:42,720
these simple organic molecules but make

199
00:09:47,360 --> 00:09:44,940
actually making biomolecules amino acids

200
00:09:49,430 --> 00:09:47,370
to make up proteins or or the building

201
00:09:51,770 --> 00:09:49,440
blocks of DNA and RNA that's that's more

202
00:09:53,810 --> 00:09:51,780
difficult to do in an atmosphere on

203
00:09:56,240 --> 00:09:53,820
Titan the problem is there's really not

204
00:09:58,100 --> 00:09:56,250
much oxygen in its atmosphere and if you

205
00:10:00,740 --> 00:09:58,110
want to make a biomolecule you really

206
00:10:03,440 --> 00:10:00,750
need oxygen for most of them for example

207
00:10:05,780 --> 00:10:03,450
here's the aminoacyl I seen and you'll

208
00:10:08,780 --> 00:10:05,790
notice there's the two oxygens here in

209
00:10:11,120 --> 00:10:08,790
red forming this carbonyl group on the

210
00:10:13,520 --> 00:10:11,130
side here so I'm you're going to need

211
00:10:15,500 --> 00:10:13,530
oxygen to get a biomolecule and that's

212
00:10:17,570 --> 00:10:15,510
basically locking and titan's atmosphere

213
00:10:19,160 --> 00:10:17,580

the early Earth there was probably quite

214
00:10:22,130 --> 00:10:19,170
a bit of oxygen in the form of carbon

215
00:10:24,920 --> 00:10:22,140
monoxide carbon dioxide however if you

216
00:10:26,780 --> 00:10:24,930
try to make organic molecules out of

217
00:10:28,610 --> 00:10:26,790
such an atmosphere by sparking them in

218
00:10:31,390 --> 00:10:28,620
sort of this miller-urey experiment um

219
00:10:34,490 --> 00:10:31,400
you don't actually make very many

220
00:10:36,260 --> 00:10:34,500
prebiotic molecules Miller did some work

221
00:10:39,500 --> 00:10:36,270
in 1983 where you took his original

222
00:10:41,450 --> 00:10:39,510
experiment and added co and co2 and the

223
00:10:43,310 --> 00:10:41,460
only amino acid he was able to make was

224
00:10:44,810 --> 00:10:43,320
glycine as opposed to his original

225
00:10:49,160 --> 00:10:44,820
experiment done in a reducing atmosphere

226
00:10:52,400 --> 00:10:49,170
which produce quite a few amino acids so

227
00:10:54,500 --> 00:10:52,410
okay we've got organic molecules we

228
00:10:57,350 --> 00:10:54,510
don't have biomolecules is there another

229
00:10:59,030 --> 00:10:57,360
way and so that when I'm proposing this

230
00:11:01,070 --> 00:10:59,040
talk is that there might be another way

231
00:11:02,690 --> 00:11:01,080
instead of making them directly in the

232
00:11:04,940 --> 00:11:02,700
atmosphere is if you may have those

233
00:11:11,240 --> 00:11:04,950
organics made in the in the atmosphere

234
00:11:12,950 --> 00:11:11,250
Oh mr. can you go back one anyway so if

235
00:11:14,930 --> 00:11:12,960
you have those organics they might rain

236
00:11:18,560 --> 00:11:14,940
down onto the surface and interact with

237
00:11:20,000 --> 00:11:18,570
liquid water there and I tighten there

238
00:11:22,100 --> 00:11:20,010

with some work done in the 80s where

239
00:11:23,810 --> 00:11:22,110
they took Titan solace these are these

240
00:11:25,520 --> 00:11:23,820
haze analogues I'm going to use the word

241
00:11:26,960 --> 00:11:25,530
though and throughout the talk but

242
00:11:28,940 --> 00:11:26,970
basically what i mean by that are these

243
00:11:31,220 --> 00:11:28,950
haze analogs that i'm making in the

244
00:11:33,560 --> 00:11:31,230
laboratory and if you put them in water

245
00:11:35,870 --> 00:11:33,570
and hydrolyzed them hydrolysis just

246
00:11:38,180 --> 00:11:35,880
refers to any reaction with a chemical

247
00:11:42,140 --> 00:11:38,190
compound in water you will produce amino

248
00:11:43,520 --> 00:11:42,150
acids on the early Earth it turns out if

249
00:11:45,860 --> 00:11:43,530
you have a high enough concentration of

250
00:11:51,940 --> 00:11:45,870
hydrogen cyanide you'll make quite a few

251
00:11:59,420 --> 00:11:55,310
things that make up DNA and RNA as well

252
00:12:02,030 --> 00:11:59,430
as amino acids simply by hydrolyzing HD

253
00:12:04,329 --> 00:12:02,040
and oligomers and oligomers is just a

254
00:12:07,550 --> 00:12:04,339
connection of a lot of hydrogen cyanide

255
00:12:10,819 --> 00:12:07,560
components which I have highlighted but

256
00:12:12,740 --> 00:12:10,829
I can't get to that slide so okay I'm

257
00:12:15,139 --> 00:12:12,750
just here I'm just describing what what

258
00:12:17,030 --> 00:12:15,149
i mean by something appearing for

259
00:12:20,620 --> 00:12:17,040
example adenine is a purine that makes a

260
00:12:23,509 --> 00:12:20,630
DNA and RNA cytosine a pyrimidine also

261
00:12:25,699 --> 00:12:23,519
very very important to the information

262
00:12:27,290 --> 00:12:25,709
structure of molecules and then amino

263
00:12:31,579 --> 00:12:27,300

acids like glycine the one I showed you

264
00:12:34,880 --> 00:12:31,589
before so next slide and just explaining

265
00:12:37,069 --> 00:12:34,890
what and oligomers for non canvas all

266
00:12:39,710 --> 00:12:37,079
right so so I can you can see how we

267
00:12:42,319 --> 00:12:39,720
might have liquid water on on the early

268
00:12:43,430 --> 00:12:42,329
Earth there is evidence of having liquid

269
00:12:44,750 --> 00:12:43,440
water in the earlier but if you're

270
00:12:47,449 --> 00:12:44,760
familiar with Titan at all you might

271
00:12:50,269 --> 00:12:47,459
think this is crazy Titan is very cold

272
00:12:51,710 --> 00:12:50,279
it's out at 10a you so it's very far

273
00:12:54,949 --> 00:12:51,720
from the Sun a lot cooler than you'd

274
00:12:56,150 --> 00:12:54,959
find on earth and in fact its

275
00:12:57,769 --> 00:12:56,160
temperature at surface temperatures

276
00:13:00,650 --> 00:12:57,779
about 200 degrees below the freezing

277
00:13:03,710 --> 00:13:00,660
point of water so water on Titan is not

278
00:13:07,280 --> 00:13:03,720
really water anymore it's ice and ice is

279
00:13:10,189 --> 00:13:07,290
a rock however just like it's unlikely

280
00:13:12,290 --> 00:13:10,199
to see a solid rock on earth flowing

281
00:13:13,639 --> 00:13:12,300
across the surface occasionally you do

282
00:13:16,009 --> 00:13:13,649
see that if you've ever been to Hawaii

283
00:13:18,350 --> 00:13:16,019
you have seen the lava there which is

284
00:13:20,900 --> 00:13:18,360
liquid liquid rock flowing across the

285
00:13:24,500 --> 00:13:20,910
surface and similar things can happen on

286
00:13:27,079 --> 00:13:24,510
Titan in impact melts on the left here

287
00:13:29,360 --> 00:13:27,089
you see sin lap which is one of the

288
00:13:31,550 --> 00:13:29,370

craters we found on tight and on the

289
00:13:33,889 --> 00:13:31,560
right here is possibly a cryo volcanic

290
00:13:35,240 --> 00:13:33,899
flow so it's possible that you can get

291
00:13:38,630 --> 00:13:35,250
liquid water for short amounts of time

292
00:13:41,720 --> 00:13:38,640
in these impact melt and probable

293
00:13:44,090 --> 00:13:41,730
cannock flows and these are doing a

294
00:13:45,500 --> 00:13:44,100
thermal conduction modeling we find we

295
00:13:47,990 --> 00:13:45,510
expect them to probably last summer

296
00:13:50,269 --> 00:13:48,000
between 100 to 10,000 years so not a lot

297
00:13:52,990 --> 00:13:50,279
of times on compared to the scale is

298
00:13:55,040 --> 00:13:53,000
solar system but maybe enough time to do

299
00:13:58,590 --> 00:13:55,050
interesting chemistry and that's what

300
00:14:03,600 --> 00:13:58,600
we're investigating here in this work

301
00:14:05,879 --> 00:14:03,610
so next slide so the question is given a

302
00:14:08,249 --> 00:14:05,889
freezing time scale of 100 to 10,000

303
00:14:10,319 --> 00:14:08,259
years on Titan is there enough time to

304
00:14:12,900 --> 00:14:10,329
have interesting reactions between these

305
00:14:15,180 --> 00:14:12,910
tight and aerosol organics and water and

306
00:14:17,610 --> 00:14:15,190
in the end these in these transient

307
00:14:19,410 --> 00:14:17,620
liquid water environments in addition we

308
00:14:21,120 --> 00:14:19,420
want to consider what these reactions

309
00:14:23,730 --> 00:14:21,130
might tell us about possible origins of

310
00:14:25,350 --> 00:14:23,740
life scenario on the earlier and one

311
00:14:27,180 --> 00:14:25,360
when good analogue might actually be the

312
00:14:29,490 --> 00:14:27,190
cold origin of life hypothesis which

313
00:14:33,480 --> 00:14:29,500

I'll just mention here briefly by the

314
00:14:36,660 --> 00:14:33,490
next slide so as I touched on briefly

315
00:14:38,370 --> 00:14:36,670
earlier when life began presumably about

316
00:14:39,870 --> 00:14:38,380
four billion years ago the the son of a

317
00:14:43,290 --> 00:14:39,880
lot fainter than it is now and the earth

318
00:14:44,850 --> 00:14:43,300
was correspondingly would probably have

319
00:14:49,680 --> 00:14:44,860
been cooler had the atmosphere been the

320
00:14:52,530 --> 00:14:49,690
same so it's possible that there might

321
00:14:55,050 --> 00:14:52,540
have been more ice on the earth it might

322
00:14:57,629 --> 00:14:55,060
have been cooler and so we might have

323
00:15:00,360 --> 00:14:57,639
had life starting in basically little

324
00:15:03,090 --> 00:15:00,370
half frozen ponds and this might

325
00:15:06,720 --> 00:15:03,100
actually protected early life ice is

326
00:15:09,420 --> 00:15:06,730
good at protecting life from say solar

327
00:15:10,800 --> 00:15:09,430
UV also perhaps the increased amount of

328
00:15:13,050 --> 00:15:10,810
impacts that would have been around at

329
00:15:13,920 --> 00:15:13,060
the time of early life so if you grow

330
00:15:17,160 --> 00:15:13,930
the next slide there's a little

331
00:15:19,499 --> 00:15:17,170
schematic showing how um how life might

332
00:15:22,530 --> 00:15:19,509
have started in this kind of cold origin

333
00:15:25,650 --> 00:15:22,540
life scenario under it in a small amount

334
00:15:28,769 --> 00:15:25,660
of cool water under under an ice layer

335
00:15:31,710 --> 00:15:28,779
which is checking it from from impacts

336
00:15:34,410 --> 00:15:31,720
and and see UV so we're gonna thinking

337
00:15:36,329 --> 00:15:34,420
here about how the reactions that may be

338
00:15:38,460 --> 00:15:36,339

taking place in these transient liquid

339
00:15:42,210 --> 00:15:38,470
water environments on Titan might inform

340
00:15:45,360 --> 00:15:42,220
us about the origin of life on Earth so

341
00:15:48,240 --> 00:15:45,370
go to the next slide so here's here's

342
00:15:50,550 --> 00:15:48,250
the plan we want to find out how much of

343
00:15:53,249 --> 00:15:50,560
these oxygen containing prebiotic

344
00:15:55,350 --> 00:15:53,259
biomolecules you might find in in aqua

345
00:15:58,590 --> 00:15:55,360
solutions and so number one we're going

346
00:16:00,629 --> 00:15:58,600
to make our organics in in a manner I'll

347
00:16:02,449 --> 00:16:00,639
describe in a minute which I'll call

348
00:16:05,340 --> 00:16:02,459
Poland's probably throughout this talk

349
00:16:08,400 --> 00:16:05,350
next and then we're going to figure out

350
00:16:10,040 --> 00:16:08,410
how fast these organics react with the

351
00:16:11,660 --> 00:16:10,050
organic polymers at differ

352
00:16:14,530 --> 00:16:11,670
temperatures and in different solutions

353
00:16:17,240 --> 00:16:14,540
and then lastly we're going to compare

354
00:16:18,740 --> 00:16:17,250
these timescales to climb skills for

355
00:16:24,199 --> 00:16:18,750
which we imagine liquid water might be

356
00:16:26,660 --> 00:16:24,209
available on planetary surfaces so I'm

357
00:16:28,730 --> 00:16:26,670
going to study all the possible reaction

358
00:16:31,639 --> 00:16:28,740
pathways I'm going to do two studies the

359
00:16:33,079 --> 00:16:31,649
first one is just in pure water at

360
00:16:35,360 --> 00:16:33,089
temperatures ranging from its freezing

361
00:16:37,100 --> 00:16:35,370
point zero degrees Celsius up to you

362
00:16:38,960 --> 00:16:37,110
about 40 degrees Celsius and this is

363
00:16:41,930 --> 00:16:38,970

just to get that first cut at how fast

364
00:16:43,639 --> 00:16:41,940
these reactions take place and this

365
00:16:45,680 --> 00:16:43,649
applies both to tighten in the earlier I

366
00:16:47,780 --> 00:16:45,690
also want to do a separate study that

367
00:16:50,300 --> 00:16:47,790
only applies to tighten because it's

368
00:16:51,680 --> 00:16:50,310
very likely that any solution that we

369
00:16:55,310 --> 00:16:51,690
find on Titan would probably contain

370
00:16:58,699 --> 00:16:55,320
quite a bit of ammonia it's predicted to

371
00:17:00,440 --> 00:16:58,709
be present in say subsurface ocean not

372
00:17:03,650 --> 00:17:00,450
unlike the one that we we expect also on

373
00:17:05,120 --> 00:17:03,660
on Europa that to have a subsurface

374
00:17:07,579 --> 00:17:05,130
ocean on Titan which there is evidence

375
00:17:10,340 --> 00:17:07,589
of that we need ammonia to have that

376
00:17:12,650 --> 00:17:10,350
they're so so we're going to start first

377
00:17:15,710 --> 00:17:12,660
with the water study so just in pure

378
00:17:17,090 --> 00:17:15,720
water and so the first step as I

