
AbSciCon
2019

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

2
00:00:13,600 --> 00:00:09,060
[Applause]

3
00:00:17,350 --> 00:00:13,610
good afternoon I think it's fair to say

4
00:00:20,740 --> 00:00:17,360
that most of the microbial cells on this

5
00:00:23,319 --> 00:00:20,750
planet belong to general for which there

6
00:00:25,540 --> 00:00:23,329
are no cultured representatives majority

7
00:00:28,269 --> 00:00:25,550
it might be you know it's been quoted as

8
00:00:30,519 --> 00:00:28,279
saying maybe as many as 80% or more so

9
00:00:31,690 --> 00:00:30,529
if you realize that most of the

10
00:00:33,250 --> 00:00:31,700
organisms have no cultured

11
00:00:36,100 --> 00:00:33,260
representatives and you want to know

12
00:00:38,020 --> 00:00:36,110
about metabolism it would help to bring

13
00:00:40,090 --> 00:00:38,030

them into culture so there are certainly

14
00:00:41,770 --> 00:00:40,100
other ways to study metabolism but

15
00:00:44,560 --> 00:00:41,780
certainly having organisms and culture

16
00:00:46,239 --> 00:00:44,570
is one of the best ways now it's also

17
00:00:49,630 --> 00:00:46,249
likely I would argue that if there are

18
00:00:52,779 --> 00:00:49,640
so many organisms that are not yet in

19
00:00:54,759 --> 00:00:52,789
culture that perhaps some of those are

20
00:00:56,500 --> 00:00:54,769
doing metabolisms we have not yet

21
00:00:59,319 --> 00:00:56,510
discovered something that we don't yet

22
00:01:00,939 --> 00:00:59,329
know about so the idea of finding new

23
00:01:03,069 --> 00:01:00,949
metabolisms I think is pretty exciting

24
00:01:05,079 --> 00:01:03,079
one and predicting what those

25
00:01:06,280 --> 00:01:05,089
metabolisms might be is certainly one

26
00:01:09,370 --> 00:01:06,290
approach and then to look for those

27
00:01:11,730 --> 00:01:09,380
organisms one way to predict new

28
00:01:13,780 --> 00:01:11,740
metabolisms is to use energetics and

29
00:01:15,070 --> 00:01:13,790
this is something that has been done

30
00:01:18,340 --> 00:01:15,080
before and that's what I'm going to be

31
00:01:19,960 --> 00:01:18,350
using in my presentation today before I

32
00:01:22,570 --> 00:01:19,970
get too deeply into this I want to make

33
00:01:24,010 --> 00:01:22,580
sure that I say just briefly why I'm

34
00:01:25,360 --> 00:01:24,020
using catabolism rather than the

35
00:01:27,190 --> 00:01:25,370
metabolism metabolism sort of a

36
00:01:29,740 --> 00:01:27,200
catch-all phrase that most people often

37
00:01:32,020 --> 00:01:29,750
use in place of catabolism but here we

38
00:01:33,910 --> 00:01:32,030

really mean the energy yielding reaction

39
00:01:35,620 --> 00:01:33,920
the the reactants going into the

40
00:01:37,570 --> 00:01:35,630
organism the organism doing its thing

41
00:01:40,110 --> 00:01:37,580
giving off waste products and the energy

42
00:01:42,220 --> 00:01:40,120
yield from that overall catabolism

43
00:01:43,990 --> 00:01:42,230
methanogenesis being an example

44
00:01:47,350 --> 00:01:44,000
aerobic respiration being example

45
00:01:49,690 --> 00:01:47,360
separate from biomass synthesis inside

46
00:01:52,000 --> 00:01:49,700
the cell which would be an AB ilysm so I

47
00:01:53,830 --> 00:01:52,010
will try to be consistent with

48
00:01:56,050 --> 00:01:53,840
catabolism but like I said some people

49
00:01:58,480 --> 00:01:56,060
just end up using metabolism to mean

50
00:02:01,570 --> 00:01:58,490
catabolism all right so the best example

51
00:02:03,250 --> 00:02:01,580
I think in using energetics to predict

52
00:02:07,440 --> 00:02:03,260
