
AbSciCon
2019

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

2
00:00:11,949 --> 00:00:09,150
[Applause]

3
00:00:12,580 --> 00:00:11,959
right good morning thank you all for

4
00:00:15,190 --> 00:00:12,590
being here

5
00:00:18,600 --> 00:00:15,200
on a Friday and extra special thanks to

6
00:00:21,940 --> 00:00:18,610
the conveners for the invitation

7
00:00:23,230 --> 00:00:21,950
before I dive into this I wanted to none

8
00:00:25,269 --> 00:00:23,240
of you were listening to anything I'm

9
00:00:27,429 --> 00:00:25,279
saying is I got this cool video on but

10
00:00:30,089 --> 00:00:27,439
before I do I dive into this I'll tell

11
00:00:32,620 --> 00:00:30,099
you a little bit about myself so I'm a

12
00:00:34,330 --> 00:00:32,630
biochemist and physiologist it's really

13
00:00:37,720 --> 00:00:34,340

interested in how matter and energy move

14
00:00:40,720 --> 00:00:37,730
through our biosphere right and we think

15
00:00:42,880 --> 00:00:40,730
a lot about these processes in the deep

16
00:00:44,560 --> 00:00:42,890
ocean for microbes to animals now for

17
00:00:46,450 --> 00:00:44,570
the last 15 years we've been using the

18
00:00:48,599 --> 00:00:46,460
kinds of bio electrochemical systems

19
00:00:53,470 --> 00:00:48,609
that lloyd did a wonderful job of

20
00:00:57,069 --> 00:00:53,480
talking about in the context of thinking

21
00:01:00,189 --> 00:00:57,079
about how organisms might well let's

22
00:01:02,709 --> 00:01:00,199
just say partake in and benefit from bio

23
00:01:04,810 --> 00:01:02,719
electrochemical reactions in these

24
00:01:07,060 --> 00:01:04,820
systems and Laurie I may be throwing in

25
00:01:09,460 --> 00:01:07,070
my CV for your postdoc application you

26
00:01:10,840 --> 00:01:09,470
guys are up to some cool stuff in my lab

27
00:01:12,640 --> 00:01:10,850
we've been using these approaches to

28
00:01:15,460 --> 00:01:12,650
study seeps and vents and in particular

29
00:01:16,780 --> 00:01:15,470
microbes that we think are engaged in

30
00:01:19,030 --> 00:01:16,790
some of these by electrochemical

31
00:01:20,670 --> 00:01:19,040
processes the work I want to show you

32
00:01:23,440 --> 00:01:20,680
today is representative of the kind of

33
00:01:24,700 --> 00:01:23,450
work that we do in the lab and the

34
00:01:29,350 --> 00:01:24,710
take-home message that I want to share

35
00:01:31,390 --> 00:01:29,360
with you is is that all living systems

36
00:01:33,190 --> 00:01:31,400
are by electrochemical systems and many

37
00:01:35,380 --> 00:01:33,200
of them not all of them but many of them

38
00:01:37,780 --> 00:01:35,390

have kind of a unique diagnostic

39
00:01:41,760 --> 00:01:37,790
fingerprint that you can detect if you

40
00:01:45,100 --> 00:01:41,770
are interrogating them electrochemically

41
00:01:47,500 --> 00:01:45,110
that being said living systems are

42
00:01:49,420 --> 00:01:47,510
inextricably tied to and influence their

43
00:01:51,940 --> 00:01:49,430
abiotic environment so a lot of what I

44
00:01:54,340 --> 00:01:51,950
want to share with you today is how we

45
00:01:56,140 --> 00:01:54,350
can use these systems to understand how

46
00:01:58,740 --> 00:01:56,150
microbes influence and shape their

47
00:02:00,820 --> 00:01:58,750
environment and in turn how their

48
00:02:02,740 --> 00:02:00,830
influence on that environment affects

49