379
00:17:21,319 --> 00:17:17,100
mentioned earlier is we want to make our

380
00:17:22,939 --> 00:17:21,329
organic molecules and so can you see it

381
00:17:26,720 --> 00:17:22,949
if I if I if I move my little arrow

382
00:17:29,299 --> 00:17:26,730
around no you don't have an arrow ok let

383
00:17:31,580 --> 00:17:29,309
me get an arrow then no I'm running your

384
00:17:33,980 --> 00:17:31,590
slides um all right I don't have an

385
00:17:35,750 --> 00:17:33,990
arrow ok just all right this will be a

386
00:17:38,990 --> 00:17:35,760
thought experiment and if you see the

387
00:17:41,570 --> 00:17:39,000
young the YouTube on the left so what

388
00:17:43,520 --> 00:17:41,580

happens there is that gas comes in on

389
00:17:45,080 --> 00:17:43,530
the left and it flows through that

390
00:17:47,540 --> 00:17:45,090
YouTube and as its flowing through it

391
00:17:50,270 --> 00:17:47,550
sparked by the two electrodes you see

392
00:17:52,549 --> 00:17:50,280
there and this dissociates the gas the

393
00:17:54,470 --> 00:17:52,559
methane in the nitrogen and and they be

394
00:17:57,290 --> 00:17:54,480
combined to make these heavier organic

395
00:17:59,390 --> 00:17:57,300
molecules which attach on the sides of

396
00:18:02,299 --> 00:17:59,400
the YouTube which you can see labeled

397
00:18:04,760 --> 00:18:02,309
there and then we we can extract it and

398
00:18:07,159 --> 00:18:04,770
it looks sort of like this brownish or

399
00:18:09,799 --> 00:18:07,169
just reddish sort of substance which you

400
00:18:13,360 --> 00:18:09,809
can see on the right there so that's how

401
00:18:18,190 --> 00:18:15,940
and the next slide and so then the next

402
00:18:20,740 --> 00:18:18,200
step is that we're going to put them in

403
00:18:25,270 --> 00:18:20,750
water so on the left you see that's that

404
00:18:26,590 --> 00:18:25,280
that's our apparatus for um for making

405
00:18:29,560 --> 00:18:26,600
the solans and then we dump them in

406
00:18:31,540 --> 00:18:29,570
water obviously not that water but just

407
00:18:33,760 --> 00:18:31,550
that's represents water and then place

408
00:18:37,180 --> 00:18:33,770
them in a very high resolution mass

409
00:18:40,360 --> 00:18:37,190
spectrometer and what's really important

410
00:18:42,790 --> 00:18:40,370
about this work and this is actually the

411
00:18:44,200 --> 00:18:42,800
key to the entire work is that we have

412
00:18:46,600 --> 00:18:44,210
this really high-resolution mass

413
00:18:48,850 --> 00:18:46,610

spectrometry what it allows us to do is

414
00:18:52,480 --> 00:18:48,860
tell us tells us exactly what molecule

415
00:18:54,580 --> 00:18:52,490
we're looking at it's so good in fact

416
00:18:58,810 --> 00:18:54,590
that we can tell say an oxygen molecule

417
00:19:01,630 --> 00:18:58,820
RS sorry oxygen atom from say ch4 or a

418
00:19:03,160 --> 00:19:01,640
nitrogen atom from CH 2 this is really

419
00:19:05,710 --> 00:19:03,170
important when we're trying to look at

420
00:19:07,780 --> 00:19:05,720
these tiny differences in mass that were

421
00:19:12,580 --> 00:19:07,790
able to have such high mass resolution

422
00:19:15,010 --> 00:19:12,590
next slide and here's an example of one

423
00:19:16,150 --> 00:19:15,020
of our our mass spectra and you can see

424
00:19:19,240 --> 00:19:16,160
there's a whole bunch of different

425
00:19:22,419 --> 00:19:19,250
molecules in this spectra on the x-axis

426
00:19:23,980 --> 00:19:22,429
is the mass and you see we get it so

427
00:19:26,799 --> 00:19:23,990
those little Peaks there are every mass

428
00:19:28,120 --> 00:19:26,809
unit those Peaks actually if will zoom

429
00:19:30,669 --> 00:19:28,130
in in a minute and you'll see there's

430
00:19:34,150 --> 00:19:30,679
actually quite a few peeks inside of

431
00:19:37,030 --> 00:19:34,160
those big Peaks and then on the y axis

432
00:19:39,730 --> 00:19:37,040
we have intensity of the of the molecule

433
00:19:40,780 --> 00:19:39,740
that basically gives us um tells us a

434
00:19:42,790 --> 00:19:40,790
little bit about how much of that

435
00:19:44,799 --> 00:19:42,800
molecule we have so we can monitor that

436
00:19:47,380 --> 00:19:44,809
over time to see if we're if that

437
00:19:50,020 --> 00:19:47,390
molecule is growing in intensity or or

438
00:19:51,700 --> 00:19:50,030

decaying and I'll draw your attention to

439
00:19:53,230 --> 00:19:51,710
the peak on the very left hand side

440
00:19:56,680 --> 00:19:53,240
which is labeled as an internal standard

441
00:19:58,480 --> 00:19:56,690
and so we have internal standards which

442
00:20:00,040 --> 00:19:58,490
are presumably remain constant

443
00:20:01,690 --> 00:20:00,050
throughout the run so that we can

444
00:20:04,369 --> 00:20:01,700
compare them to our other molecules to

445
00:20:06,840 --> 00:20:04,379
see whether or not their decaying

446
00:20:09,090 --> 00:20:06,850
growing and if you if you're the next

447
00:20:12,930 --> 00:20:09,100
slide you'll notice that after after six

448
00:20:14,879 --> 00:20:12,940
hours at 40 degrees centigrade um our

449
00:20:16,560 --> 00:20:14,889
piece of these three I'm not oxygen

450
00:20:18,479 --> 00:20:16,570
molecules I've highlighted here in the

451
00:20:20,129 --> 00:20:18,489
middle are now about the same level as

452
00:20:22,229 --> 00:20:20,139
the internal standard whereas before

453
00:20:24,239 --> 00:20:22,239
they were looked at they were higher and

454
00:20:28,499 --> 00:20:24,249
then if we go to 25 hours in the next

455
00:20:30,539 --> 00:20:28,509
slide you'll see that they've actually

456
00:20:32,009 --> 00:20:30,549
dropped so this doesn't mean that the

457
00:20:34,830 --> 00:20:32,019
internal standard is growing what it

458
00:20:36,330 --> 00:20:34,840
means is that these these organic

459
00:20:38,430 --> 00:20:36,340
molecules are decaying presumably

460
00:20:42,089 --> 00:20:38,440
they're reacting with something to

461
00:20:43,560 --> 00:20:42,099
create a new a new molecule so if we go

462
00:20:46,200 --> 00:20:43,570
to the next slide I'm going to zoom in

463
00:20:47,700 --> 00:20:46,210

on this one peek at 251 mass units

464
00:20:51,330 --> 00:20:47,710
interval let's zoom in and we'll see

465
00:20:54,119 --> 00:20:51,340
what what's going on there see there we

466
00:20:55,919 --> 00:20:54,129
go and so we can see that we have an

467
00:20:59,430 --> 00:20:55,929
oxygenated molecule this is again at 0

468
00:21:01,919 --> 00:20:59,440
20 hours so this this initial of peak is

469
00:21:03,539 --> 00:21:01,929
probably just contamination that takes

470
00:21:05,460 --> 00:21:03,549
place when we're making the organic

471
00:21:07,619 --> 00:21:05,470
molecules unfortunately some air leaks

472
00:21:09,479 --> 00:21:07,629
in on this very oxygenated planet we

473
00:21:13,259 --> 00:21:09,489
have here but you'll notice that over

474
00:21:16,529 --> 00:21:13,269
time if we go the next slide it's

475
00:21:18,359 --> 00:21:16,539
actually grown compared to the

476
00:21:22,200 --> 00:21:18,369
non-oxygenated species next to it and

477
00:21:23,669 --> 00:21:22,210
then after 25 hours it it simply dwarfs

478
00:21:28,080 --> 00:21:23,679
the entire spectrum the food nor the

479
00:21:29,789 --> 00:21:28,090
next slide so there we go so here here

480
00:21:31,999 --> 00:21:29,799
for example is an example of an

481
00:21:34,979 --> 00:21:32,009
oxygenated species that is growing and

482
00:21:38,399 --> 00:21:34,989
so weak and we can look at that on the

483
00:21:39,960 --> 00:21:38,409
next slide at four different

484
00:21:42,299 --> 00:21:39,970
temperatures and they all show this

485
00:21:44,639 --> 00:21:42,309
beautiful what's known as a first order

486
00:21:47,549 --> 00:21:44,649
growth curve um basically you'll see the

487
00:21:49,200 --> 00:21:47,559
equation up at the top top right that

488
00:21:51,930 --> 00:21:49,210

equation just comes as a result where we

489
00:21:54,359 --> 00:21:51,940
assume the concentration of the molecule

490
00:21:57,899 --> 00:21:54,369
is directly proportional to the rate at

491
00:21:59,460 --> 00:21:57,909
which it's growing so we see that on

492
00:22:01,710 --> 00:21:59,470
these nice growth curves at all for

493
00:22:04,139 --> 00:22:01,720
temperatures that we looked at and

494
00:22:06,930 --> 00:22:04,149
you'll notice also that the growth

495
00:22:09,509 --> 00:22:06,940
growth rate at zero degrees Celsius is

496
00:22:11,009 --> 00:22:09,519
lower than the one at 40 degrees Celsius

497
00:22:12,899 --> 00:22:11,019
which is something else that we'd expect

498
00:22:16,560 --> 00:22:12,909
we expect reactions to slow down at

499
00:22:33,100 --> 00:22:21,280
we can see that we did this from any

500
00:22:36,880 --> 00:22:33,110
good anyways anyways so we did this for

501
00:22:37,990 --> 00:22:36,890
many different molecules at these four

502
00:22:39,790 --> 00:22:38,000
different temperatures and will notice

503
00:22:42,370 --> 00:22:39,800
that even at zero degrees Celsius so

504
00:22:44,800 --> 00:22:42,380
that's a pretty cool solution the growth

505
00:22:47,350 --> 00:22:44,810
curves had half-lives of on the order of

506
00:22:49,600 --> 00:22:47,360
days so what this means is that the time

507
00:22:51,610 --> 00:22:49,610
it takes to go halfway between the

508
00:22:55,480 --> 00:22:51,620
starting point and that plateau point is

509
00:22:57,430 --> 00:22:55,490
on the order of days so given that we

510
00:22:59,110 --> 00:22:57,440
have at least 100 years and say an

511
00:23:02,230 --> 00:22:59,120
impact melt pool or cry level and

512
00:23:03,940 --> 00:23:02,240
tighten and probably you know more than

513
00:23:05,860 --> 00:23:03,950

much more than that on the early Earth

514
00:23:08,170 --> 00:23:05,870
it seems like these reactions are

515
00:23:10,450 --> 00:23:08,180
happening very quickly with comparison

516
00:23:14,320 --> 00:23:10,460
to the time scales for which water is

517
00:23:17,170 --> 00:23:14,330
available on on planetary surfaces that

518
00:23:20,020 --> 00:23:17,180
was very exciting so if we go to the

519
00:23:22,060 --> 00:23:20,030
next slide so now we're going to talk

520
00:23:24,010 --> 00:23:22,070
just about a tight and specific

521
00:23:25,570 --> 00:23:24,020
experiment I did very basically

522
00:23:27,820 --> 00:23:25,580
identical to the web I just talked about

523
00:23:30,640 --> 00:23:27,830
but now we did it in ammonia water which

524
00:23:32,140 --> 00:23:30,650
is relevant for for Titan so instead of

525
00:23:34,630 --> 00:23:32,150
placing them in pure water we just

526
00:23:36,730 --> 00:23:34,640
placed them in 13 weight percent ammonia

527
00:23:38,610 --> 00:23:36,740
water and what's great about this is we

528
00:23:41,230 --> 00:23:38,620
can do even lower temperatures since

529
00:23:45,130 --> 00:23:41,240
ammonia water freezes that a lot lower

530
00:23:47,080 --> 00:23:45,140
temperature then on then pure water we

531
00:23:53,830 --> 00:23:47,090
could take it down to a temperatures as

532
00:23:57,010 --> 00:23:53,840
low as minus 20 degrees Celsius yeah I

533
00:23:58,720 --> 00:23:57,020
our computer to show off too so I was I

534
00:24:00,580 --> 00:23:58,730
was I was trying to indicate to somebody

535
00:24:05,080 --> 00:24:00,590
agent to plug it in but I guess my my my

536
00:24:07,090 --> 00:24:05,090
name didn't work you can just questions

537
00:24:12,880 --> 00:24:07,100
any other one that you have and tell me

538
00:24:15,120 --> 00:24:12,890

when to go to the next slide oh um yeah

539
00:24:19,130 --> 00:24:15,130
and now I can control it myself perhaps

540
00:24:25,050 --> 00:24:19,140
get out no just tell me next slide okay

541
00:24:30,810 --> 00:24:25,060
next slide so can you see the spectrum

542
00:24:32,040 --> 00:24:30,820
there now yes okay great so here's a

543
00:24:35,430 --> 00:24:32,050
very similar spectrum to the one I

544
00:24:38,760 --> 00:24:35,440
showed you in pure water except this was

545
00:24:40,440 --> 00:24:38,770
done in an ammonia water and we're going

546
00:24:46,230 --> 00:24:40,450
to again zoom in on one of these peaks

547
00:24:47,820 --> 00:24:46,240
so next slide and then and so again here

548
00:24:51,300 --> 00:24:47,830
we have a very similar spectrum to the

549
00:24:53,760 --> 00:24:51,310
one I showed you before we have a tiny

550
00:24:55,740 --> 00:24:53,770
contamination of oxygen there and in a

551
00:24:59,810 --> 00:24:55,750
very big peak with without oxygen in it

552
00:25:03,440 --> 00:24:59,820
but then as time progresses next slide

553
00:25:06,390 --> 00:25:03,450
the oxygenated peak again begins to grow

554
00:25:08,310 --> 00:25:06,400
next slide and after 50 hours at room

555
00:25:10,920 --> 00:25:08,320
temperature it's quite a bit higher than

556
00:25:14,460 --> 00:25:10,930
every other peak at that at that same

557
00:25:16,560 --> 00:25:14,470
mass so and we can again plot a growth

558
00:25:21,660 --> 00:25:16,570
curve like we did in water next slide

559
00:25:24,570 --> 00:25:21,670
and we can see that it follows the same

560