metabolisms and I think most people know

53
00:02:10,869 --> 00:02:07,450
about this one is from Baroda in 1977

54
00:02:13,990 --> 00:02:10,879
the energetics were not quite done right

55
00:02:15,520 --> 00:02:14,000
but it didn't matter in this case but in

56
00:02:18,220 --> 00:02:15,530
the seventy-seven papers a two-page

57
00:02:20,590 --> 00:02:18,230
paper that had a huge influence he

58
00:02:22,449 --> 00:02:20,600
basically wrote that ammonium plus

59
00:02:24,819 --> 00:02:22,459
nitrite going to

60
00:02:27,580 --> 00:02:24,829
dinitrogen gas and water has a negative

61
00:02:29,949 --> 00:02:27,590
Delta G zero or here in this Delta g0

62
00:02:32,289 --> 00:02:29,959
prime of minus eighty Killick eighty-six

63
00:02:34,630 --> 00:02:32,299

kilocalories so multiply that by four

64
00:02:36,369 --> 00:02:34,640
point one to get it into joules so the

65
00:02:38,500 --> 00:02:36,379
argument raised here was hey there's a

66
00:02:40,420 --> 00:02:38,510
large negative sign on this Delta G

67
00:02:43,569 --> 00:02:40,430
there must be an organism out there

68
00:02:46,210 --> 00:02:43,579
doing it well it took almost 20 years

69
00:02:48,460 --> 00:02:46,220
until high screenings group at the

70
00:02:50,830 --> 00:02:48,470
University of Delft determined that this

71
00:02:53,619 --> 00:02:50,840
process was in fact happening and it was

72
00:02:55,960 --> 00:02:53,629
in fact happening by being mediated by

73
00:02:57,970 --> 00:02:55,970
microorganisms and then it took another

74
00:02:59,589 --> 00:02:57,980
you know about ten years or so before

75
00:03:01,839 --> 00:02:59,599
Marcel Kuiper's at the Max Planck

76
00:03:04,509 --> 00:03:01,849
Institute found that anammox which was

77
00:03:05,860 --> 00:03:04,519
then later termed was actually a very

78
00:03:07,929 --> 00:03:05,870
common process in natural environments

79
00:03:10,210 --> 00:03:07,939
and now we talk about all the time as if

80
00:03:13,270 --> 00:03:10,220
we always knew it existed but in 77 it

81
00:03:15,280 --> 00:03:13,280
was a thermodynamic prediction so I want

82
00:03:18,429 --> 00:03:15,290
to use that same approach and think

83
00:03:20,800 --> 00:03:18,439
about a few other new metabolisms so

84
00:03:22,179 --> 00:03:20,810
going back to this Anna marks idea you

85
00:03:23,410 --> 00:03:22,189
see there in that green circle in the

86
00:03:25,690 --> 00:03:23,420
middle that's basically what Baroda

87
00:03:27,250 --> 00:03:25,700
based is prediction on and a couple of

88
00:03:30,000 --> 00:03:27,260

things here to note one is that of

89
00:03:32,770 --> 00:03:30,010
course thermodynamics or in this case

90
00:03:34,780 --> 00:03:32,780
Delta G calculations are temperature

91
00:03:36,729 --> 00:03:34,790
dependent so in some cases the

92
00:03:39,339 --> 00:03:36,739
temperature dependence is pretty minor

93
00:03:42,220 --> 00:03:39,349
in some cases that's pretty good or

94
00:03:43,629 --> 00:03:42,230
meaning pretty pretty dominant sometimes

95
00:03:46,479 --> 00:03:43,639
the you know the curve goes down

96
00:03:49,119 --> 00:03:46,489
sometimes goes up so we need to think

97
00:03:50,349 --> 00:03:49,129
about energetics in terms of temperature

98
00:03:51,670 --> 00:03:50,359
as well as pressure but pressure is a

99
00:03:53,830 --> 00:03:51,680
little bit less of an effect unless you

100
00:03:55,599 --> 00:03:53,840
get to really high pressures alright so

101
00:03:56,939 --> 00:03:55,609
a temperature dependent function the

102
00:03:59,469 --> 00:03:56,949
other thing to think about is that it's

103