00:02:04,180 --> 00:02:02,750
their activity and the interest of time

50
00:02:05,920 --> 00:02:04,190
I'll move through some of these intro

51
00:02:08,469 --> 00:02:05,930
slides at a quick pace because Laurie

52
00:02:11,020 --> 00:02:08,479
set us up very nicely so I'm go ahead

53
00:02:12,850 --> 00:02:11,030
and get started so as you all know

54
00:02:14,080 --> 00:02:12,860
offense or some of Earth's most extreme

55
00:02:16,910 --> 00:02:14,090
environments you know you're talking

56
00:02:19,730 --> 00:02:16,920
about places where you have

57
00:02:23,240 --> 00:02:19,740
really high-temperature chemically

58
00:02:24,890 --> 00:02:23,250
reduced low pH fluids moving from the

59
00:02:29,000 --> 00:02:24,900
subsurface into an overlying

60
00:02:30,470 --> 00:02:29,010
kulaks ik water column and bear in mind

61
00:02:33,230 --> 00:02:30,480
that these fluids are enriched in

62
00:02:35,270 --> 00:02:33,240
hydrogen hydrogen sulfide dissolved

63
00:02:37,340 --> 00:02:35,280

metals including arsenic lead zinc and

64
00:02:40,070 --> 00:02:37,350
indeed many of the rare earth elements

65
00:02:42,590 --> 00:02:40,080
that analyse mentioned before now

66
00:02:44,630 --> 00:02:42,600
hydrogen will vent chimneys are their

67
00:02:46,220 --> 00:02:44,640
their mineral precipitates so you really

68
00:02:48,230 --> 00:02:46,230
can't think of them as being sort of

69
00:02:51,160 --> 00:02:48,240
consolidated in the way you might think

70
00:02:53,690 --> 00:02:51,170
of a metamorphic rock or an igneous rock

71
00:02:56,540 --> 00:02:53,700
the way this starts as you have fluid

72
00:02:58,850 --> 00:02:56,550
flow that that comes out of a crack

73
00:03:01,100 --> 00:02:58,860
right where perhaps you have tectonic

74
00:03:03,350 --> 00:03:01,110
activity that's reshaped the subsurface

75
00:03:05,000 --> 00:03:03,360
plumbing as soon as you have that hot

76
00:03:07,460 --> 00:03:05,010
fluid emerging into seawater you get the

77
00:03:09,949 --> 00:03:07,470
precipitation of anhydride there's

78
00:03:12,020 --> 00:03:09,959
calcium sulfate compound and eventually

79
00:03:13,880 --> 00:03:12,030
over time what seems to happen is that

80
00:03:16,430 --> 00:03:13,890
the anhydride acts as a physical barrier

81
00:03:19,280 --> 00:03:16,440
between the surrounding cool oxic water

82
00:03:21,110 --> 00:03:19,290
and then the hydrothermal and member

83
00:03:24,500 --> 00:03:21,120
fluid if you will and you start to see

84
00:03:26,150 --> 00:03:24,510
the precipitation of metal sulfides you

85
00:03:29,600 --> 00:03:26,160
end up with poly metallic sulfides and

86
00:03:33,170 --> 00:03:29,610
as this assembly assembly sort of

87
00:03:35,030 --> 00:03:33,180
thickens you end up with more often than

88
00:03:37,100 --> 00:03:35,040

not chalcopyrite lining the inner walls

89
00:03:39,440 --> 00:03:37,110
and so on now as mentioned these are

90
00:03:41,539 --> 00:03:39,450
natural electrochemical reactors because

91
00:03:45,890 --> 00:03:41,549
you have the semiconductive and

92
00:03:49,060 --> 00:03:45,900
conductive matrix that separates fluids

93
00:03:51,830 --> 00:03:49,070
of different potentials all right so

94
00:03:53,449 --> 00:03:51,840
what you can measure this right is our

95
00:03:57,500 --> 00:03:53,459
colleagues Nakamura and others have done

96
00:04:00,380 --> 00:03:57,510
and and and and measure this this