00:25:28,170 --> 00:25:24,580
same pattern as we saw with with the

561
00:25:30,120 --> 00:25:28,180
water and if we go to the next slide we

562
00:25:32,010 --> 00:25:30,130
see that we did this again at this very

563
00:25:33,780 --> 00:25:32,020

lower lower temperatures as low as minus

564
00:25:36,750 --> 00:25:33,790
20 degrees centigrade where this is

565
00:25:41,280 --> 00:25:36,760
still liquid and and even there it

566
00:25:42,780 --> 00:25:41,290
reacted on the order of days so so even

567
00:25:45,780 --> 00:25:42,790
in these really low temperatures in

568
00:25:47,910 --> 00:25:45,790
ammonia water the reactions are still

569
00:25:53,400 --> 00:25:47,920
taking place on a very fast time scale

570
00:25:58,880 --> 00:25:53,410
so if we can go to the next slide we can

571
00:26:01,620 --> 00:25:58,890
show you oh here we know perfect that

572
00:26:06,060 --> 00:26:01,630
that this is true of all cases at all

573
00:26:08,320 --> 00:26:06,070
temperatures that in ammonia water as

574
00:26:10,960 --> 00:26:08,330
well as water that these reactions

575
00:26:15,970 --> 00:26:10,970
purring on timescales of days so for the

576
00:26:17,620 --> 00:26:15,980
next slide so then the next question we

577
00:26:19,960 --> 00:26:17,630
would ask yourself as well how does this

578
00:26:21,070 --> 00:26:19,970
it is ammonia and better than water you

579
00:26:25,110 --> 00:26:21,080
know is tight and going to be a better

580
00:26:28,180 --> 00:26:25,120
place to say start making life in tight

581
00:26:29,799 --> 00:26:28,190
and and so we can compare we can make

582
00:26:31,659 --> 00:26:29,809
direct comparisons at two temperatures

583
00:26:33,070 --> 00:26:31,669
it's your degree Celsius and room

584
00:26:35,409 --> 00:26:33,080
temperature because we did both of those

585
00:26:38,139 --> 00:26:35,419
temperatures in both studies and we see

586
00:26:40,629 --> 00:26:38,149
here in this craft we've got great on

587
00:26:43,539 --> 00:26:40,639
the other y axis and then math on the

588
00:26:45,909 --> 00:26:43,549

x-axis and and then the blue dots

589
00:26:47,560 --> 00:26:45,919
represent those rates done in ammonia

590
00:26:49,779 --> 00:26:47,570
water and the red dots represent those

591
00:26:51,009 --> 00:26:49,789
rates going and pure water and you'll

592
00:26:55,659 --> 00:26:51,019
notice just by looking at this graph

593
00:26:57,310 --> 00:26:55,669
that the ammonia water in general has

594
00:26:59,740 --> 00:26:57,320
higher rates with the same masses that

595
00:27:02,440 --> 00:26:59,750
then in water and if we do this again at

596
00:27:04,509 --> 00:27:02,450
room temperature on the next slide we'll

597
00:27:07,870 --> 00:27:04,519
see the trend has actually been even

598
00:27:09,399 --> 00:27:07,880
better at at room temperature we have

599
00:27:12,399 --> 00:27:09,409
seventy percent of these masses do not

600
00:27:14,710 --> 00:27:12,409
overlap and rate and of these ninety

601
00:27:16,509 --> 00:27:14,720
percent are higher in ammonia water so

602
00:27:19,450 --> 00:27:16,519
it seems we seem to be seeing is that

603
00:27:20,769 --> 00:27:19,460
rates are faster in ammonia water which

604
00:27:23,049 --> 00:27:20,779
is great because when you're down at

605
00:27:25,690 --> 00:27:23,059
temperatures like minus 23 7 centigrade

606
00:27:28,330 --> 00:27:25,700
you really want faster rates so if we go

607
00:27:31,330 --> 00:27:28,340
to the next slide kind of just ponder

608
00:27:33,820 --> 00:27:31,340
about why this might be the case and it

609
00:27:35,950 --> 00:27:33,830
might simply be an effective pH what

610
00:27:38,500 --> 00:27:35,960
we've done is in essence by going from

611
00:27:40,960 --> 00:27:38,510
pure water to thirteen percent ammonia

612
00:27:44,019 --> 00:27:40,970
water is that we've increased the pH for

613
00:27:45,580 --> 00:27:44,029

about 7 to 11 and there was some studies

614
00:27:47,950 --> 00:27:45,590
done in the 60s where they looked at

615
00:27:50,830 --> 00:27:47,960
emmys and that's basically any organic

616
00:27:53,019 --> 00:27:50,840
group attached food and h2 which are

617
00:27:53,840 --> 00:27:53,029
almost certainly a part of the organic

618
00:27:55,940 --> 00:27:53,850
compounds

619
00:27:59,539 --> 00:27:55,950
looking at and you'll notice that over

620
00:28:02,539 --> 00:27:59,549
the pagerank interest rates either seem

621
00:28:04,520 --> 00:28:02,549
to rise or steak about constant so it

622
00:28:06,860 --> 00:28:04,530
could simply be due to the fact that the

623
00:28:08,630 --> 00:28:06,870
PHS increased however another more

624
00:28:10,760 --> 00:28:08,640
exciting possibilities there actually

625
00:28:13,029 --> 00:28:10,770
might be new reaction pathways being

626
00:28:15,380 --> 00:28:13,039
introduced by the presence of ammonia

627
00:28:17,480 --> 00:28:15,390
and this is borne out by observation

628
00:28:20,090 --> 00:28:17,490
here you can see we actually did a study

629
00:28:22,669 --> 00:28:20,100
in labeled ammonia water where the

630
00:28:26,029 --> 00:28:22,679
ammonia was labeled with nitrogen 50 and

631
00:28:28,310 --> 00:28:26,039
so you can see again we have brewing

632
00:28:31,460 --> 00:28:28,320
akshay vp you can see that the species

633
00:28:33,350 --> 00:28:31,470
i've highlighted on the left is growing

634
00:28:35,000 --> 00:28:33,360
as we saw on every other study but then

635
00:28:37,220 --> 00:28:35,010
right next to that big pecan on the

636
00:28:39,110 --> 00:28:37,230
right there you'll see a species that

637
00:28:42,020 --> 00:28:39,120
contains absolutely no oxygen but it

638
00:28:44,120 --> 00:28:42,030

does have an emotive genitive and steam

639
00:28:45,919 --> 00:28:44,130
and it too is growing so it looks like

640
00:28:48,710 --> 00:28:45,929
in addition to just having an increase

641
00:28:51,159 --> 00:28:48,720
pH we're also getting a new chemistry

642
00:28:55,220 --> 00:28:51,169
made possible by the presence of ammonia

643
00:28:58,520 --> 00:28:55,230
which we see here in this so just to

644
00:29:00,380 --> 00:28:58,530
wrap up finger the next slide the take

645
00:29:02,659 --> 00:29:00,390
home message from this this talk is that

646
00:29:04,340 --> 00:29:02,669
if you take these sort of haze particles

647
00:29:06,080 --> 00:29:04,350
and we might find them Titan and perhaps

648
00:29:07,700 --> 00:29:06,090
also the early Earth and place them in

649
00:29:10,250 --> 00:29:07,710
with the water you've been very easily

650
00:29:13,340 --> 00:29:10,260
on the order of days produce oxygen

651
00:29:15,350 --> 00:29:13,350
species and so it's important this is

652
00:29:17,960 --> 00:29:15,360
important to make start the steps

653
00:29:21,649 --> 00:29:17,970
towards biology by incorporating oxygen

654
00:29:23,960 --> 00:29:21,659
into into these these species and so it

655
00:29:26,360 --> 00:29:23,970
seems to happen quickly and easily so

656
00:29:28,970 --> 00:29:26,370
that's take-home message and I just like

657
00:29:32,419 --> 00:29:28,980
to thank my co-authors and my advisor

658
00:29:42,950 --> 00:29:32,429
dr. Lee and my funding agency and you

659
00:29:45,370 --> 00:29:42,960
all for your attention thanks in the

660
00:29:47,840 --> 00:29:45,380
interest of time we're going to take

661
00:29:49,730 --> 00:29:47,850
unquestioned while I switch presenters

662
00:29:52,700 --> 00:29:49,740
over to Billy at University of

663
00:29:54,680 --> 00:29:52,710

Washington so is there anyone that has a

664
00:29:56,690 --> 00:29:54,690
question they'd like to ask and we will

665
00:29:59,899 --> 00:29:56,700
go back to questions at the end of

666
00:30:00,419 --> 00:29:59,909
Billy's talk as well looks like Ames has

667
00:30:03,419 --> 00:30:00,429
raised

668
00:30:06,480 --> 00:30:03,429
hand so great game array let's go to

669
00:30:08,460 --> 00:30:06,490
your site they're just the question and

670
00:30:10,139 --> 00:30:08,470
that is the specific molecules that you

671
00:30:11,580 --> 00:30:10,149
see growing are there any additional

672
00:30:16,379 --> 00:30:11,590
comments you can make about what these

673
00:30:17,940 --> 00:30:16,389
species are right that was actually one

674
00:30:19,379 --> 00:30:17,950
of the reasons we started this work was

675
00:30:22,560 --> 00:30:19,389
hope was hoping to get some information

676
00:30:24,680 --> 00:30:22,570
on structure about these molecules and

677
00:30:27,330 --> 00:30:24,690
so one of the things we looked at was

678
00:30:30,060 --> 00:30:27,340
looked for correlations between growing

679
00:30:31,350 --> 00:30:30,070
oxygen species and decaying non oxygen

680
00:30:33,810 --> 00:30:31,360
species because then you could perhaps

681
00:30:36,409 --> 00:30:33,820
link them to see what reaction might

682
00:30:38,430 --> 00:30:36,419
have might have made these molecules and

683
00:30:42,600 --> 00:30:38,440
unfortunately there was no clear

684
00:30:46,320 --> 00:30:42,610
consensus we saw some evidence of loss

685
00:30:50,039 --> 00:30:46,330
of like say of ammonia or methyl amine

686
00:30:52,850 --> 00:30:50,049
or ethyl amine which might indicate that

687
00:30:56,960 --> 00:30:52,860
we had alcohols or aldehydes being made

688
00:30:59,279 --> 00:30:56,970

and and this we also did as a

689
00:31:00,960 --> 00:30:59,289
fragmentation study where you basically

690
00:31:02,460 --> 00:31:00,970
bombard the molecule and they split

691
00:31:04,560 --> 00:31:02,470
apart little molecules and we did see

692
00:31:06,749 --> 00:31:04,570
evidence of both water and carbon

693
00:31:08,700 --> 00:31:06,759
monoxide coming coming off of these fret

694
00:31:11,310 --> 00:31:08,710
in these fragments so there are some of

695
00:31:15,090 --> 00:31:11,320
evidence that perhaps we're seeing sort

696
00:31:16,919 --> 00:31:15,100
of amine hydrolysis but but I wouldn't

697
00:31:18,989 --> 00:31:16,929
say the I wouldn't say it's a closed

698
00:31:20,430 --> 00:31:18,999
book III don't think I think there's a

699
00:31:22,759 --> 00:31:20,440
lot of still uncertainties about what

700
00:31:29,299 --> 00:31:22,769
exactly it is we're dealing with

701
00:31:31,289 --> 00:31:29,309
unfortunately so great thanks David

702
00:31:33,269 --> 00:31:31,299
Goddard I know you have a question if

703
00:31:35,639 --> 00:31:33,279
you can hold it till the end so we can

704
00:31:37,019 --> 00:31:35,649
make sure that billy gets this time and

705
00:31:40,499 --> 00:31:37,029
then we'll open the floor to questions

706
00:31:42,090 --> 00:31:40,509
and discussion at that point so Billy it

707
00:31:44,970 --> 00:31:42,100
looks like your slide you're working so

708
00:31:49,409 --> 00:31:44,980
go ahead take it away okay great can

709
00:31:51,930 --> 00:31:49,419
everybody hear me yeah all right thanks

710
00:31:53,460 --> 00:31:51,940
thanks a lot thanks Kathryn for getting

711
00:31:55,799 --> 00:31:53,470
people thinking about chemistry because

712
00:31:58,049 --> 00:31:55,809
I'm a biologist I'm supposed to talk

713
00:31:59,879 --> 00:31:58,059

about prebiotic chemistry the reason why

714
00:32:01,859 --> 00:31:59,889
that's relevant is because the organisms

715
00:32:04,049 --> 00:32:01,869
that I study lived in a place that's

716
00:32:06,419 --> 00:32:04,059
dominated by this chemical reaction

717
00:32:08,220 --> 00:32:06,429
Beltre Fenton ization and I'll talk a

718
00:32:10,049 --> 00:32:08,230
lot about sue pet anization in just a

719
00:32:10,870 --> 00:32:10,059
moment first I'm going to talk to be

720
00:32:12,700 --> 00:32:10,880
some like the over

721
00:32:16,300 --> 00:32:12,710
all big picture astrobiological themes

722
00:32:18,010 --> 00:32:16,310
of why related to this talk so first of

723
00:32:19,990 --> 00:32:18,020
all this pent enunciation reaction

724
00:32:21,250 --> 00:32:20,000
produces lots of methane and some people

725
00:32:22,930 --> 00:32:21,260
have proposed that the methane that's

726
00:32:26,080 --> 00:32:22,940
been protective atmosphere Mars might

727
00:32:27,700 --> 00:32:26,090
have been produced by this process the

728
00:32:30,670 --> 00:32:27,710
study site that I have which will

729
00:32:32,410 --> 00:32:30,680
explain in a few minutes some people

730
00:32:36,250 --> 00:32:32,420
have said might be a great place for the

731
00:32:38,530 --> 00:32:36,260
first metabolic reactions involved and

732
00:32:40,450 --> 00:32:38,540
also I study bio photos which our

733
00:32:42,400 --> 00:32:40,460
community of selves and some people

734
00:32:43,630 --> 00:32:42,410
think that the first the first cell is

735
00:32:45,580 --> 00:32:43,640
not have evolved from a community of

736
00:32:46,780 --> 00:32:45,590
cells like the ones that I study so

737
00:32:50,320 --> 00:32:46,790
those are just the big picture themes

738
00:32:52,060 --> 00:32:50,330

that I want you to keep your to keep

739
00:32:54,730 --> 00:32:52,070
your eye off work as I talked about the

740
00:32:57,490 --> 00:32:54,740
details of my IT suspect so this is a

741
00:32:59,860 --> 00:32:57,500
surprise ation it's the chemical

742
00:33:02,770 --> 00:32:59,870