00:04:01,330 --> 00:03:59,479
Broudy used a little circle above the

104
00:04:03,219 --> 00:04:01,340
Delta G so use only a standard state

105
00:04:05,740 --> 00:04:03,229
energetics again with Anna marks it

106
00:04:07,719 --> 00:04:05,750
didn't really matter but in reality we

107
00:04:09,580 --> 00:04:07,729
want to use the chemical environment to

108
00:04:11,319 --> 00:04:09,590
really get at the real energetics and

109
00:04:13,659 --> 00:04:11,329
that's a cue term on the right hand side

110
00:04:15,699 --> 00:04:13,669
of the equation so I've got up here a

111
00:04:17,080 --> 00:04:15,709
low energy and a high energy example so

112
00:04:19,509 --> 00:04:17,090
I mean just walk through that really

113
00:04:21,759 --> 00:04:19,519

briefly the low energy example so that

114
00:04:24,370 --> 00:04:21,769
blue curve means that there's very low

115
00:04:26,260 --> 00:04:24,380
concentrations of ammonium very low

116
00:04:28,060 --> 00:04:26,270
concentrations of nitrites all the

117
00:04:29,680 --> 00:04:28,070
things on the left hand side and high

118
00:04:32,350 --> 00:04:29,690
concentrations of the product so

119
00:04:34,360 --> 00:04:32,360
something like maybe 0.78 bars of

120
00:04:36,010 --> 00:04:34,370
nitrogen like atmospheric that would be

121
00:04:38,020 --> 00:04:36,020
a low energy example

122
00:04:40,930 --> 00:04:38,030
a high-energy example would be opposite

123
00:04:42,430 --> 00:04:40,940
high ammonium high nitrite low-end to

124
00:04:44,499 --> 00:04:42,440
content and you can see that the

125
00:04:46,629 --> 00:04:44,509
chemistry and this is not just randomly

126
00:04:48,999 --> 00:04:46,639
picking the most extreme numbers these

127
00:04:51,249 --> 00:04:49,009
are geo chemically reasonable

128
00:04:52,689 --> 00:04:51,259
concentrations that I've chosen to put

129
00:04:54,550 --> 00:04:52,699
into the low energy or high energy

130
00:04:56,559 --> 00:04:54,560
example the point is that there's a

131
00:05:00,339 --> 00:04:56,569
temperature dependence and as a that can

132
00:05:02,620 --> 00:05:00,349
be quite a big dependence on the

133
00:05:05,290 --> 00:05:02,630
energetics coming from the chemical

134
00:05:08,430 --> 00:05:05,300
environment all right so that's anammox

135
00:05:12,249 --> 00:05:08,440
now here I've got three examples of

136
00:05:14,650 --> 00:05:12,259
either unknown or little-known potential

137
00:05:17,200 --> 00:05:14,660
always remember these are potential

138
00:05:19,270 --> 00:05:17,210

metabolism so catabolism sorry so in

139
00:05:22,110 --> 00:05:19,280
this case it's a ferric iron mineral or

140
00:05:24,640 --> 00:05:22,120
mixed iron valence a mineral magnetite

141
00:05:27,159 --> 00:05:24,650
being reduced with hydrogen to make

142
00:05:29,820 --> 00:05:27,169
ferrous iron and then protons and water

143
00:05:32,439 --> 00:05:29,830
to balance the reaction so delta g r0

144
00:05:33,879 --> 00:05:32,449
sitting there about minus 100 kilojoule

145
00:05:36,670 --> 00:05:33,889
with not much of a temperature

146
00:05:39,040 --> 00:05:36,680
dependence now I want to introduce

147
00:05:40,330 --> 00:05:39,050
briefly this this prime next to the

148
00:05:42,279 --> 00:05:40,340
Delta G zero right so this is known as

149
00:05:43,689 --> 00:05:42,289
the biological standard state and lots

150
00:05:45,879 --> 00:05:43,699
of people know what this is for those

151
00:05:48,999 --> 00:05:45,889
who don't it basically says that the

152
00:05:51,189 --> 00:05:49,009
system is at neutrality so the proton at

153
00:05:54,159 --> 00:05:51,199