97
00:04:03,620 --> 00:04:00,390
potential where you can where you can

98
00:04:06,020 --> 00:04:03,630
see through this porous chimney a lek

99
00:04:07,850 --> 00:04:06,030
tron flow you can also imagine that that

100
00:04:12,920 --> 00:04:07,860
porous chimneys a fantastic place for

101
00:04:14,420 --> 00:04:12,930
microorganisms to thrive a number of us

102
00:04:16,099 --> 00:04:14,430
have been working on this over the years

103
00:04:18,940 --> 00:04:16,109
and we find that organisms that live

104
00:04:21,800 --> 00:04:18,950
inside these chimney walls are

105
00:04:23,540 --> 00:04:21,810
capitalizing on this uh on this

106
00:04:26,300 --> 00:04:23,550
electrical potential in any number of

107
00:04:28,100 --> 00:04:26,310
different ways the way a lot of them do

108
00:04:29,839 --> 00:04:28,110
this is through microbial extracellular

109
00:04:30,710 --> 00:04:29,849
electron transfer and I'm giving you a

110
00:04:33,200 --> 00:04:30,720
very simple cart

111
00:04:36,650 --> 00:04:33,210
soonish version of this but the idea is

112
00:04:38,300 --> 00:04:36,660
- is that for us we humans we are and

113
00:04:39,470 --> 00:04:38,310

forgive me a little physiologically

114
00:04:42,020 --> 00:04:39,480
boring when it comes to our energy

115
00:04:43,820 --> 00:04:42,030
metabolism right you eat the living

116
00:04:45,860 --> 00:04:43,830
you eat the bodies of dead things more

117
00:04:48,050 --> 00:04:45,870
or less or whatever they may be you

118
00:04:49,700 --> 00:04:48,060
breathe in oxygen and you move those

119
00:04:52,490 --> 00:04:49,710
into the inside of your cell and carry

120
00:04:54,920 --> 00:04:52,500
out metabolic reactions eeet is really

121
00:04:59,810 --> 00:04:54,930
about extending energy metabolism beyond

122
00:05:01,520 --> 00:04:59,820
the cell by having outward-facing redox

123
00:05:03,260 --> 00:05:01,530
active molecules that allow you to

124
00:05:06,170 --> 00:05:03,270
engage with the solid phase in your

125
00:05:09,350 --> 00:05:06,180
environment say for example iron oxides

126
00:05:11,150 --> 00:05:09,360
right that you can use as electron

127
00:05:12,800 --> 00:05:11,160
acceptors it's like breathing rust

128
00:05:14,720 --> 00:05:12,810
imagine putting your hand on a rusty

129
00:05:17,420 --> 00:05:14,730
plate and using that as a your electron

130
00:05:18,920 --> 00:05:17,430
acceptor or conversely taking up

131
00:05:21,200 --> 00:05:18,930
electrons from the environment through

132
00:05:24,080 --> 00:05:21,210
these redox active moieties that allow

133
00:05:25,970 --> 00:05:24,090
allow you to to harvest those electrons

134
00:05:27,800 --> 00:05:25,980
and use them to do work by

135
00:05:29,630 --> 00:05:27,810
electrochemical systems are really

136
00:05:32,750 --> 00:05:29,640
useful in studying these kinds of

137
00:05:34,310 --> 00:05:32,760
organisms and not not only those but for

138
00:05:36,710 --> 00:05:34,320

the purpose of this talk we're gonna

139
00:05:39,500 --> 00:05:36,720
focus on on organisms that we think are

140
00:05:40,670 --> 00:05:39,510
engaged in the e-team now one thing

141
00:05:42,590 --> 00:05:40,680
that's really interesting is when we

142
00:05:45,110 --> 00:05:42,600
think about chimney growth and we think

143
00:05:46,520 --> 00:05:45,120
about the fact that we know that

144
00:05:48,650 --> 00:05:46,530