reaction that occurs when rocks pretty

743
00:33:06,250 --> 00:33:02,780
tight rocks like all of being our come

744
00:33:07,990 --> 00:33:06,260
into contact with water and then they

745
00:33:09,970 --> 00:33:08,000
turn into the black rock called serpent

746
00:33:11,680 --> 00:33:09,980
tonight and the reason why this is

747
00:33:13,060 --> 00:33:11,690
biologically important an important for

748
00:33:14,290 --> 00:33:13,070
urgent life is that when this reaction

749
00:33:17,170 --> 00:33:14,300
happens first of all it's exothermic

750
00:33:18,910 --> 00:33:17,180
which means releases lots of energy huh

751
00:33:21,130 --> 00:33:18,920
which can mean heats not drives

752
00:33:22,630 --> 00:33:21,140
hydrothermal circulation there's also

753
00:33:24,580 --> 00:33:22,640
lots of hydrogen that is produced so

754
00:33:26,650 --> 00:33:24,590
hydrogen is a great energy molecule for

755
00:33:29,170 --> 00:33:26,660
living things I'll also produces

756
00:33:31,600 --> 00:33:29,180
organics but its food for biology and we

757
00:33:32,710 --> 00:33:31,610
don't know everything like all the other

758
00:33:34,660 --> 00:33:32,720
things that might happen when this

759
00:33:36,040 --> 00:33:34,670
reaction occurs for example not many not

760
00:33:37,630 --> 00:33:36,050
much is known about what happens with

761
00:33:39,790 --> 00:33:37,640
nitrogen and sulfur stations trainees

762
00:33:41,350 --> 00:33:39,800
process but when thinking about the

763
00:33:42,430 --> 00:33:41,360

origin of life you want a chemical

764
00:33:44,500 --> 00:33:42,440
reaction that happens spontaneously

765
00:33:46,420 --> 00:33:44,510
between rocks and water the produces

766
00:33:48,340 --> 00:33:46,430
energy and food for life that's a pretty

767
00:33:51,340 --> 00:33:48,350
attractive process if you want to think

768
00:33:52,650 --> 00:33:51,350
about George applies so I study place

769
00:33:55,060 --> 00:33:52,660
called the lost city hydrothermal

770
00:33:57,540 --> 00:33:55,070
hydrothermal field it's on the

771
00:34:01,810 --> 00:33:57,550
mid-atlantic ridge although unlike most

772
00:34:03,310 --> 00:34:01,820
hydrothermal fields it is not right on

773
00:34:05,110 --> 00:34:03,320
the spreading reach it's actually 15

774
00:34:06,610 --> 00:34:05,120
kilometers away and the reason why it

775
00:34:08,919 --> 00:34:06,620
can do that is because it's not actually

776
00:34:10,540 --> 00:34:08,929
a volcano it's not primarily driven by

777
00:34:12,850 --> 00:34:10,550
magnetic heat like most type of

778
00:34:15,070 --> 00:34:12,860
Commerce's instead is driven by this

779
00:34:15,760 --> 00:34:15,080
organization reaction this translation

780
00:34:17,500 --> 00:34:15,770
reaction

781
00:34:20,409 --> 00:34:17,510
in the subsurface it produces heat that

782
00:34:22,240 --> 00:34:20,419
drives fluids flow in the system and

783
00:34:24,060 --> 00:34:22,250
here I often show a movie that shows you

784
00:34:26,169 --> 00:34:24,070
the fluid coming out of the chimneys and

785
00:34:27,820 --> 00:34:26,179
the vial comes that are looking on the

786
00:34:29,230 --> 00:34:27,830
chimneys the movies it's not going to

787
00:34:31,030 --> 00:34:29,240
work today but here's a picture of a

788
00:34:33,070 --> 00:34:31,040

chimney at laxity first thing you might

789
00:34:34,750 --> 00:34:33,080
notice that it's bright white that's

790
00:34:36,540 --> 00:34:34,760
because it made a carbonate minerals not

791
00:34:39,370 --> 00:34:36,550
metal sulfides like black smokers are

792
00:34:41,770 --> 00:34:39,380
the cart the chimneys at last city never

793
00:34:42,970 --> 00:34:41,780
been fluid it's much more than 100

794
00:34:45,010 --> 00:34:42,980
degrees Celsius whereas the black

795
00:34:47,320 --> 00:34:45,020
smokers you see on the Discovery Channel

796
00:34:50,260 --> 00:34:47,330
and so they can get even on 350 or 400

797
00:34:52,750 --> 00:34:50,270
degrees Celsius so it's much much much

798
00:34:55,899 --> 00:34:52,760
cooler the ph is very high up to 10 or

799
00:34:59,500 --> 00:34:55,909
11 it's very high pH it's like toilet

800
00:35:00,760 --> 00:34:59,510
bowl cleaner and as I said lots of

801
00:35:02,020 --> 00:35:00,770
hydrogen and methane are coming out of

802
00:35:03,760 --> 00:35:02,030
these chimneys and also there are no two

803
00:35:05,620 --> 00:35:03,770
berms there are no gigantic animals like

804
00:35:08,350 --> 00:35:05,630
you see on black smokers hardly any

805
00:35:09,790 --> 00:35:08,360
involves at all hardly new large animals

806
00:35:13,330 --> 00:35:09,800
there are lots of microscopic animals

807
00:35:16,600 --> 00:35:13,340
like our tiny arthropods and gastropods

808
00:35:18,400 --> 00:35:16,610
but the most obvious sign of white a

809
00:35:20,320 --> 00:35:18,410
lhasa dr actually microbes because they

810
00:35:22,030 --> 00:35:20,330
form these thick snotty by outcomes that

811
00:35:24,790 --> 00:35:22,040
are covering the chimney you can't

812
00:35:27,280 --> 00:35:24,800
really see in this picture but if you

813
00:35:28,660 --> 00:35:27,290

look at these chimneys they're just

814
00:35:30,100 --> 00:35:28,670
completely every single available

815
00:35:33,640 --> 00:35:30,110
service areas coated with a thick stock

816
00:35:35,080 --> 00:35:33,650
which is it should borrow times as i

817
00:35:37,090 --> 00:35:35,090
said lots of organics coming out of the

818
00:35:40,270 --> 00:35:37,100
commodities chimneys and urs troszke a

819
00:35:42,130 --> 00:35:40,280
colleague what soul has studied these

820
00:35:43,720 --> 00:35:42,140
and here's a plot showing the

821
00:35:46,180 --> 00:35:43,730
concentration of these organics up to

822
00:35:48,190 --> 00:35:46,190
four carbon atoms per molecule and he

823
00:35:49,840 --> 00:35:48,200
has a stable isotope evidence in case

824
00:35:51,700 --> 00:35:49,850
that these were actually synthesized

825
00:35:53,530 --> 00:35:51,710
abiotic ileana subsurface elasticity

826
00:35:56,950 --> 00:35:53,540
these organics are not just buy products

827
00:35:58,540 --> 00:35:56,960
apart upon in another group send some

828
00:36:00,190 --> 00:35:58,550
modeling on lost city chinese it shows

829
00:36:01,900 --> 00:36:00,200
that because they are so porous that's a

830
00:36:03,220 --> 00:36:01,910
great way to concentrate organic

831
00:36:05,500 --> 00:36:03,230
compounds that are coming out of the

832
00:36:07,240 --> 00:36:05,510
fluid and put them into close proximity

833
00:36:08,590 --> 00:36:07,250
with each other it's build larger

834
00:36:10,570 --> 00:36:08,600
organic compounds that's really

835
00:36:13,680 --> 00:36:10,580
important for the thinking about the

836
00:36:15,810 --> 00:36:13,690
sizing things ironically

837
00:36:17,640 --> 00:36:15,820
here's some some of the details in the

838
00:36:20,100 --> 00:36:17,650

chemistry of the velocity fluids as I

839
00:36:21,570 --> 00:36:20,110
said there's lots of hydrogen we let

840
00:36:23,700 --> 00:36:21,580
millions of times higher than you'd find

841
00:36:25,200 --> 00:36:23,710
a normal seawater it's really a lot of

842
00:36:28,140 --> 00:36:25,210
writers you know their significant

843
00:36:30,810 --> 00:36:28,150
amount of methane as well because of the

844
00:36:32,520 --> 00:36:30,820
high pH is almost no co2 available for

845
00:36:34,710 --> 00:36:32,530
microbes it's all either precipitated

846
00:36:36,600 --> 00:36:34,720
out in these carbonate minerals but

847
00:36:40,350 --> 00:36:36,610
there are other simple carbon compounds

848
00:36:42,270 --> 00:36:40,360
that we don't normally think of with

849
00:36:44,180 --> 00:36:42,280
most organism for main and acetate are

850
00:36:46,950 --> 00:36:44,190
actually more biologically available

851
00:36:49,470 --> 00:36:46,960
than co2 I'm going to talk about this in

852
00:36:51,300 --> 00:36:49,480
defense down a bit there's a little bit

853
00:36:53,190 --> 00:36:51,310
of fixed nitrogen and I'm a former

854
00:36:56,070 --> 00:36:53,200
ammonia and nitrate really into is the

855
00:36:57,600 --> 00:36:56,080
best nitrogen source so as a biologist I

856
00:36:59,220 --> 00:36:57,610
think look at this chemistry and think

857
00:37:00,870 --> 00:36:59,230
about if I were to imagine the ideal

858
00:37:02,100 --> 00:37:00,880
organism that could survive in this

859
00:37:03,420 --> 00:37:02,110
environment what I would think of is

860
00:37:05,910 --> 00:37:03,430
something that could use hydrogen energy

861
00:37:08,340 --> 00:37:05,920
source of course and something that

862
00:37:11,010 --> 00:37:08,350
could use a carbon source other than co2

863
00:37:13,100 --> 00:37:11,020

select methane ch4 minor acetate and if

864
00:37:16,470 --> 00:37:13,110
it could fix nitrogen that with the idea

865
00:37:18,030 --> 00:37:16,480
so when we looked at these carbonation

866
00:37:21,120 --> 00:37:18,040
he's under microscope and we extracted

867
00:37:23,010 --> 00:37:21,130
DNA what we found is that the hot the

868
00:37:24,540 --> 00:37:23,020
hottest interior most portions of the

869
00:37:27,990 --> 00:37:24,550
chimneys are completely dominated by

870
00:37:29,820 --> 00:37:28,000
this one organism that belongs matano

871
00:37:31,140 --> 00:37:29,830
source Nellie's trooper mechanic that's

872
00:37:34,200 --> 00:37:31,150
interesting because the methane absorbs

873
00:37:36,120 --> 00:37:34,210
Nellie's group of companions could fit

874
00:37:37,910 --> 00:37:36,130
this criteria of the ideal off city

875
00:37:41,550 --> 00:37:37,920
microbes some members of this group

876
00:37:43,410 --> 00:37:41,560
cannot utilize hydrogen and what's

877
00:37:45,180 --> 00:37:43,420
the--oh to but they can also use other

878
00:37:47,640 --> 00:37:45,190
carbon compounds like acetate another

879
00:37:50,100 --> 00:37:47,650
month later come back compounds that can

880
00:37:51,810 --> 00:37:50,110
even use methane and oxidize the methane

881
00:37:53,940 --> 00:37:51,820
instead of produce it and some of them

882
00:37:55,950 --> 00:37:53,950
can fix nitrogen so no one species in

883
00:37:57,960 --> 00:37:55,960
the script can do all of these things so

884
00:37:59,580 --> 00:37:57,970
no known member could do all it could be

885
00:38:01,730 --> 00:37:59,590
the idea Luxa tea maker but perhaps this

886
00:38:03,900 --> 00:38:01,740
one at live city can do all these things

887
00:38:05,190 --> 00:38:03,910
so there are other things besides us for

888
00:38:06,960 --> 00:38:05,200

my faction that live but they mostly

889
00:38:09,900 --> 00:38:06,970
live in the more oxidized cooler

890
00:38:11,130 --> 00:38:09,910
portions of the outside divisions what

891
00:38:12,780 --> 00:38:11,140
I'm going to be talking most about my

892
00:38:14,310 --> 00:38:12,790
stock is this hot too hot really

893
00:38:15,840 --> 00:38:14,320
interior portion ever those

894
00:38:20,490 --> 00:38:15,850
really they're supporting group antigens

895
00:38:22,200 --> 00:38:20,500
that dominates and so for one aspect my

896
00:38:24,420 --> 00:38:22,210
thesis is the test hypothesis that these

897
00:38:25,980 --> 00:38:24,430
mansions can't utilize hydrogen and I

898
00:38:29,640 --> 00:38:25,990
can use a carbon compounds other than

899
00:38:30,930 --> 00:38:29,650
co2 so like a lot of organisms in these

900
00:38:33,210 --> 00:38:30,940
types of environments we can't culture

901
00:38:35,670 --> 00:38:33,220
the famous unfortunately I've tried very

902
00:38:36,720 --> 00:38:35,680
hard so what I did do to try to get an

903
00:38:39,660 --> 00:38:36,730
idea of what these things are actually

904
00:38:41,520 --> 00:38:39,670
doing in ecstasy for as I just took a

905
00:38:42,840 --> 00:38:41,530
chunk of the carbon a chimney and

906
00:38:45,210 --> 00:38:42,850
incubated at high temperature and high

907
00:38:47,340 --> 00:38:45,220
pH and use them I stopped the label

908
00:38:48,680 --> 00:38:47,350
compounds a little bit like what

909
00:38:51,330 --> 00:38:48,690
catherine was doing to see what happens

910
00:38:54,720 --> 00:38:51,340
so here are two experiments on the left

911
00:38:57,060 --> 00:38:54,730
I tested whether I stoppable able to co2

912
00:38:58,500 --> 00:38:57,070
was give her to the methane and the

913
00:39:01,170 --> 00:38:58,510

second one was whether I stava cleavable

914
00:39:02,760 --> 00:39:01,180
methane was converted to co2 and I also

915
00:39:05,430 --> 00:39:02,770
tested whether either of these processes

916
00:39:09,600 --> 00:39:05,440
was stimulated would go faster in the

917
00:39:10,890 --> 00:39:09,610
presence of hydrogen and my God look at

918
00:39:12,030 --> 00:39:10,900
the number look at the numbers in too

919
00:39:13,560 --> 00:39:12,040
much detail here but it's obvious that

920
00:39:15,450 --> 00:39:13,570
when I added hydrogen both of the

921
00:39:17,070 --> 00:39:15,460
reactions were faster which is not what

922
00:39:19,590 --> 00:39:17,080
you would expect if methane production

923
00:39:21,870 --> 00:39:19,600
and methane oxidation were competing or

924
00:39:23,760 --> 00:39:21,880