least at 25 degrees would be a 10 to the

154
00:05:56,649 --> 00:05:54,169
minus 7 instead of the 1 molar or 1

155
00:05:58,719 --> 00:05:56,659
mol/l unit that's used generally for

156
00:06:00,430 --> 00:05:58,729
standard states so you can see here

157
00:06:02,260 --> 00:06:00,440
there are 6 protons in the reaction and

158
00:06:04,300 --> 00:06:02,270
if you go from 1 molar to 10 to the

159
00:06:05,860 --> 00:06:04,310
minus 7 7 or as a magnitude raised to

160
00:06:07,420 --> 00:06:05,870
the sixth power yeah that's going to

161
00:06:10,450 --> 00:06:07,430
have an effect on your energetic so

162
00:06:14,290 --> 00:06:10,460
that's why that curve moves up by over a

163
00:06:16,870 --> 00:06:14,300

hundred kilojoules in this example if

164
00:06:18,399 --> 00:06:16,880
you consider the low energy example that

165
00:06:20,350 --> 00:06:18,409
I mentioned before again that would mean

166
00:06:22,540 --> 00:06:20,360
in this case low concentration of

167
00:06:25,120 --> 00:06:22,550
protons or in other words a basic system

168
00:06:27,129 --> 00:06:25,130
high pH system low hydrogen

169
00:06:29,320 --> 00:06:27,139
concentrations and high fares iron

170
00:06:31,659 --> 00:06:29,330
that's where the energetics would be and

171
00:06:34,680 --> 00:06:31,669
would be above zero and organic not a

172
00:06:36,820 --> 00:06:34,690
good potential metabolism or catabolism

173
00:06:38,950 --> 00:06:36,830
however if you consider an environment

174
00:06:42,159 --> 00:06:38,960
that's acidic so high proton activity

175
00:06:43,560 --> 00:06:42,169
high hydrogen low ferrous iron then you

176
00:06:46,329 --> 00:06:43,570
can actually see that there would be

177
00:06:49,450 --> 00:06:46,339
somewhere on the order of minus 50 to

178
00:06:50,830 --> 00:06:49,460
minus 20 kilojoules per mole

179
00:06:52,210 --> 00:06:50,840
of electron transferred over this

180
00:06:54,160 --> 00:06:52,220
temperature range so certainly in the

181
00:06:56,530 --> 00:06:54,170
low temperature range in an acidic

182
00:07:00,670 --> 00:06:56,540
environment with high hydrogen this is a

183
00:07:03,310 --> 00:07:00,680
potential catabolism here's another

184
00:07:04,840 --> 00:07:03,320
example so this would be a new type of

185
00:07:06,820 --> 00:07:04,850
methanogenesis if you want to think of

186
00:07:09,550 --> 00:07:06,830
it that way co2 and ammonium going to

187
00:07:12,100 --> 00:07:09,560
methane and n2 again protons and water

188
00:07:14,260 --> 00:07:12,110

to balance the reaction the Delta g0 is

189
00:07:15,520 --> 00:07:14,270
incredibly boring here as a function of

190
00:07:17,020 --> 00:07:15,530
temperature it doesn't do much as

191
00:07:19,060 --> 00:07:17,030
sitting there about 13 and a half 14

192
00:07:22,270 --> 00:07:19,070
kilojoules per mole electron transferred

193
00:07:24,160 --> 00:07:22,280
if we then again consider the biological

194
00:07:26,650 --> 00:07:24,170
standard stage you know huge effect

195
00:07:28,600 --> 00:07:26,660
again again there are eight protons in

196
00:07:30,850 --> 00:07:28,610
the reaction so changing it from one

197
00:07:32,200 --> 00:07:30,860
molar to ten to the minus seven and then

198
00:07:34,630 --> 00:07:32,210
raising it to the eighth power has a

199
00:07:37,030 --> 00:07:34,640
huge effect what about when you also

200
00:07:39,220 --> 00:07:37,040
then include then the environment I'm

201
00:07:41,680 --> 00:07:39,230
not showing the low energy example here

202
00:07:45,760 --> 00:07:41,690
because it was endergonic so above that

203
00:07:49,480 --> 00:07:45,770