chimneys under growth this mineralogical

145
00:05:51,200 --> 00:05:48,660
evolution that you end up with this

146
00:05:53,870 --> 00:05:51,210
metallic sulfide matrix that

147
00:05:55,310 --> 00:05:53,880
semiconductive now there is a bit of a

148
00:05:57,560 --> 00:05:55,320
chicken or the egg question here when it

149
00:06:00,320 --> 00:05:57,570
comes to hydrothermal vent growth is it

150
00:06:03,200 --> 00:06:00,330
that you have this abiotic process where

151
00:06:04,909 --> 00:06:03,210
you have the deposition if arguably the

152
00:06:06,710 --> 00:06:04,919
electrochemical deposition of poly

153
00:06:09,080 --> 00:06:06,720
metallic sulfides that create an

154
00:06:11,450 --> 00:06:09,090
environment for microbes or conversely

155
00:06:15,770 --> 00:06:11,460
our microbes that are capable of eet or

156
00:06:20,780 --> 00:06:15,780
engaged in in eet participating in the

157
00:06:23,060 --> 00:06:20,790
formation of chimneys so we've made a

158
00:06:24,260 --> 00:06:23,070
few different artificial vents over the

159
00:06:25,400 --> 00:06:24,270
years the one I'm gonna show you today

160
00:06:27,860 --> 00:06:25,410
is a high pressure high temperature

161
00:06:30,320 --> 00:06:27,870
reactor I've simplified this

162
00:06:32,540 --> 00:06:30,330
dramatically in which you can imagine a

163
00:06:34,640 --> 00:06:32,550

high pressure vessel in which you have a

164
00:06:36,530 --> 00:06:34,650
working electrode that acts as our site

165
00:06:38,989 --> 00:06:36,540
of nucleation if you will a place where

166
00:06:43,039 --> 00:06:38,999
we can start the deposition

167
00:06:46,189 --> 00:06:43,049
and hydrate and and and polymetallic

168
00:06:47,839 --> 00:06:46,199
sulfites and of course that's a working

169
00:06:49,489 --> 00:06:47,849
electrode elsewhere there's a counter

170
00:06:51,829 --> 00:06:49,499
electrode and a reference electrode for

171
00:06:54,589 --> 00:06:51,839
simplicity I've left them off we can use

172
00:06:56,449 --> 00:06:54,599
potential stats to poises potential we

173
00:07:00,489 --> 00:06:56,459
can wire it so that we let the chemicals

174
00:07:03,139 --> 00:07:00,499
do the work and so on and so forth but

175
00:07:05,059 --> 00:07:03,149
again in the interest of simplicity I

176
00:07:06,169 --> 00:07:05,069
wanted to show you is that we can

177
00:07:07,789 --> 00:07:06,179
irrigate this high-pressure

178
00:07:10,159 --> 00:07:07,799
high-temperature vessel with hot and

179
00:07:13,069 --> 00:07:10,169
offset vent fluid into an overlying cold

180
00:07:14,600 --> 00:07:13,079
oxic water column it's a little picture

181
00:07:16,579 --> 00:07:14,610
of some of our of our artificial

182
00:07:19,069 --> 00:07:16,589
hydrothermal vents and what we did is we

183
00:07:20,869 --> 00:07:19,079
then took these and we did a series of

184
00:07:23,359 --> 00:07:20,879
experiments this is work done by Amy

185
00:07:24,979 --> 00:07:23,369
Garvin who is now at the USGS anode

186
00:07:25,759 --> 00:07:24,989
Picard who's at the University of Nevada

187
00:07:28,219 --> 00:07:25,769
in Las Vegas

188
00:07:30,139 --> 00:07:28,229

did a series of experiments in which we

189
00:07:31,879 --> 00:07:30,149
set these up at different temperatures

190
00:07:32,659 --> 00:07:31,889
different potentials and so on and so

191
00:07:35,209 --> 00:07:32,669
forth

192