were reverse reactions compared to each

925
00:39:25,290 --> 00:39:23,770
other in that case hydrogen would have

926
00:39:26,910 --> 00:39:25,300
stimulated to go in one direction but

927
00:39:28,500 --> 00:39:26,920
not the other in this case both

928
00:39:32,040 --> 00:39:28,510
directions of this reaction are going

929
00:39:33,150 --> 00:39:32,050
faster which is a bit surprising and

930
00:39:35,340 --> 00:39:33,160
what it must mean is that they're not

931
00:39:37,560 --> 00:39:35,350
reverse reactions is that the must be

932
00:39:39,510 --> 00:39:37,570
but these methane production methane

933
00:39:41,880 --> 00:39:39,520
oxidation must be two different parts

934
00:39:43,560 --> 00:39:41,890
and the same overall pathway and they're

935
00:39:45,960 --> 00:39:43,570
somehow links there somehow cooperate

936
00:39:49,710 --> 00:39:45,970
and we want to figure out how that's

937
00:39:51,870 --> 00:39:49,720
happening so one clue is to look at the

938
00:39:54,990 --> 00:39:51,880

thermodynamics of the chemistry Alexa T

939
00:39:56,730 --> 00:39:55,000
so as I said co2 is not a very good

940
00:39:59,520 --> 00:39:56,740
source because it's not very abundant

941
00:40:02,460 --> 00:39:59,530
and this table I listed the energies of

942
00:40:03,630 --> 00:40:02,470
reaction to be for the reactions

943
00:40:05,100 --> 00:40:03,640
associated these using these different

944
00:40:06,960 --> 00:40:05,110
carbon compounds are so here's co2

945
00:40:08,850 --> 00:40:06,970
here's acetate here's formate and

946
00:40:10,160 --> 00:40:08,860
methane and all these reactions are

947
00:40:12,620 --> 00:40:10,170
favorable under these

948
00:40:14,840 --> 00:40:12,630
90 degrees Celsius ph10 with lots of

949
00:40:16,400 --> 00:40:14,850
hydrogen methane around but the amount

950
00:40:18,920 --> 00:40:16,410
of energy you get from each of these

951
00:40:20,540 --> 00:40:18,930
reactions given how much of that

952
00:40:23,750 --> 00:40:20,550
substrate is coming out of the chimney

953
00:40:25,310 --> 00:40:23,760
per unit of time is very different co2

954
00:40:27,980 --> 00:40:25,320
would take you five hundred thousand

955
00:40:29,840 --> 00:40:27,990
years to get them out of biomass we stay

956
00:40:32,300 --> 00:40:29,850
at lost city if you only use you to aid

957
00:40:33,980 --> 00:40:32,310
your carbon source so let's not break it

958
00:40:35,270 --> 00:40:33,990
whereas if you use acetate for made of

959
00:40:37,750 --> 00:40:35,280
methane you could do it never a small

960
00:40:40,400 --> 00:40:37,760
amount so clearly they must be using

961
00:40:44,000 --> 00:40:40,410
just using the chemistry they must be

962
00:40:46,820 --> 00:40:44,010
using acetate or four mainstays so we

963
00:40:48,320 --> 00:40:46,830

have a little bit of metagenomic DNA

964
00:40:50,720 --> 00:40:48,330
sequencing data in these locks at each

965
00:40:53,660 --> 00:40:50,730
other and one of the things we found is

966
00:40:55,250 --> 00:40:53,670
a gene that encodes the enzyme a silicon

967
00:40:56,900 --> 00:40:55,260
that a synthesis of gene that is only

968
00:40:58,970 --> 00:40:56,910
found in organisms that directly use

969
00:41:00,860 --> 00:40:58,980
acetate from the environment and the

970
00:41:02,930 --> 00:41:00,870
closest relative of the version that we

971
00:41:04,820 --> 00:41:02,940
found a Lodge city are genes that

972
00:41:07,670 --> 00:41:04,830
belongs to acetate using the manager

973
00:41:09,170 --> 00:41:07,680
Mike Matheny so this is really support

974
00:41:13,430 --> 00:41:09,180
of our process that these things are

975
00:41:15,980 --> 00:41:13,440
using acetates as you do at least they

976
00:41:18,290 --> 00:41:15,990
are able to but this is confusing

977
00:41:19,970 --> 00:41:18,300
because of we don't know what you have

978
00:41:22,280 --> 00:41:19,980
any methanogens that i know of any way

979
00:41:24,380 --> 00:41:22,290
that can use both hydrogen and acetate

980
00:41:25,760 --> 00:41:24,390
usually if you have acetate that use it

981
00:41:27,260 --> 00:41:25,770
if you have hydrogen then use that be

982
00:41:29,180 --> 00:41:27,270
there are no matta engines that I know

983
00:41:30,470 --> 00:41:29,190
if it is both looking same time but a

984
00:41:32,240 --> 00:41:30,480
las cydia be really great if you could

985
00:41:34,220 --> 00:41:32,250
use book because you'd be crazy not to

986
00:41:35,630 --> 00:41:34,230
use a lot hydrogen acetate significant

987
00:41:37,670 --> 00:41:35,640
carbon source it's not just not suited

988
00:41:40,850 --> 00:41:37,680

to see here i will have a diagram of how

989
00:41:42,890 --> 00:41:40,860
that might work and um when I thinking

990
00:41:44,780 --> 00:41:42,900
is that when organisms use access date

991
00:41:46,250 --> 00:41:44,790
or methane as well and convert it into

992
00:41:48,260 --> 00:41:46,260
biomass there's a little bit of co2

993
00:41:49,550 --> 00:41:48,270
leagues out I'm gonna see the two that

994
00:41:52,370 --> 00:41:49,560
leaks out of that might be actually

995
00:41:55,100 --> 00:41:52,380
better source of carbon dioxide I'm just

996
00:41:56,870 --> 00:41:55,110
getting it from a clue to perhaps some

997
00:41:59,210 --> 00:41:56,880
of that co2 is derived from acetate and

998
00:42:02,450 --> 00:41:59,220
then passed over to rap with hydrogen to

999
00:42:03,240 --> 00:42:02,460
make methane and that's part of energy

1000
00:42:05,520 --> 00:42:03,250
conservation

1001
00:42:07,230 --> 00:42:05,530
so in that way you'd actually be the

1002
00:42:08,970 --> 00:42:07,240
fuse methane must've acetate you being

1003
00:42:11,400 --> 00:42:08,980
oxidizing my thing and making my thing

1004
00:42:14,040 --> 00:42:11,410
and getting ATP and making bio matches

1005
00:42:15,450 --> 00:42:14,050
so this is the hypothesis of excess and

1006
00:42:17,250 --> 00:42:15,460
not anywhere close to the proving us

1007
00:42:18,900 --> 00:42:17,260
what's going on but that's what I'm

1008
00:42:20,580 --> 00:42:18,910
thinking to work I think this has

1009
00:42:22,530 --> 00:42:20,590
implications for version of life studies

1010
00:42:26,100 --> 00:42:22,540
because some people think that the selah

1011
00:42:28,080 --> 00:42:26,110
kawai pathway this pathway that tangents

1012
00:42:30,320 --> 00:42:28,090
currently used to fix carbon dioxide

1013
00:42:32,700 --> 00:42:30,330

into biomass might have been the first

1014
00:42:35,160 --> 00:42:32,710
carbon fixation pathway and if it did

1015
00:42:37,560 --> 00:42:35,170
it'd probably evolved in an environment

1016
00:42:39,090 --> 00:42:37,570
with lots of high-capacity means it's a

1017
00:42:40,470 --> 00:42:39,100
lot easier to make acetate in diverse

1018
00:42:42,300 --> 00:42:40,480
fields away which is the first molecule

1019
00:42:45,360 --> 00:42:42,310
mostly live playback way that is the mix

1020
00:42:46,650 --> 00:42:45,370
co2 and if you're living in just look

1021
00:42:48,900 --> 00:42:46,660
away back way bald in a high pitch

1022
00:42:50,310 --> 00:42:48,910
environment that perhaps dominated by

1023
00:42:51,750 --> 00:42:50,320
surprise ation that the obviously

1024
00:42:54,060 --> 00:42:51,760
acetate would be the one you use not

1025
00:42:55,320 --> 00:42:54,070
coming outside so it's one of the one or

1026
00:42:57,570 --> 00:42:55,330
more about this i highly recommend this

1027
00:42:59,040 --> 00:42:57,580
review the reason that came out and

1028
00:43:02,640 --> 00:42:59,050
nature reviews and microbiology which

1029
00:43:04,560 --> 00:43:02,650
talks a lot about that idea so in our

1030
00:43:07,620 --> 00:43:04,570
metagenomic data we also have some

1031
00:43:10,770 --> 00:43:07,630
insight into the nitrogen cycle we found

1032
00:43:12,390 --> 00:43:10,780
operon for encoding for genes involved

1033
00:43:14,040 --> 00:43:12,400
in nitrogen fixation so i mentioned

1034
00:43:15,390 --> 00:43:14,050
earlier one of my hypothesis that this

1035
00:43:16,410 --> 00:43:15,400
ideal micro would be able to fix

1036
00:43:19,590 --> 00:43:16,420
nitrogen because there's so little

1037
00:43:21,180 --> 00:43:19,600
ammonium nitrate around so here's four

1038
00:43:22,440 --> 00:43:21,190

genes that are responsible for that and

1039
00:43:24,630 --> 00:43:22,450
if you look at the diversity of one of

1040
00:43:26,100 --> 00:43:24,640
these communes this niche gene and the

1041
00:43:27,240 --> 00:43:26,110
different offset chimneys you see that

1042
00:43:32,070 --> 00:43:27,250
there are several different versions of

1043
00:43:33,570 --> 00:43:32,080
this in fh you more than that slightly

1044
00:43:35,970 --> 00:43:33,580
different hydrothermal chimneys have

1045
00:43:37,380 --> 00:43:35,980
different h genes so that shows there's

1046
00:43:39,840 --> 00:43:37,390
quite a bit of diversity in this

1047
00:43:41,610 --> 00:43:39,850
nitrogen cycle you look at the nitrogen

1048
00:43:43,010 --> 00:43:41,620
kings much more diversity then you see

1049
00:43:45,040 --> 00:43:43,020
if you just look at the 60s

1050
00:43:48,220 --> 00:43:45,050
was Amon RA which is usually that

1051
00:43:50,750 --> 00:43:48,230
barcode that microbiologists used sucks

1052
00:43:52,160 --> 00:43:50,760
species diversity so looks like there's

1053
00:43:53,390 --> 00:43:52,170
just one myth antigen that's living in

1054
00:43:55,220 --> 00:43:53,400
these chimneys but this one methanogens

1055
00:43:56,690 --> 00:43:55,230
accounting for lots of different if a

1056
00:43:58,550 --> 00:43:56,700
stinks lots of different James involve

1057
00:44:01,910 --> 00:43:58,560
the nitrogen fixation that's kind of

1058
00:44:03,710 --> 00:44:01,920
confusing and one possible explanation

1059
00:44:06,080 --> 00:44:03,720
is that there's a lot of horizontal

1060
00:44:08,870 --> 00:44:06,090
transfer going on between slightly

1061
00:44:10,610 --> 00:44:08,880
different subspecies with them as one

1062
00:44:12,320 --> 00:44:10,620
imagine species and we also have some

1063
00:44:14,030 --> 00:44:12,330

evidence for that looking at our

1064
00:44:17,060 --> 00:44:14,040
metagenomic data where we find lots of

1065
00:44:19,850 --> 00:44:17,070
different transposing which are enzymes

1066
00:44:21,890 --> 00:44:19,860
that are involved in moving DNA around

1067
00:44:26,120 --> 00:44:21,900
within a genome or between you nuts

1068
00:44:28,040 --> 00:44:26,130
here's a pot of the size of an assembled

1069
00:44:30,260 --> 00:44:28,050
DNA fragment in our genomic studies and

1070
00:44:32,180 --> 00:44:30,270
the read depth or coverage which is a

1071
00:44:33,950 --> 00:44:32,190
measure of how well basically how many

1072
00:44:35,810 --> 00:44:33,960
times that particular DNA signatures

1073
00:44:38,210 --> 00:44:35,820
found and whole data set you see this

1074
00:44:40,550 --> 00:44:38,220
peak of highly abundant but very small

1075
00:44:43,630 --> 00:44:40,560
DNA fragments and almost all of them

1076
00:44:46,670 --> 00:44:43,640
contain these transpose aces so this is

1077
00:44:49,040 --> 00:44:46,680
indicating a lot of plasmids or viruses

1078
00:44:50,930 --> 00:44:49,050
in these biofilms what we want to know

1079
00:44:52,760 --> 00:44:50,940
is what they're doing they might be

1080
00:44:54,380 --> 00:44:52,770
involved in moving these nitrogen

1081
00:44:56,450 --> 00:44:54,390
fixation genes which are known to be

1082
00:44:58,850 --> 00:44:56,460
often horizontal transfer between cells

1083
00:45:00,560 --> 00:44:58,860
and actually creating more diversity

1084
00:45:02,300 --> 00:45:00,570
more metabolic diversity from this

1085
00:45:05,780 --> 00:45:02,310
biofilm than we see by just looking at

1086
00:45:08,960 --> 00:45:05,790
the typical barcode 16s ribosomal RNA

1087
00:45:12,470 --> 00:45:08,970
diversity let's know it's a little bit

1088
00:45:14,420 --> 00:45:12,480

about 50 films as a strobe I illogical

1089
00:45:16,430 --> 00:45:14,430
study company so biofilms are social

1090
00:45:17,780 --> 00:45:16,440
communities and some people have said

1091
00:45:20,810 --> 00:45:17,790
that biofilms are multi cellular

1092
00:45:23,090 --> 00:45:20,820
microbes and there's a modeling paper

1093
00:45:25,100 --> 00:45:23,100
that recently came out in pinas which

1094
00:45:27,350 --> 00:45:25,110
shows that if you horizontal transfer of

1095
00:45:28,900 --> 00:45:27,360
DNA of genes within these biofilms can

1096
00:45:31,130 --> 00:45:28,910
actually introduce and stabilize the

1097
00:45:34,190 --> 00:45:31,140
existence of multiple genotypes of them

1098
00:45:35,390 --> 00:45:34,200
that bio from the reason why that's

1099
00:45:38,780 --> 00:45:35,400
interesting is this is known that lots

1100
00:45:40,670 --> 00:45:38,790
of cells between within biofilms can

1101
00:45:42,980 --> 00:45:40,680
actually differentiate without really

1102
00:45:45,260 --> 00:45:42,990
changing their genotype but can change

1103
00:45:46,690 --> 00:45:45,270
their phenotype to fill specific rules

1104
00:45:50,170 --> 00:45:46,700
within that biofilm eternity

1105
00:45:52,240 --> 00:45:50,180
overall both of the biofilm this is an