that zero line the whole way but at high

204
00:07:52,240 --> 00:07:49,490
co2 high ammonium low end - and low

205
00:07:55,330 --> 00:07:52,250
protons so again in a basic or like

206
00:07:56,770 --> 00:07:55,340
alcholic system there is a small amount

207
00:07:59,440 --> 00:07:56,780
of energy here now I want to remind

208
00:08:01,000 --> 00:07:59,450
people these reactions are written well

209
00:08:03,520 --> 00:08:01,010
the energetics are written in terms of

210
00:08:05,830 --> 00:08:03,530
kilojoules per mole electron transferred

211
00:08:07,780 --> 00:08:05,840
so these are all normalized - that the

212
00:08:11,350 --> 00:08:07,790
reaction as written here is a 24

213
00:08:12,640 --> 00:08:11,360

electron transfer reaction so for this

214
00:08:15,160 --> 00:08:12,650
reaction you'd have to multiply the

215
00:08:16,540 --> 00:08:15,170
energetics by 24 and then you would see

216
00:08:20,730 --> 00:08:16,550
that this you know quite a bit of energy

217
00:08:23,050 --> 00:08:20,740
to be had for this potential catabolism

218
00:08:24,670 --> 00:08:23,060
so the one I want to really focus mostly

219
00:08:27,430 --> 00:08:24,680
on the one we're most excited about is

220
00:08:29,770 --> 00:08:27,440
this one here so this is called sulfur

221
00:08:31,210 --> 00:08:29,780
comprar Porsche nation lots of people

222
00:08:33,280 --> 00:08:31,220
don't know that term but people have

223
00:08:36,340 --> 00:08:33,290
certainly heard the term sulfur or other

224
00:08:37,750 --> 00:08:36,350
or other element disproportionation so

225
00:08:39,100 --> 00:08:37,760
that would be the back and reaction here

226
00:08:41,040 --> 00:08:39,110
alright let's start with sulfur

227
00:08:43,210 --> 00:08:41,050
disproportionation elemental sulfur

228
00:08:45,100 --> 00:08:43,220
intermediate oxidation state going to

229
00:08:47,470 --> 00:08:45,110
something more reduced sulfide and more

230
00:08:49,630 --> 00:08:47,480
oxidized sulfate people know that the

231
00:08:52,270 --> 00:08:49,640
back reaction happens and the organisms

232
00:08:54,880 --> 00:08:52,280
that can do that but the back reaction

233
00:08:56,650 --> 00:08:54,890
has a positive Delta g0 so again it's a

234
00:08:58,570 --> 00:08:56,660
it's just evidence that the chemistry

235
00:09:00,490 --> 00:08:58,580
the system absolutely is essential in

236
00:09:02,150 --> 00:09:00,500
getting the energetics right we're

237
00:09:04,130 --> 00:09:02,160
interested in the forward reaction as

238
00:09:07,130 --> 00:09:04,140

and here calm proportion Asian sulfide

239
00:09:10,940 --> 00:09:07,140
plus sulfate protons for the balancing

240
00:09:12,080 --> 00:09:10,950
to make elemental sulfur Delta G zero

241
00:09:13,820 --> 00:09:12,090
for this reaction again not very

242
00:09:16,910 --> 00:09:13,830
temperature dependent sitting down there

243
00:09:19,130 --> 00:09:16,920
about a minus 120 if you wanted to

244
00:09:20,420 --> 00:09:19,140
consider the biological standard state

245
00:09:23,300 --> 00:09:20,430
that's what it would look like as a

246
00:09:26,600 --> 00:09:23,310
function of temperature again the

247
00:09:29,540 --> 00:09:26,610
low-energy example won't work but in a

248
00:09:33,880 --> 00:09:29,550
system of high sulfide high sulfate and

249
00:09:36,470 --> 00:09:33,890
low pH this is a potential catabolism

250
00:09:38,990 --> 00:09:36,480
you know especially at low temperature

251
00:09:42,410 --> 00:09:39,000
main as you know in the 0 to 50 degree

252
00:09:44,060 --> 00:09:42,420
range let's say this is the same

253