00:07:38,989 --> 00:07:35,219
we then inoculated them with a modest

193
00:07:41,419 --> 00:07:38,999
amount of material from East Pacific

194
00:07:43,009 --> 00:07:41,429
Rise hydrothermal vents now remember

195
00:07:44,959 --> 00:07:43,019
you're irrigating with vent fluid that's

196
00:07:47,119 --> 00:07:44,969
enriched in hydrogen sulfide and so on

197
00:07:49,159 --> 00:07:47,129
and so forth and into an overlying oxide

198
00:07:51,199 --> 00:07:49,169
water column and we started to look at

199
00:07:54,109 --> 00:07:51,209
mineral deposit mineral deposition on

200
00:07:56,600 --> 00:07:54,119
the electrode we measured changes in

201
00:07:59,509 --> 00:07:56,610
geochemistry both the volatile and

202
00:08:03,049 --> 00:07:59,519
dissolved and solid phase and and looked

203
00:08:06,259 --> 00:08:03,059
at changes in the microbial ecology on

204
00:08:08,359 --> 00:08:06,269
those deposits who was growing at what

205
00:08:10,519 --> 00:08:08,369
point in time and so on so I'm gonna

206
00:08:12,229 --> 00:08:10,529
give you some highlights here we set

207
00:08:14,029 --> 00:08:12,239
these systems up so they're to an extent

208
00:08:16,219 --> 00:08:14,039
they mimic the kind of tidal pumping we

209
00:08:18,319 --> 00:08:16,229
see at hydrothermal vents which isn't

210
00:08:20,089 --> 00:08:18,329
technically quite you know title but the

211
00:08:22,249 --> 00:08:20,099
point is you see oscillations in the

212
00:08:24,799 --> 00:08:22,259
influx of sulfinic water and so on and

213
00:08:29,989 --> 00:08:24,809

what's interesting is by measuring the

214
00:08:32,749 --> 00:08:29,999
current density on our on our electrodes

215
00:08:34,939 --> 00:08:32,759
you begin to see that when we have a

216
00:08:38,299 --> 00:08:34,949
system in which we used our kill control

217
00:08:40,369 --> 00:08:38,309
right we gamma-irradiated the the

218
00:08:43,399 --> 00:08:40,379
sulfide deposits before we inoculated

219
00:08:45,139 --> 00:08:43,409
them you end up with peaks as soon as

220
00:08:46,879 --> 00:08:45,149
you introduce the sulfide this is a

221
00:08:49,009 --> 00:08:46,889
biotic sulfide oxidation on the

222
00:08:51,650 --> 00:08:49,019
electrode where the sulfide is actually

223
00:08:52,520 --> 00:08:51,660
oxidized to Amorphis sulfur and then you

224
00:08:54,170 --> 00:08:52,530
get a sort of

225
00:08:56,780 --> 00:08:54,180
a typical kind of cat rally and decay

226
00:08:59,450 --> 00:08:56,790
and reach a sort of baseline here a very

227
00:09:01,100 --> 00:08:59,460
low current in an abiotic system when

228
00:09:03,140 --> 00:09:01,110
you look at the black lines what you see

229
00:09:06,020 --> 00:09:03,150
is that with every sulfide intrusion

230
00:09:07,520 --> 00:09:06,030
into the reactor you you reach a steady

231
00:09:09,380 --> 00:09:07,530
state where you have a modest bit of

232
00:09:11,780 --> 00:09:09,390
current production and that continues to

233
00:09:14,240 --> 00:09:11,790
increase over the course of the

234
00:09:18,530 --> 00:09:14,250
incubation which we took out to about 50

235
00:09:20,030 --> 00:09:18,540
days this is indicative of biological

236
00:09:21,560 --> 00:09:20,040
growth on the electrode and we've seen

237
00:09:23,210 --> 00:09:21,570
this time and again not only at

238
00:09:26,480 --> 00:09:23,220

hydrothermal vents but it seeps and

239