1106
00:45:54,970 --> 00:45:52,250
example basically microbes cooperating

1107
00:45:56,410 --> 00:45:54,980
to fulfill different functions in order

1108
00:45:59,050 --> 00:45:56,420
to have the overall multi-cellular

1109
00:46:03,450 --> 00:45:59,060
entity have bit more evolutionary

1110
00:46:05,530 --> 00:46:03,460
fitness and that's a very interesting

1111
00:46:08,710 --> 00:46:05,540
thing for thinking about evolution and

1112
00:46:11,260 --> 00:46:08,720
particularly thinking about perhaps had

1113
00:46:13,089 --> 00:46:11,270

the very first of all there's this idea

1114
00:46:14,710 --> 00:46:13,099
of the predominant community of pre

1115
00:46:16,630 --> 00:46:14,720
cells which is an idea that the very

1116
00:46:18,640 --> 00:46:16,640
first cells evolved from primitive cell

1117
00:46:21,609 --> 00:46:18,650
like things and very few genes each cell

1118
00:46:22,960 --> 00:46:21,619
had very few genes and therefore their

1119
00:46:24,700 --> 00:46:22,970
metabolically dependent on each other

1120
00:46:26,440 --> 00:46:24,710
and they compensated by this very small

1121
00:46:28,750 --> 00:46:26,450
genes by transferring genes among each

1122
00:46:31,060 --> 00:46:28,760
other wrinkly not really caring who it

1123
00:46:35,829 --> 00:46:31,070
came from where it was going to and as

1124
00:46:38,260 --> 00:46:35,839
this community evolved um the cells as

1125
00:46:39,819 --> 00:46:38,270
we know them became less can be more

1126
00:46:41,710 --> 00:46:39,829
resistant to horizontal transfer and

1127
00:46:44,200 --> 00:46:41,720
became the cells Lena and so I'm

1128
00:46:45,490 --> 00:46:44,210
thinking that studying biofilms like the

1129
00:46:47,290 --> 00:46:45,500
one at laughs today that have lots of

1130
00:46:48,880 --> 00:46:47,300
worlds on transfer going on but I've

1131
00:46:50,890 --> 00:46:48,890
limited genomic diversity but somehow

1132
00:46:52,690 --> 00:46:50,900
more have more about a bolic diversity

1133
00:46:53,980 --> 00:46:52,700
possibly as a result to the sorrel

1134
00:46:55,210 --> 00:46:53,990
entrance there might be a great way to

1135
00:46:57,250 --> 00:46:55,220
studying the dynamics of this

1136
00:47:02,319 --> 00:46:57,260
hypothetical free Darwinian community

1137
00:47:04,540 --> 00:47:02,329
pieces so you I've been saying that

1138
00:47:06,309 --> 00:47:04,550

there's if you look at this typical 16s

1139
00:47:08,020 --> 00:47:06,319
ribosomal RNA barcode that you really

1140
00:47:10,180 --> 00:47:08,030
only see one species in the Phantom's

1141
00:47:13,089 --> 00:47:10,190
and that's true with most techniques

1142
00:47:15,430 --> 00:47:13,099
that only we're now understand only

1143
00:47:17,890 --> 00:47:15,440
scratching the surface of what the most

1144
00:47:19,690 --> 00:47:17,900
abundant microbes are they recently we

1145
00:47:21,609 --> 00:47:19,700
have been able to get this very next

1146
00:47:23,079 --> 00:47:21,619
data set from international scent of

1147
00:47:25,180 --> 00:47:23,089
submarine microbes which is using this

1148
00:47:27,099 --> 00:47:25,190
new sequencing technology that can

1149
00:47:29,740 --> 00:47:27,109
actually sample the environment and much

1150
00:47:31,870 --> 00:47:29,750
much greater detail what is much higher

1151
00:47:34,240 --> 00:47:31,880
detective detection sensitivity than

1152
00:47:37,750 --> 00:47:34,250
we've had before and I can select very

1153
00:47:41,290 --> 00:47:37,760
very rare organisms-- so here's a figure

1154
00:47:45,150 --> 00:47:41,300
from one of our samples of a sequence of

1155
00:47:48,539 --> 00:47:45,160
this technology we got 20,000

1156
00:47:50,460 --> 00:47:48,549
using reads so 20,000 DNA sequences that

1157
00:47:52,170 --> 00:47:50,470
came from this one sample eighty-five

1158
00:47:53,970 --> 00:47:52,180
percent of the 20,000 have the exact

1159
00:47:55,620 --> 00:47:53,980
same DNA sequence the corresponds to

1160
00:47:57,990 --> 00:47:55,630
this myth an engine that dominates the

1161
00:47:59,910 --> 00:47:58,000
Biafran but the remaining fifteen

1162
00:48:02,760 --> 00:47:59,920
percent represented 87 additional

1163
00:48:08,130 --> 00:48:02,770

species or operational taxonomic unix so

1164
00:48:10,380 --> 00:48:08,140
to use which is the microbiologist can't

1165
00:48:12,690 --> 00:48:10,390
see we have same species and if you look

1166
00:48:15,809 --> 00:48:12,700
at how many of these rare species were

1167
00:48:17,819 --> 00:48:15,819
detected with increased sampling depth

1168
00:48:19,620 --> 00:48:17,829
which is what this curve is shown is

1169
00:48:22,410 --> 00:48:19,630
that you found eight found 88 species

1170
00:48:24,390 --> 00:48:22,420
after sequencing almost 20,000 DNA

1171
00:48:26,370 --> 00:48:24,400
sequences but that curve isn't anywhere

1172
00:48:27,900 --> 00:48:26,380
close to level enough so if we had a

1173
00:48:30,539 --> 00:48:27,910
technology that could sequence even more

1174
00:48:32,010 --> 00:48:30,549
than 20,000 pink 20,000 DNA sequences

1175
00:48:36,270 --> 00:48:32,020
from the environment we could find even

1176
00:48:39,089 --> 00:48:36,280
more speeches and so this is the

1177
00:48:40,529 --> 00:48:39,099
bringing up the idea of the rare

1178
00:48:42,420 --> 00:48:40,539
biosphere that you might have heard

1179
00:48:44,160 --> 00:48:42,430
about before and we see that even in

1180
00:48:46,109 --> 00:48:44,170
this an ecosystem where there's really

1181
00:48:47,339 --> 00:48:46,119
just one species at least we thought

1182
00:48:48,960 --> 00:48:47,349
there was just one species of the

1183
00:48:52,829 --> 00:48:48,970
previous technology there's a verb

1184
00:48:55,079 --> 00:48:52,839
biosphere within as a background to that

1185
00:48:57,839 --> 00:48:55,089
major species and on this particular

1186
00:49:00,059 --> 00:48:57,849
case all these most of these 87

1187
00:49:02,579 --> 00:49:00,069
additional species are very very closely

1188
00:49:04,170 --> 00:49:02,589

related to this dominant species and so

1189
00:49:05,760 --> 00:49:04,180
we don't quite know what that means but

1190
00:49:08,039 --> 00:49:05,770
we wondering if that might be a

1191
00:49:09,720 --> 00:49:08,049
reflection of this metabolic diversity

1192
00:49:10,920 --> 00:49:09,730
that we're seeing intelligence and right

1193
00:49:12,630 --> 00:49:10,930
now we're trying to figure out how to

1194
00:49:15,990 --> 00:49:12,640
correlate this metabolic diversity I'm

1195
00:49:18,450 --> 00:49:16,000
aware or 16 s diversity so I've been

1196
00:49:19,890 --> 00:49:18,460
talking sort of abstractly about these

1197
00:49:21,359 --> 00:49:19,900
things but here's a picture of what this

1198
00:49:22,920 --> 00:49:21,369
biofilms look like this is a

1199
00:49:24,510 --> 00:49:22,930
transmission electron micrograph you've

1200
00:49:26,700 --> 00:49:24,520
got your steel bar here it's one micron

1201
00:49:30,720 --> 00:49:26,710
basically each one of these cells is

1202
00:49:32,460 --> 00:49:30,730
approximately 1 micron wide this grey

1203
00:49:33,779 --> 00:49:32,470
part and the white part here that's the

1204
00:49:35,430 --> 00:49:33,789
carbonate mineral so you see the

1205
00:49:37,890 --> 00:49:35,440
biofilms have directly attached to the

1206
00:49:39,450 --> 00:49:37,900
carbonate minerals and these cells over

1207
00:49:41,849 --> 00:49:39,460
here have this very characteristic

1208
00:49:44,670 --> 00:49:41,859
morphology of the cells in this methanol

1209
00:49:46,380 --> 00:49:44,680
search snail engine hack very

1210
00:49:48,290 --> 00:49:46,390
characteristic but there's lots of other

1211
00:49:49,400 --> 00:49:48,300
morphology is here too that we were not

1212
00:49:51,530 --> 00:49:49,410
to see if we don't really know what

1213
00:49:54,170 --> 00:49:51,540

those things correspond to you know

1214
00:49:55,820 --> 00:49:54,180
based on those 16s sequences at least

1215
00:49:57,320 --> 00:49:55,830
eighty five percent question more the

1216
00:49:58,610 --> 00:49:57,330
install should be the exact same thing

1217
00:50:01,580 --> 00:49:58,620
that's not what we're really what we're

1218
00:50:03,470 --> 00:50:01,590
seeing here this might be an example of

1219
00:50:07,040 --> 00:50:03,480
how cells within a biofilm can

1220
00:50:08,840 --> 00:50:07,050
differentiate the form fill various

1221
00:50:12,860 --> 00:50:08,850
roles even if they have the same

1222
00:50:15,260 --> 00:50:12,870
phenotype and that's as I said before

1223
00:50:16,460 --> 00:50:15,270
that's hypothesized to be what might

1224
00:50:20,690 --> 00:50:16,470
have happened in these very first

1225
00:50:23,410 --> 00:50:20,700
community pieces so I'm just summarizing

1226
00:50:25,460 --> 00:50:23,420
ourselves here to reiterate the

1227
00:50:26,990 --> 00:50:25,470
chemistry of the lost city flutes

1228
00:50:28,790 --> 00:50:27,000
because they're Sopranos ation is very

1229
00:50:31,060 --> 00:50:28,800
high pH fairly warm about hundred

1230
00:50:33,770 --> 00:50:31,070
degrees lots of hydrogen and mechanics

1231
00:50:37,730 --> 00:50:33,780
we found both methane production and

1232
00:50:39,560 --> 00:50:37,740
methane oxidation are being mediated by

1233
00:50:41,960 --> 00:50:39,570
microbes and they're stimulated by

1234
00:50:43,550 --> 00:50:41,970
hydrogen we have as many gnomic data

1235
00:50:45,380 --> 00:50:43,560
shows that they have the genetic

1236
00:50:47,840 --> 00:50:45,390
potential to use carbon compounds other

1237
00:50:49,430 --> 00:50:47,850
than carbon dioxide lots of horizontal

1238
00:50:51,710 --> 00:50:49,440

gene transfer that has the potential to

1239
00:50:54,590 --> 00:50:51,720
be going on the phylogenetic diversity

1240
00:50:56,210 --> 00:50:54,600
this was a rare biosphere as evidenced

1241
00:50:57,620 --> 00:50:56,220
by sickness sequences but there's also

1242
00:51:00,410 --> 00:50:57,630
lots of diversity of nitrogen fixation

1243
00:51:01,970 --> 00:51:00,420
jeans and you see this great

1244
00:51:04,790 --> 00:51:01,980
morphological diversity despite limited

1245
00:51:06,170 --> 00:51:04,800
genetic diversity all right here's my

1246
00:51:09,080 --> 00:51:06,180
last slide I'm just throwing out some

1247
00:51:12,770 --> 00:51:09,090
ideas about how all this is Astra

1248
00:51:15,410 --> 00:51:12,780
biologically relevant for example um if

1249
00:51:17,450 --> 00:51:15,420
these cells have differentiated and

1250
00:51:18,800 --> 00:51:17,460
specific niches are they engaging us in

1251
00:51:20,170 --> 00:51:18,810
traffic partnership or some of those

1252
00:51:22,310 --> 00:51:20,180
cells that we saw on that picture

1253
00:51:23,780 --> 00:51:22,320
undergoing methane production some of

1254
00:51:25,070 --> 00:51:23,790
them doing methane oxidation and they're

1255
00:51:27,560 --> 00:51:25,080
somehow cooperating with each other

1256
00:51:30,050 --> 00:51:27,570
passing along metabolites which might be

1257
00:51:31,730 --> 00:51:30,060
much a great thing to do in a biofilm

1258
00:51:33,890 --> 00:51:31,740
because inhibits diffusion away from

1259
00:51:35,030 --> 00:51:33,900
things so for example you've got co2

1260
00:51:36,260 --> 00:51:35,040
from the acetate instead of

1261
00:51:38,300 --> 00:51:36,270
precipitating out immediately the

1262
00:51:40,160 --> 00:51:38,310
biofilm might make that carbon dioxide

1263
00:51:42,530 --> 00:51:40,170

aqueous dissolved for longer period of

1264
00:51:45,860 --> 00:51:42,540
time than it would it had been outside

1265
00:51:47,210 --> 00:51:45,870
the bathroom and then if these centric

1266
00:51:48,950 --> 00:51:47,220
metabolic relationships were happening

1267
00:51:51,020 --> 00:51:48,960
in a very early biofilm early

1268
00:51:52,579 --> 00:51:51,030
perhaps that might have contributed the

1269
00:51:55,880 --> 00:51:52,589
disability of biochemistry that with me

1270
00:51:57,740 --> 00:51:55,890
today speculation as far as like

1271
00:51:59,420 --> 00:51:57,750
stressed your life I think it's a

1272
00:52:00,980 --> 00:51:59,430
question asked could you have an

1273
00:52:02,150 --> 00:52:00,990
organism living entirely office

1274
00:52:04,130 --> 00:52:02,160
organization I think that might be

1275
00:52:06,260 --> 00:52:04,140
happening at LA City but because there's

1276
00:52:07,960 --> 00:52:06,270
so much oxygenated sea water circulating

1277
00:52:10,160 --> 00:52:07,970
around it's kind of hard to tell a study

1278
00:52:11,930 --> 00:52:10,170
and also this the methane on Mars has

1279
00:52:13,550 --> 00:52:11,940
been pretty spicy but incision I think

1280
00:52:14,810 --> 00:52:13,560
we got a look in the sub service to see

1281
00:52:16,520 --> 00:52:14,820
if they're biofilms like they say it

1282
00:52:26,349 --> 00:52:16,530
laughs it is directly living off thats

1283
00:52:33,440 --> 00:52:30,800
thank you Billy all right well I want to

1284
00:52:36,410 --> 00:52:33,450
turn questions over to headquarters and

1285
00:52:38,270 --> 00:52:36,420
thank Max burn sign my canoe and Mary

1286
00:52:45,140 --> 00:52:38,280