00:09:47,000 --> 00:09:44,070
reaction but plotted slightly

254
00:09:49,280 --> 00:09:47,010
differently so pH on the y axis going

255
00:09:51,470 --> 00:09:49,290
from 0 to 7 temperature just up to a

256
00:09:54,650 --> 00:09:51,480
hundred degrees and then color coded

257
00:09:57,620 --> 00:09:54,660
basically on these temperature profiles

258
00:09:59,990 --> 00:09:57,630
with a dark blue minus 50 kilojoules in

259
00:10:02,090 --> 00:10:00,000
the greens minus 30 the yellows minus 10

260
00:10:05,030 --> 00:10:02,100
and the yellow to white transition being

261
00:10:08,180 --> 00:10:05,040
equilibrium so you can see here again

262
00:10:10,160 --> 00:10:08,190
that you know in the in acidic range pH

263
00:10:11,750 --> 00:10:10,170

1 2 3 somewhere in that neighborhood and

264
00:10:14,240 --> 00:10:11,760
there's certainly plenty of acidophiles

265
00:10:17,570 --> 00:10:14,250
that can handle then in environments

266
00:10:19,600 --> 00:10:17,580
with low high sulfide high sulfate this

267
00:10:22,900 --> 00:10:19,610
would be an energy yielding reaction and

268
00:10:26,180 --> 00:10:22,910
energy yields that are not unreasonable

269
00:10:28,340 --> 00:10:26,190
10 20 30 40 kilojoules we heard from

270
00:10:29,780 --> 00:10:28,350
Sanjoy this morning that sort of 10

271
00:10:31,220 --> 00:10:29,790
kilojoules per moles often a cut-off

272
00:10:32,660 --> 00:10:31,230
anything more than that might be

273
00:10:34,640 --> 00:10:32,670
reasonable and here we're certainly

274
00:10:39,140 --> 00:10:34,650
dipping into the 30 to 50 kilo Joule per

275
00:10:42,050 --> 00:10:39,150
mole range so what kind of environments

276
00:10:44,270 --> 00:10:42,060
might you find this metabolism of

277
00:10:45,680 --> 00:10:44,280
metabolism in so that's so that in the

278
00:10:47,180 --> 00:10:45,690
next step you predict a new metabolism

279
00:10:50,150 --> 00:10:47,190
then you go hunt for them and my

280
00:10:51,320 --> 00:10:50,160
graduate student heidi Aronson is going

281
00:10:53,510 --> 00:10:51,330
to be going off to the frasassi caves

282
00:10:56,720 --> 00:10:53,520
system with Jen Mack alladhi in about

283
00:10:58,430 --> 00:10:56,730
two weeks to hunt for these organisms so

284
00:11:00,380 --> 00:10:58,440
why frasassi well it's an environment

285
00:11:02,390 --> 00:11:00,390
where there's it's a cave system in

286
00:11:04,340 --> 00:11:02,400
northern Italy it's it's a cave system

287
00:11:06,380 --> 00:11:04,350
where this gypsum so sulfate minerals

288
00:11:09,050 --> 00:11:06,390

precipitating there's the smell of

289
00:11:11,450 --> 00:11:09,060
hydrogen sulfide in the cave and they've

290
00:11:12,860 --> 00:11:11,460
measured PHS as low as one and two so

291
00:11:15,470 --> 00:11:12,870
that's the kind of environment that

292
00:11:17,420 --> 00:11:15,480
would seem to be ideal for this but it's

293
00:11:19,010 --> 00:11:17,430
the only kind shallow sea hydrothermal

294
00:11:21,410 --> 00:11:19,020
systems where I've worked for quite a

295
00:11:23,360 --> 00:11:21,420
while I might also be good hunting

296
00:11:25,310 --> 00:11:23,370
grounds you have a marine system so

297
00:11:27,380 --> 00:11:25,320
generally high sulfate you have organic

298
00:11:29,360 --> 00:11:27,390
gases including sulfurous gases coming

299
00:11:31,310 --> 00:11:29,370
into the system high sulfide in many

300
00:11:33,710 --> 00:11:31,320
cases we've measured two to

301
00:11:36,410 --> 00:11:33,720
two-and-a-half volume percent h2s and

302
00:11:38,780 --> 00:11:36,420
the gas phases of the gases in the gas

303