00:09:27,920 --> 00:09:26,490
elsewhere what was really cool right

240
00:09:30,530 --> 00:09:27,930
just to kind of get to the punchline

241
00:09:32,390 --> 00:09:30,540
here is that we see striking differences

242
00:09:35,270 --> 00:09:32,400
in the rate and extent of mineralization

243
00:09:36,830 --> 00:09:35,280
and reactors with live microbes that is

244
00:09:38,810 --> 00:09:36,840
to say when you look at the deposition

245
00:09:41,540 --> 00:09:38,820
on an electrode in a reactor with

246
00:09:45,020 --> 00:09:41,550
gamma-irradiated sample versus that with

247
00:09:47,720 --> 00:09:45,030
a sample with the the live microbes from

248
00:09:49,670 --> 00:09:47,730
the EPR you see really striking

249
00:09:52,370 --> 00:09:49,680
differences in metal sulphide deposition

250
00:09:55,130 --> 00:09:52,380
primarily Makenna white and that you

251
00:09:57,620 --> 00:09:55,140
don't see on the irradiated sample we do

252
00:09:59,810 --> 00:09:57,630
recover a few adsorbed microbes these

253
00:10:03,620 --> 00:09:59,820
may in fact also be alive right I mean

254
00:10:05,660 --> 00:10:03,630
gamma radiation works pretty well but we

255
00:10:07,580 --> 00:10:05,670
do see a few bugs here and here you see

256
00:10:11,540 --> 00:10:07,590
this really extensive network of

257
00:10:13,460 --> 00:10:11,550
microbes interlaced with the poly

258
00:10:15,380 --> 00:10:13,470
metallic sulfides and anhydride and so

259
00:10:19,220 --> 00:10:15,390
on and about 10 to the fifth cells per

260
00:10:20,900 --> 00:10:19,230
centimeter squared these nascent

261
00:10:22,490 --> 00:10:20,910
precipitates as we start to look at this

262
00:10:24,470 --> 00:10:22,500
over time we start to see some of the

263
00:10:28,070 --> 00:10:24,480

first colonizers being sulfate reducing

264
00:10:30,920 --> 00:10:28,080
bacteria to sulfa mona dis also some

265
00:10:33,050 --> 00:10:30,930
rather which is a known electro active

266
00:10:35,840 --> 00:10:33,060
sulfate reducer as well as de Ferro

267
00:10:37,329 --> 00:10:35,850
bacter same thing and known electro

268
00:10:40,010 --> 00:10:37,339
active sulfate reducer

269
00:10:42,500 --> 00:10:40,020
are finding themselves associating with

270
00:10:44,540 --> 00:10:42,510
our electrodes we saw increases in

271
00:10:46,490 --> 00:10:44,550
diversity over time and ultimately you

272
00:10:48,440 --> 00:10:46,500
get the kind of organisms we typically

273
00:10:50,420 --> 00:10:48,450
see their sulfate reducers sulfide

274
00:10:54,079 --> 00:10:50,430
oxidized their sulphur oxidizers and

275
00:10:55,670 --> 00:10:54,089
even methanogens so we're really

276
00:10:57,760 --> 00:10:55,680
starting to think about the deposition

277
00:11:01,610 --> 00:10:57,770
events now as being a kind of a

278
00:11:03,020 --> 00:11:01,620
microbial mineral amalgamation this is

279
00:11:04,500 --> 00:11:03,030
sort of our current model for how

280
00:11:06,660 --> 00:11:04,510
chimneys grow and that

281
00:11:09,540 --> 00:11:06,670
venting fluids begin but depth by

282
00:11:12,510 --> 00:11:09,550
depositing anhydride and then to an

283
00:11:15,930 --> 00:11:12,520
extent iron oxides and this sort of

284
00:11:17,550 --> 00:11:15,940
forms a geochemical setting for the

285
00:11:20,580 --> 00:11:17,560
colonization by sulfate reducing

286
00:11:22,950 --> 00:11:20,590
bacteria and some iron reducers as well