wojtek for joining us I believe there's

1287
00:52:53,370 --> 00:52:50,190
and you might be muted oh my hairy yeah

1288
00:52:59,960 --> 00:52:53,380

go ahead a question about what you knew

1289
00:53:06,630 --> 00:53:04,530
can you repeat the question we're okay

1290
00:53:08,700 --> 00:53:06,640
my question was for Billy and I was

1291
00:53:10,560 --> 00:53:08,710
wondering if he wanted to comment on if

1292
00:53:13,620 --> 00:53:10,570
art be heading information about sulfate

1293
00:53:15,570 --> 00:53:13,630
reduction either from his metagenomic or

1294
00:53:20,340 --> 00:53:15,580
any direct measurements at the velocity

1295
00:53:22,830 --> 00:53:20,350
sites we've been looking at the question

1296
00:53:24,660 --> 00:53:22,840
it's a very confusing topic and the

1297
00:53:26,850 --> 00:53:24,670
metagenomic data that we did find one

1298
00:53:28,740 --> 00:53:26,860
gene this via sarging that's evolving

1299
00:53:30,750 --> 00:53:28,750
sulfate reduction but it's not involved

1300
00:53:32,610 --> 00:53:30,760
it it belongs to a firm acute it does

1301
00:53:34,140 --> 00:53:32,620
not belong to the typical bacteria that

1302
00:53:36,450 --> 00:53:34,150
are involved in an hour with methane

1303
00:53:37,890 --> 00:53:36,460
oxidation in fact we don't find any of

1304
00:53:39,780 --> 00:53:37,900
the typical bacteria that are found

1305
00:53:40,680 --> 00:53:39,790
associated in a repentant oxidation so

1306
00:53:46,650 --> 00:53:40,690
we're still trying to figure that out

1307
00:53:52,020 --> 00:53:49,470
I just wondering if you thought it might

1308
00:53:54,360 --> 00:53:52,030
be involved when you proposed in trophic

1309
00:53:55,620 --> 00:53:54,370
partnerships and that could have been a

1310
00:53:58,140 --> 00:53:55,630
more traditional type of

1311
00:54:01,110 --> 00:53:58,150
sulfate-reducing that's involved in this

1312
00:54:03,570 --> 00:54:01,120
imperfect relationship facilitated by

1313
00:54:07,260 --> 00:54:03,580

the supply of hydrogen with an advantage

1314
00:54:09,150 --> 00:54:07,270
in yeah I think sulfate reduction could

1315
00:54:10,860 --> 00:54:09,160
definitely be involved in this possible

1316
00:54:13,140 --> 00:54:10,870
some terrific relationship but it's not

1317
00:54:14,280 --> 00:54:13,150
involving one of the bacterial species

1318
00:54:15,840 --> 00:54:14,290
that have been found in other

1319
00:54:19,470 --> 00:54:15,850
environments it has to be a different

1320
00:54:21,060 --> 00:54:19,480
bacteria if it's involved and when

1321
00:54:22,590 --> 00:54:21,070
looking at the bacteria that are there

1322
00:54:24,360 --> 00:54:22,600
it's hard to imagine one of these

1323
00:54:26,880 --> 00:54:24,370
bacteria living at 80 degrees or 90

1324
00:54:33,600 --> 00:54:26,890
degrees Celsius and a page time but

1325
00:54:35,670 --> 00:54:33,610
maybe it's happening okay thanks okay

1326
00:54:39,720 --> 00:54:35,680
Goddard Space Flight Center you have a

1327
00:54:42,800 --> 00:54:39,730
question yeah let's see actually two

1328
00:54:46,800 --> 00:54:42,810
more questions 12 comma can you hear me

1329
00:54:49,830 --> 00:54:46,810
are you okay one of the comment to Billy

1330
00:54:51,630 --> 00:54:49,840
and that is that our team has just

1331
00:54:54,810 --> 00:54:51,640
submitted two papers which are now

1332
00:54:59,480 --> 00:54:54,820
currently under review regarding methane

1333
00:55:02,870 --> 00:54:59,490
on Mars and the second one reports

1334
00:55:06,690 --> 00:55:02,880
detection of significant plumes over two

1335
00:55:09,540 --> 00:55:06,700
regions of interest to your talk one is

1336
00:55:12,900 --> 00:55:09,550
over the southeast quadrant of a low

1337
00:55:16,260 --> 00:55:12,910
shield volcano and that quadrant shows

1338
00:55:18,120 --> 00:55:16,270

evidence of local collapse which

1339
00:55:20,160 --> 00:55:18,130
suggests that the surface is connected

1340
00:55:25,140 --> 00:55:20,170
through fissures at least seasonally as

1341
00:55:27,030 --> 00:55:25,150
ice clears to some surface zones that we

1342
00:55:28,530 --> 00:55:27,040
can't say whether serpenton ization is

1343
00:55:30,360 --> 00:55:28,540
still occurring there or not it's

1344
00:55:32,480 --> 00:55:30,370
interesting to consider your remarks

1345
00:55:35,850 --> 00:55:32,490
regarding biofilms in that connection

1346
00:55:39,390 --> 00:55:35,860
which would become a prime region for

1347
00:55:41,640 --> 00:55:39,400
landed missions to further explore the

1348
00:55:45,750 --> 00:55:41,650
effluent gases and they're like oh topic

1349
00:55:49,400 --> 00:55:45,760
ratios you have any further comments on

1350
00:55:51,870 --> 00:55:49,410
what kinds of signatures might be sought

1351
00:55:55,620 --> 00:55:51,880
in such regions

1352
00:55:57,779 --> 00:55:55,630
to differentiate the suggestion you made

1353
00:56:01,349 --> 00:55:57,789
Samantha nization plus biofilm

1354
00:56:06,299 --> 00:56:01,359
generation from other means of producing

1355
00:56:09,329 --> 00:56:06,309
methane yeah I think would be extremely

1356
00:56:11,160 --> 00:56:09,339
difficult if you look at the isotopic

1357
00:56:12,749 --> 00:56:11,170
signatures of hydrogen and methane at LA

1358
00:56:15,599 --> 00:56:12,759
City I brought up a slight ear and if

1359
00:56:17,670 --> 00:56:15,609
anyone everyone can see it but other

1360
00:56:19,049 --> 00:56:17,680
authors have have used this figure to

1361
00:56:21,210 --> 00:56:19,059
show you how you can differentiate

1362
00:56:22,499 --> 00:56:21,220
between biogenic and a biogenic methane

1363
00:56:25,529 --> 00:56:22,509

if you looked at the methane elasticity

1364
00:56:27,960 --> 00:56:25,539
it has a puree of biogenic signal and i

1365
00:56:29,700 --> 00:56:27,970
could be because but they be produced by

1366
00:56:31,200 --> 00:56:29,710
the biofilms is very small compared to

1367
00:56:34,249 --> 00:56:31,210
the methane being produced diabolically

1368
00:56:36,299 --> 00:56:34,259
or because the ice topic fractionation

1369
00:56:37,859 --> 00:56:36,309
associated with by phones is extremely

1370
00:56:39,779 --> 00:56:37,869
small to the very high temperature it's

1371
00:56:41,940 --> 00:56:39,789
not a very high temperature reduces

1372
00:56:44,039 --> 00:56:41,950
fractionation or also because the

1373
00:56:45,870 --> 00:56:44,049
biofilms are using substrates that are

1374
00:56:47,819 --> 00:56:45,880
also that are coming from the state

1375
00:56:50,400 --> 00:56:47,829
biogenic source they're not fractionated

1376
00:56:52,049 --> 00:56:50,410
very much that for you see so I some I

1377
00:56:55,109 --> 00:56:52,059
guess my comment would be to be careful

1378
00:56:56,759 --> 00:56:55,119
to be disappointed if we saw such a

1379
00:56:58,200 --> 00:56:56,769
signature at Mars because that this

1380
00:57:00,599 --> 00:56:58,210
mature velocity and there's lots of

1381
00:57:02,190 --> 00:57:00,609
biofilms there so as a biologist would

1382
00:57:05,390 --> 00:57:02,200
i'd like to see us in microscope images

1383
00:57:07,799 --> 00:57:05,400
at first but i would suggest a sulfur

1384
00:57:13,680 --> 00:57:07,809
like maybe sulfur isotopes might be a

1385
00:57:16,079 --> 00:57:13,690
better way well did you probably know

1386
00:57:19,019 --> 00:57:16,089
Barbara Sherwood Lollar particularly

1387
00:57:21,390 --> 00:57:19,029
from the uptight team has taken the lead

1388
00:57:23,609 --> 00:57:21,400

in showing that it's not sufficient to

1389
00:57:28,799 --> 00:57:23,619
look forward to fractionation of carbon

1390
00:57:31,529 --> 00:57:28,809
13 in samples produced from to decide

1391
00:57:34,319 --> 00:57:31,539
whether biogenic or not but rather that

1392
00:57:37,349 --> 00:57:34,329
plus looking for a hydrogen

1393
00:57:39,660 --> 00:57:37,359
fractionation form of deuterium is far

1394
00:57:43,620 --> 00:57:39,670
more diagnostic has that been done in

1395
00:57:45,799 --> 00:57:43,630
the case of lost city europe Rostovski

1396
00:57:48,839 --> 00:57:45,809
what's all is done hydrogen isotopes

1397
00:57:51,349 --> 00:57:48,849
exactly as in some of the chimneys a

1398
00:57:55,200 --> 00:57:51,359
lost city show evidence of hydrogen

1399
00:57:56,790 --> 00:57:55,210
utilization but however the main gym

1400
00:57:58,859 --> 00:57:56,800
most of state does not really show much

1401
00:58:00,480 --> 00:57:58,869
energy utilization which we don't

1402
00:58:04,920 --> 00:58:00,490
understand why that is but there's lots

1403
00:58:06,359 --> 00:58:04,930
of fun yeah I mean we definitely want to

1404
00:58:08,370 --> 00:58:06,369
measure those gases but we should be

1405
00:58:12,000 --> 00:58:08,380
careful too disappointed if they don't

1406
00:58:14,760 --> 00:58:12,010
show an obvious biological signal ok

1407
00:58:16,829 --> 00:58:14,770
I'll have another question for Catherine

1408
00:58:19,770 --> 00:58:16,839
but perhaps we should let this yeah

1409
00:58:22,200 --> 00:58:19,780
we're on the hour right now so if people

1410
00:58:24,839 --> 00:58:22,210
need to get going i'll let you do that

1411
00:58:28,200 --> 00:58:24,849
and and i just want to thank everyone

1412
00:58:30,570 --> 00:58:28,210
for joining Michael will come back to

1413
00:58:33,500 --> 00:58:30,580

you but let's go to ames and let them

1414
00:58:37,020 --> 00:58:33,510
ask their question and then welcome back

1415
00:58:39,030 --> 00:58:37,030
yeah hi this is Dave Dima right here the

1416
00:58:41,099 --> 00:58:39,040
question I have of you is really relates

1417
00:58:43,170 --> 00:58:41,109
to the ph of the actual environments of

1418
00:58:45,150 --> 00:58:43,180
the biofilms people in this studying the

1419
00:58:47,880 --> 00:58:45,160
Cedars in California found very low

1420
00:58:49,020 --> 00:58:47,890
activity at ph is 11 and so I'm

1421
00:58:51,359 --> 00:58:49,030
wondering you need a little bit of

1422
00:58:53,220 --> 00:58:51,369
dilution of lower ph water for the most

1423
00:58:55,200 --> 00:58:53,230
robust biofilms to develop can you

1424
00:58:57,660 --> 00:58:55,210
comment a little bit about ph of the

1425
00:59:01,950 --> 00:58:57,670
micro environments that you studied the

1426
00:59:04,050 --> 00:59:01,960
genetics and the excitation the only

1427
00:59:06,450 --> 00:59:04,060
thing I really have data on is that even

1428
00:59:07,890 --> 00:59:06,460
that that the rates that I measured in

1429
00:59:09,839 --> 00:59:07,900
these methane production oxidation

1430
00:59:12,210 --> 00:59:09,849
experiments were the same at ph 8 or

1431
00:59:13,530 --> 00:59:12,220
page 9 or page time they vary a little

1432
00:59:14,940 --> 00:59:13,540
bit but I don't look believe the numbers

1433
00:59:17,099 --> 00:59:14,950
because of other errors of all the

1434
00:59:18,480 --> 00:59:17,109
experiments so I don't really know I

1435
00:59:21,030 --> 00:59:18,490
don't have any data that actually do

1436
00:59:22,859 --> 00:59:21,040
anything h11 I live it up to 10 and also

1437
00:59:24,150 --> 00:59:22,869
we don't have a lot of really good data

1438
00:59:26,190 --> 00:59:24,160

on the page from our city because we

1439
00:59:27,810 --> 00:59:26,200
really at least on the micro scale if

1440
00:59:29,430 --> 00:59:27,820
relevant to my clubs because we haven't

1441
00:59:31,320 --> 00:59:29,440
really put a good microcenter down there

1442
00:59:36,909 --> 00:59:31,330
to see what the pH we're a biofilm is

1443
00:59:41,870 --> 00:59:40,189
okay okay just a reminder if anyone has

1444
00:59:44,449 --> 00:59:41,880
questions to raise your hand in WebEx

1445
00:59:47,839 --> 00:59:44,459
and Mike back to you for a question for

1446
00:59:50,359 --> 00:59:47,849
Catherine right Catherine your talk was

1447
00:59:53,719 --> 00:59:50,369
extremely interesting I was interested

1448
00:59:57,019 --> 00:59:53,729
in why you chose that mass range from 2

1449
01:00:00,649 --> 00:59:57,029
40 to 60 am you assume you have other

1450
01:00:04,249 --> 01:00:00,659
major peak ranges in your overall

1451
01:00:06,709 --> 01:00:04,259
spectrum we are limited to about a

1452
01:00:10,219 --> 01:00:06,719
hundred to about 400 am you just given

1453
01:00:13,279 --> 01:00:10,229
the the mass spectrometer we're using it

1454
01:00:14,599 --> 01:00:13,289
can't go much lower than 100 and after

1455
01:00:17,120 --> 01:00:14,609
about four hundred you don't really see

1456
01:00:19,459 --> 01:00:17,130
very many tolling species anymore so I

1457
01:00:21,349 --> 01:00:19,469
just showed you a arrange that actually

1458
01:00:23,659 --> 01:00:21,359
though the one figure I showed that in

1459
01:00:25,069 --> 01:00:23,669
purple which I can't bring up now

1460
01:00:26,899 --> 01:00:25,079
because I don't seem to have any control

1461
01:00:29,059 --> 01:00:26,909
over these computers but that showed

1462
01:00:31,489 --> 01:00:29,069
more of the actual range we would have

1463
01:00:33,709 --> 01:00:31,499

which is from about a hundred to and for

1464
01:00:35,419 --> 01:00:33,719
it which unfortunately limits a lot of

1465
01:00:37,609 --> 01:00:35,429
these smaller mass things that where you