00:11:40,670 --> 00:11:38,790
phase some of the systems can be quite

304
00:11:43,640 --> 00:11:40,680
acidic that might work acid mine

305
00:11:45,680 --> 00:11:43,650
drainage sites might also have some

306
00:11:47,750 --> 00:11:45,690
combination of the high sulphate high

307
00:11:49,880 --> 00:11:47,760
sulfide low pH that would make them

308
00:11:53,360 --> 00:11:49,890
attractive ask the sulphate crater lakes

309
00:11:55,730 --> 00:11:53,370
and so on and so forth so again so they

310
00:11:58,940 --> 00:11:55,740
just drive this point home we're looking

311
00:12:01,400 --> 00:11:58,950
strictly from a chemical geochemical

312
00:12:04,580 --> 00:12:01,410
thermodynamic standpoint are there redox

313
00:12:08,180 --> 00:12:04,590

reactions which under certain reasonable

314
00:12:10,940 --> 00:12:08,190
geochemical environments would be have

315
00:12:13,640 --> 00:12:10,950
it would have an Delta G that's that's

316
00:12:16,820 --> 00:12:13,650
negative and would it have a Delta G

317
00:12:20,690 --> 00:12:16,830
that's negative enough to then start

318
00:12:23,720 --> 00:12:20,700
using that as a sort of a first step in

319
00:12:25,250 --> 00:12:23,730
looking for organisms then the hard part

320
00:12:27,680 --> 00:12:25,260
really begins getting the samples

321
00:12:29,630 --> 00:12:27,690
bringing them into lab trying to culture

322
00:12:32,690 --> 00:12:29,640
them and so on and so forth so this is

323
00:12:34,310 --> 00:12:32,700
absolutely not saying these metabolisms

324
00:12:36,410 --> 00:12:34,320
are Kaplan's exist well that these

325
00:12:38,260 --> 00:12:36,420
organs exists is really just the first

326
00:12:41,390 --> 00:12:38,270
step it's very analogous to Baroda

327
00:12:42,950 --> 00:12:41,400
saying hey here's Anna marks maybe

328
00:12:44,660 --> 00:12:42,960
there's something out there I'm hoping

329
00:12:48,320 --> 00:12:44,670
it won't take twenty to thirty years

330
00:12:50,090 --> 00:12:48,330
until we find these I'll be dead but you

331
00:12:52,370 --> 00:12:50,100
know would be nice if maybe you know in

332
00:12:53,720 --> 00:12:52,380
the in the in in the meantime we could

333
00:12:55,460 --> 00:12:53,730
find them a little bit more quickly than

334
00:12:57,950 --> 00:12:55,470
we did for animals but remember animal

335
00:13:00,470 --> 00:12:57,960
walks is nitrogen calm proportion Asian

336
00:13:02,900 --> 00:13:00,480
so sulphur comprehend a shoe should not

337
00:13:04,700 --> 00:13:02,910
be that weird a concept and with that

338
00:13:11,940 --> 00:13:04,710

I'm happy to take questions if there are

339
00:13:22,120 --> 00:13:14,170
we have time for a few questions for

340
00:13:23,740 --> 00:13:22,130
Yann I had a quick question for you Yann

341
00:13:25,180 --> 00:13:23,750
so are these so when you're going out

342
00:13:27,040 --> 00:13:25,190
looking for these organisms that might

343
00:13:29,380 --> 00:13:27,050
be conducting these metabolisms the calm

344
00:13:32,020 --> 00:13:29,390
proportion Asia etc are these are

345
00:13:33,880 --> 00:13:32,030
primarily incubation based analyses

346
00:13:36,190 --> 00:13:33,890
that's certainly what we're starting so

347
00:13:38,500 --> 00:13:36,200
what what Heidi has done is used the

348
00:13:40,510 --> 00:13:38,510
chemistry of the system in this case the

349
00:13:44,260 --> 00:13:40,520
frasassi caves system based on previous

350
00:13:46,120 --> 00:13:44,270
studies analyses to design growth media

351
00:13:48,970 --> 00:13:46,130
that mimicked as closely as possible the

352
00:13:50,800 --> 00:13:48,980