287
00:11:24,810 --> 00:11:22,960
and you begin to get their growth on the

288
00:11:27,930 --> 00:11:24,820

surface and then you start to see that

289
00:11:30,630 --> 00:11:27,940
the enhanced production of iron ii and

290
00:11:33,240 --> 00:11:30,640
sulfides and so on and so you find that

291
00:11:35,760 --> 00:11:33,250
the microbes are really playing some

292
00:11:37,950 --> 00:11:35,770
role probably far more complicated than

293
00:11:39,840 --> 00:11:37,960
what I've shown you here in promoting

294
00:11:42,300 --> 00:11:39,850
the deposition of these poly metallic

295
00:11:44,190 --> 00:11:42,310
sulfides some of it may be specific and

296
00:11:46,610 --> 00:11:44,200
I'll show you a one interesting example

297
00:11:49,470 --> 00:11:46,620
of that some of it may be nonspecific

298
00:11:51,660 --> 00:11:49,480
simply through the production of biomass

299
00:11:55,650 --> 00:11:51,670
or EXO polysaccharides that may just

300
00:11:59,070 --> 00:11:55,660
facilitate this up this amalgamation one

301
00:12:00,630 --> 00:11:59,080
cool bit of work came out came out of

302
00:12:03,450 --> 00:12:00,640
ODEs work where she was studying some of

303
00:12:05,190 --> 00:12:03,460
these sulfate-reducing bacteria I was

304
00:12:08,250 --> 00:12:05,200
really interested in understanding the

305
00:12:10,320 --> 00:12:08,260
role they play in iron sulphide

306
00:12:14,210 --> 00:12:10,330
production and this is a cool example of

307
00:12:17,190 --> 00:12:14,220
a sulfate reducer sulfa Vibrio whose

308
00:12:18,870 --> 00:12:17,200
cells end up acting as points of

309
00:12:21,660 --> 00:12:18,880
nucleation and this is really cool

310
00:12:24,330 --> 00:12:21,670
because we were able to show that we end

311
00:12:26,430 --> 00:12:24,340
up with iron sulphides forming on the

312
00:12:28,350 --> 00:12:26,440
outside of these individual cells and in

313
00:12:29,940 --> 00:12:28,360

fact it's McKenna white this is a

314
00:12:32,250 --> 00:12:29,950
slightly different crystal structure

315
00:12:33,780 --> 00:12:32,260
than pyrite both are sort of

316
00:12:35,940 --> 00:12:33,790
thermodynamically favored under these

317
00:12:37,830 --> 00:12:35,950
conditions but McKenna white is more

318
00:12:41,250 --> 00:12:37,840
kinetically favored and we end up with

319
00:12:44,070 --> 00:12:41,260
pyrite production thanks to ripening

320
00:12:45,630 --> 00:12:44,080
over time but what's really cool about

321
00:12:48,300 --> 00:12:45,640
this is to also think about the

322
00:12:51,500 --> 00:12:48,310
implications for the microbes iron

323
00:12:54,150 --> 00:12:51,510
sulphides act as great sites for the

324
00:12:56,040 --> 00:12:54,160
especially in the presence of iron for

325
00:12:58,530 --> 00:12:56,050
the production of iron sulphides this

326
00:13:02,130 --> 00:12:58,540
pulls down the apparent sulfide

327
00:13:04,200 --> 00:13:02,140
concentration around the cell thus

328
00:13:06,030 --> 00:13:04,210
reducing any potential back pressure of

329
00:13:08,130 --> 00:13:06,040
sulfide buildup in and around the cell

330
00:13:09,840 --> 00:13:08,140
right so this is um the extent to which

331
00:13:11,460 --> 00:13:09,850
that matters to sulfate reduction we

332
00:13:13,650 --> 00:13:11,470
don't know yet but we're really working

333
00:13:15,720 --> 00:13:13,660
on understanding you know does this