1466
01:00:39,439 --> 01:00:37,619
might be interested and it also it

1467
01:00:41,059 --> 01:00:39,449
doesn't overlap with the mass

1468
01:00:44,179 --> 01:00:41,069
spectrometer we have on Cassini either

1469
01:00:46,969 --> 01:00:44,189
which only goes up to a hundred mass

1470
01:00:49,009 --> 01:00:46,979
units so hopefully one day day when we

1471
01:00:51,889 --> 01:00:49,019
go back to Titan weekend we can make

1472
01:00:55,069 --> 01:00:51,899
some more comparisons between faster

1473
01:00:58,370 --> 01:00:55,079
ages that actually overlap hello it's

1474
01:01:00,529 --> 01:00:58,380
also curious as I noted that your

1475
01:01:03,259 --> 01:01:00,539
nitrogen heterocycles you had only units

1476
01:01:06,109 --> 01:01:03,269
with one nitrogen six units or six

1477
01:01:07,689 --> 01:01:06,119
nitrogens are seven nitrogens and I was

1478
01:01:10,009 --> 01:01:07,699
wondering what happened to the others

1479
01:01:12,649 --> 01:01:10,019
well it just yeah it seems the ones that

1480
01:01:16,009 --> 01:01:12,659
react kind of tend to be quite a highly

1481
01:01:17,629 --> 01:01:16,019
nitrogenated we do see species with just

1482
01:01:20,629 --> 01:01:17,639
a few nitrogens in them but they just

1483
01:01:22,579 --> 01:01:20,639
don't seem to be as reactive it seems

1484
01:01:24,889 --> 01:01:22,589
like the ones that react more have more

1485
01:01:26,419 --> 01:01:24,899
nitrogen in them but even if you have

1486
01:01:29,259 --> 01:01:26,429
six and seven nitrogen I would have

1487
01:01:31,879 --> 01:01:29,269
thought you might see five and eight

1488
01:01:35,389 --> 01:01:31,889

yeah yeah we do we do I was just showing

1489
01:01:37,669 --> 01:01:35,399
a couple of examples pcs that are

1490
01:01:40,370 --> 01:01:37,679
reacting yeah I just want to share just

1491
01:01:44,089 --> 01:01:40,380
a few of them when you look at the other

1492
01:01:45,799 --> 01:01:44,099
major mass groups and your 100 to 400

1493
01:01:48,739 --> 01:01:45,809
AMU range

1494
01:01:50,959 --> 01:01:48,749
can you use the occurrence of those mass

1495
01:01:54,109 --> 01:01:50,969
groups to identify what the heterocyclic

1496
01:01:55,880 --> 01:01:54,119
structure might be and so on yeah

1497
01:01:57,289 --> 01:01:55,890
unfortunately that's something we've had

1498
01:01:59,239 --> 01:01:57,299
a lot of trouble with that we can tell

1499
01:02:01,189 --> 01:01:59,249
exactly what the molecule is since these

1500
01:02:03,589 --> 01:02:01,199
are such big heavy molecules there's

1501
01:02:05,420 --> 01:02:03,599
thousands of different structures they

1502
01:02:07,370 --> 01:02:05,430
could have and so we were just trying to

1503
01:02:10,009 --> 01:02:07,380
do it by by linking products to

1504
01:02:13,009 --> 01:02:10,019
reactants that was the best best thing

1505
01:02:15,469 --> 01:02:13,019
we could do and unfortunately the the

1506
01:02:17,630 --> 01:02:15,479
results were not very unambiguous so I

1507
01:02:18,979 --> 01:02:17,640
think the jury is still out people have

1508
01:02:20,779 --> 01:02:18,989
been trying to figure out structure

1509
01:02:24,049 --> 01:02:20,789
colin's for a very long time it's been

1510
01:02:27,410 --> 01:02:24,059
very difficult to do thanks we have

1511
01:02:28,969 --> 01:02:27,420
another question here my god let's

1512
01:02:34,219 --> 01:02:28,979
switch to John Peters real quick and

1513
01:02:37,039 --> 01:02:34,229

then we'll come back to you Michael John

1514
01:02:39,529 --> 01:02:37,049
Peters i have just do a quick question

1515
01:02:42,620 --> 01:02:39,539
one for Catherine and the question would

1516
01:02:47,239 --> 01:02:42,630
be related to what you just talked about

1517
01:02:51,289 --> 01:02:47,249
the how much control you have trying to

1518
01:02:53,179 --> 01:02:51,299
make some smaller molecular weight but

1519
01:02:58,390 --> 01:02:53,189
you could try to use to figure out some

1520
01:03:00,829 --> 01:02:58,400
sort of a mechanism of the hydrology uh

1521
01:03:02,419 --> 01:03:00,839
well we don't really need it's not that

1522
01:03:04,519 --> 01:03:02,429
we need smaller molecular weights to

1523
01:03:07,640 --> 01:03:04,529
figure out what what's happening the

1524
01:03:09,949 --> 01:03:07,650
heavy ones work just fine 24 by example

1525
01:03:15,469 --> 01:03:09,959
by linking these these products to

1526
01:03:17,689 --> 01:03:15,479
possible reactants so I guess um and

1527
01:03:19,699 --> 01:03:17,699
then you need to see you I guess what's

1528
01:03:23,120 --> 01:03:19,709
your tight I just wonder said if you my

1529
01:03:26,390 --> 01:03:23,130
mom later now we use the number of

1530
01:03:29,779 --> 01:03:26,400
possibility for structural isomers door

1531
01:03:31,400 --> 01:03:29,789
sure you're probably not going to make a

1532
01:03:32,959 --> 01:03:31,410
haze in that case you probably going to

1533
01:03:36,650 --> 01:03:32,969
make a gaseous particle which gets

1534
01:03:38,569 --> 01:03:36,660
sucked out of the of the machine also

1535
01:03:39,799 --> 01:03:38,579
that you're less likely to find those on

1536
01:03:42,529 --> 01:03:39,809
the surface of Titan because they'd be

1537
01:03:44,229 --> 01:03:42,539
in the gas phase in the atmosphere so

1538
01:03:47,839 --> 01:03:44,239

we're more interested in these heavier

1539
01:03:52,160 --> 01:03:47,849
heavier molecules so people have studied

1540
01:03:54,859 --> 01:03:52,170
the gaseous products for for bill you

1541
01:03:58,530 --> 01:03:54,869
mentioned possibility for hydrogen

1542
01:04:00,930 --> 01:03:58,540
activity do you have any information any

1543
01:04:03,720 --> 01:04:00,940
genes anything identified what type of

1544
01:04:08,970 --> 01:04:03,730
hydrogenated and large metal lines and

1545
01:04:10,980 --> 01:04:08,980
could be present I have found some genes

1546
01:04:13,050 --> 01:04:10,990
that have the best blast hits or

1547
01:04:15,690 --> 01:04:13,060
hydrogenases but I haven't looked into

1548
01:04:17,340 --> 01:04:15,700
them yet so much I just getting started

1549
01:04:23,660 --> 01:04:17,350
looking at that data yes we definitely

1550
01:04:30,770 --> 01:04:27,410
thank you thank you okay and Goddard

1551
01:04:33,349 --> 01:04:30,780
back to you what can I go ahead hi this

1552
01:04:35,480 --> 01:04:33,359
is my cali and i guarded a great talk

1553
01:04:38,180 --> 01:04:35,490
for both speakers and I have a question

1554
01:04:41,500 --> 01:04:38,190
for Catherine going back to structures

1555
01:04:43,940 --> 01:04:41,510
again for all your molecular formulas

1556
01:04:45,680 --> 01:04:43,950
have you calculated the number of double

1557
01:04:49,910 --> 01:04:45,690
bond equivalents in your suite of

1558
01:04:51,980 --> 01:04:49,920
molecules and if so also on your mass

1559
01:04:54,380 --> 01:04:51,990
spec your tandem mass spec or your msn

1560
01:04:56,030 --> 01:04:54,390
can you look at the fragmentation and

1561
01:05:00,859 --> 01:04:56,040
least get down to if these molecules are

1562
01:05:03,950 --> 01:05:00,869
linear or cyclic molecules are you

1563
01:05:05,809 --> 01:05:03,960

asking about unsaturation or yeah I mean

1564
01:05:09,530 --> 01:05:05,819
how many double bonds because these look

1565
01:05:11,180 --> 01:05:09,540
like probably linea yeah there's

1566
01:05:12,559 --> 01:05:11,190
probably ashley's probably both that's

1567
01:05:13,609 --> 01:05:12,569
the thing there's such a big molecules

1568
01:05:15,289 --> 01:05:13,619
you're probably getting a little bit of

1569
01:05:20,120 --> 01:05:15,299
everything and they do seem to be quite

1570
01:05:22,039 --> 01:05:20,130
yeah unsaturated um unfortunately you

1571
01:05:24,200 --> 01:05:22,049
can't do a lot of these standard

1572
01:05:26,299 --> 01:05:24,210
techniques on thoas because there's just

1573
01:05:28,160 --> 01:05:26,309
this big blobby mixture with everything

1574
01:05:30,410 --> 01:05:28,170
in them you can't tell anything from

1575
01:05:32,359 --> 01:05:30,420
anything so which is why we needed this

1576
01:05:34,720 --> 01:05:32,369
really high resolution mass spectrometry

1577
01:05:37,309 --> 01:05:34,730
to at least distinguish the molecules

1578
01:05:40,069 --> 01:05:37,319
the different molecular formula for me

1579
01:05:42,530 --> 01:05:40,079
from each other but um but yeah I mean

1580
01:05:45,230 --> 01:05:42,540
we can tell I guess how unsaturated the

1581
01:05:46,940 --> 01:05:45,240
molecule is and and you know study you

1582
01:05:49,069 --> 01:05:46,950
seem to indicate that there are linear

1583
01:05:50,870 --> 01:05:49,079
portions of yeah these molecules

1584
01:05:54,170 --> 01:05:50,880
although I wouldn't rule out rings

1585
01:05:56,299 --> 01:05:54,180
entirely what can you do I mean you can

1586
01:05:58,400 --> 01:05:56,309
do math fragmentation in your IC are

1587
01:06:00,500 --> 01:05:58,410
correct oh yeah yeah yeah we did that we

1588
01:06:03,109 --> 01:06:00,510

did that yeah and we found fragments of

1589
01:06:05,180 --> 01:06:03,119
like carbon monoxide and water and

1590
01:06:09,620 --> 01:06:05,190
hydrogen cyanide I just look like

1591
01:06:11,210 --> 01:06:09,630
hydrocarbon fact fragmentation because

1592
01:06:13,579 --> 01:06:11,220
if these are ring structures that we

1593
01:06:15,980 --> 01:06:13,589
heart of a fragment right so does it

1594
01:06:17,990 --> 01:06:15,990
look like these are branched molecules

1595
01:06:21,260 --> 01:06:18,000
or when you are it's just too hard to

1596
01:06:23,510 --> 01:06:21,270
tell yeah but we so yeah we saw

1597
01:06:26,359 --> 01:06:23,520
fragments we didn't see a lot of you

1598
01:06:29,150 --> 01:06:26,369
know say you know ch2 or whatever

1599
01:06:30,620 --> 01:06:29,160
fragments it was mostly we were looking

1600
01:06:34,280 --> 01:06:30,630
more for the oxygenated fragments

1601
01:06:35,480 --> 01:06:34,290
anyways but yeah yeah I guess I guess we

1602
01:06:38,540 --> 01:06:35,490
didn't really see much Hydra

1603
01:06:42,380 --> 01:06:38,550
arbic fragments we saw water and co and

1604
01:06:47,630 --> 01:06:42,390
hydro cyanide that was about it so thank

1605
01:06:52,100 --> 01:06:47,640
you great talk guys thanks anything else

1606
01:06:55,609 --> 01:06:52,110
from got her no I think that's it wait a

1607
01:06:57,770 --> 01:06:55,619
minute there's one more um avi Mandell

1608
01:07:01,250 --> 01:06:57,780
from Goddard had a question for Billy I

1609
01:07:04,190 --> 01:07:01,260
was wondering as back to the question of

1610
01:07:06,830 --> 01:07:04,200
the possibility of serpentinization or

1611
01:07:08,210 --> 01:07:06,840
biofilms on Mars the conditions

1612
01:07:09,950 --> 01:07:08,220
obviously would be very different than

1613
01:07:12,200 --> 01:07:09,960

the ones at the bottom of the ocean and

1614
01:07:14,780 --> 01:07:12,210
the temperatures would be different ph

1615
01:07:17,090 --> 01:07:14,790
might be similar but especially in terms

1616
01:07:21,650 --> 01:07:17,100
of temperature or pressure how do these

1617
01:07:23,480 --> 01:07:21,660
um processes these biological processes

1618
01:07:26,390 --> 01:07:23,490
specifically not so much the serpent

1619
01:07:28,340 --> 01:07:26,400
anization but the the biofilm pathways

1620
01:07:34,280 --> 01:07:28,350
work under different temperature and

1621
01:07:38,900 --> 01:07:34,290
pressure conditions oh well we don't we

1622
01:07:40,760 --> 01:07:38,910
have an idea the short answer especially

1623
01:07:42,740 --> 01:07:40,770
these are novel metabolic pathways in

1624
01:07:44,359 --> 01:07:42,750
the absolute no idea a lot of in all

1625
01:07:45,859 --> 01:07:44,369
other cases of an earth methane

1626
01:07:47,780 --> 01:07:45,869
oxidation actually have two fresh cold

1627
01:07:49,190 --> 01:07:47,790
temperatures like four degrees so I

1628
01:07:50,300 --> 01:07:49,200
don't think temperature would be huge

1629
01:07:54,560 --> 01:07:50,310
issue as long as you know it's about

1630
01:07:56,870 --> 01:07:54,570
reason pressure no idea really these are

1631
01:08:00,950 --> 01:07:56,880
about 800 meters depth so not a huge

1632
01:08:03,230 --> 01:08:00,960
amount of pressure there otherwise I

1633
01:08:05,270 --> 01:08:03,240
don't I think that these things are

1634
01:08:06,890 --> 01:08:05,280
adopted too high pH and high temperature

1635
01:08:08,359 --> 01:08:06,900
because that's where they have to live

1636
01:08:12,650 --> 01:08:08,369
in order to get by agent methane but I

1637
01:08:20,670 --> 01:08:15,510
okay great thanks avi any other

1638
01:08:22,380 --> 01:08:20,680

questions for many sites okay looks like

1639
01:08:25,579 --> 01:08:22,390
we're dwindling I want to thank thank

1640
01:08:28,110 --> 01:08:25,589
everyone for attending and for stain and

1641
01:08:34,349 --> 01:08:28,120
especially thanks Billy and Catherine to

1642
01:08:36,329 --> 01:08:34,359
their talks and healthy reminded tune in

1643
01:08:38,519 --> 01:08:36,339
on November third for Jennifer eigenberg

1644
01:08:41,010 --> 01:08:38,529
and Domhnall Gleeson who will be giving