system but we actually don't mimic

353
00:13:52,300 --> 00:13:50,810
perfectly we do give it a sort of a

354
00:13:53,650 --> 00:13:52,310
little extra boost we give it perhaps a

355
00:13:55,960 --> 00:13:53,660
little bit more sulfate a little bit

356
00:13:57,580 --> 00:13:55,970
more sulfide or you know vary the pH a

357
00:13:59,800 --> 00:13:57,590
little bit more than we might find in

358
00:14:01,930 --> 00:13:59,810
nature so it's not just saying exactly

359
00:14:04,120 --> 00:14:01,940
the things we've measured is the medium

360
00:14:05,830 --> 00:14:04,130
we're using but it's based on that and

361
00:14:08,140 --> 00:14:05,840
then just initially at least giving them

362
00:14:09,580 --> 00:14:08,150
a little bit extra push by giving them a

363
00:14:12,010 --> 00:14:09,590

little bit more the reactants then maybe

364
00:14:14,650 --> 00:14:12,020
is in the system and then perhaps you

365
00:14:23,650 --> 00:14:14,660
know playing off of that yeah but yeah

366
00:14:26,410 --> 00:14:23,660
it's culture based at first Pete thanks

367
00:14:28,900 --> 00:14:26,420
yeah that's super cool I am I think that

368
00:14:30,580 --> 00:14:28,910
if you're staying alive means not

369
00:14:34,080 --> 00:14:30,590
finding these and a bunch of us are

370
00:14:36,400 --> 00:14:34,090
gonna try to avoid finding them the so

371
00:14:38,200 --> 00:14:36,410
something a question for you as a

372
00:14:41,200 --> 00:14:38,210
forgive me if it's a bit out there but I

373
00:14:44,050 --> 00:14:41,210
am curious how do you think this plays

374
00:14:45,720 --> 00:14:44,060
out in terms of the prevalence of calm

375
00:14:49,390 --> 00:14:45,730
proportion nation over evolutionary time

376
00:14:53,020 --> 00:14:49,400
like in a point in time where we may not

377
00:14:55,780 --> 00:14:53,030
have had these oxidized sulfur species

378
00:14:57,580 --> 00:14:55,790
right or nitrogen species do you do I

379
00:14:59,610 --> 00:14:57,590
mean is it too heavy-handed to assert

380
00:15:01,570 --> 00:14:59,620
that this might be a slightly younger

381
00:15:03,670 --> 00:15:01,580
metabolic capacity do you see where I'm

382
00:15:05,050 --> 00:15:03,680
going with this yeah I mean if you

383
00:15:06,850 --> 00:15:05,060
didn't have sulfate you're not gonna

384
00:15:08,890 --> 00:15:06,860
have sulfur comprar partion nation right

385
00:15:12,160 --> 00:15:08,900
so would you have had sulfate until the

386
00:15:14,050 --> 00:15:12,170
system was you know quite oxidized what

387
00:15:16,540 --> 00:15:14,060
it would have been you know sulfate

388
00:15:20,020 --> 00:15:16,550

after the sort of rise of oxygen if you

389
00:15:21,940 --> 00:15:20,030
will it because it requires for the

390
00:15:25,660 --> 00:15:21,950
sulfur example quite high cost

391
00:15:28,870 --> 00:15:25,670
of sulfate as opposed to the the Anna

392
00:15:30,370 --> 00:15:28,880
marks example that may be the case so we

393
00:15:31,930 --> 00:15:30,380
have not thought about we're not saying

394
00:15:34,120 --> 00:15:31,940
that these are necessarily early

395
00:15:36,240 --> 00:15:34,130
metabolisms anything like that it would

396
00:15:38,829 --> 00:15:36,250
be fun to play around with that idea I

397
00:15:42,040 --> 00:15:38,839
think for Anna marks it's not a problem

398
00:15:43,930 --> 00:15:42,050
because nitrite or nitrate are better

399
00:15:45,519 --> 00:15:43,940
electron acceptors and sulfate is so

400
00:15:47,110 --> 00:15:45,529
which means to an organ for there to be

401
00:15:48,910 --> 00:15:47,120
energy there has to be quite a lot of