334
00:13:17,210 --> 00:13:15,730
deposition of iron sulphides actually

335
00:13:19,670 --> 00:13:17,220
mean something for the

336
00:13:23,080 --> 00:13:19,680
the energetics and the favorability of

337
00:13:24,950 --> 00:13:23,090
sulfate reduction by these organisms so

338
00:13:26,660 --> 00:13:24,960

when we think about these bio

339
00:13:28,730 --> 00:13:26,670
electrochemical processes and you think

340
00:13:30,740 --> 00:13:28,740
about eet as Laurie mentioned before

341
00:13:32,810 --> 00:13:30,750
right this really helps these kind

342
00:13:34,850 --> 00:13:32,820
so-called endo lithic microbes access

343
00:13:37,310 --> 00:13:34,860
remote oxidants and this should also say

344
00:13:39,320 --> 00:13:37,320
reductants and it could be an

345
00:13:42,050 --> 00:13:39,330
evolutionary solution to living in what

346
00:13:44,960 --> 00:13:42,060
is a stratified world in the interest of

347
00:13:46,790 --> 00:13:44,970
time I'll not wax sort of poetic about

348
00:13:48,580 --> 00:13:46,800
stratification but that is in fact the

349
00:13:51,860 --> 00:13:48,590
state of our world that it's not just

350
00:13:54,370 --> 00:13:51,870
you know homogeneous and so have this

351
00:13:56,570 --> 00:13:54,380
capacity of extending your physiological

352
00:13:58,730 --> 00:13:56,580
influence to beyond your cellular

353
00:14:01,820 --> 00:13:58,740
envelope you could imagine being

354
00:14:04,250 --> 00:14:01,830
strongly selected for EEG also

355
00:14:06,530 --> 00:14:04,260
influences proximal and distal chemistry

356
00:14:08,330 --> 00:14:06,540
one of the coolest things about in my

357
00:14:11,210 --> 00:14:08,340
opinion about this phenomenon is when

358
00:14:12,860 --> 00:14:11,220
you look at organisms that are using

359
00:14:14,360 --> 00:14:12,870
extracellular electron transfer they're

360
00:14:16,610 --> 00:14:14,370
actually changing they're kind of

361
00:14:19,370 --> 00:14:16,620
partitioning alkalinity in a way that

362
00:14:21,320 --> 00:14:19,380
eventually reaches a steady state but it

363
00:14:24,260 --> 00:14:21,330

is it is at least over short time

364
00:14:26,840 --> 00:14:24,270
domains influencing chemistry locally

365
00:14:29,450 --> 00:14:26,850
and distally in differentially speaking

366
00:14:31,450 --> 00:14:29,460
and it my opinion reshapes our notion of

367
00:14:33,680 --> 00:14:31,460
how we think about anaerobic metabolism

368
00:14:35,810 --> 00:14:33,690
some of the organisms they live in

369
00:14:37,910 --> 00:14:35,820
anaerobic sediments but in fact they are

370
00:14:41,000 --> 00:14:37,920
benefiting from access to oxidants that

371
00:14:43,340 --> 00:14:41,010
are that are at least on their spatial

372
00:14:44,960 --> 00:14:43,350
scales rather distant and so I'll just

373
00:14:46,700 --> 00:14:44,970
wrap it up by reminding us that all

374
00:14:49,790 --> 00:14:46,710
living organisms are by electrochemical

375
00:14:52,180 --> 00:14:49,800
machines that we use chemiosmosis right

376
00:14:55,040 --> 00:14:52,190
to establish charge gradients to do work

377
00:14:57,230 --> 00:14:55,050
EEG microbes have biological features

378
00:14:59,150 --> 00:14:57,240
outer membrane cytochromes and so on

379
00:15:01,880 --> 00:14:59,160
even the production of redox active

380
00:15:03,829 --> 00:15:01,890
small molecules that can be electro

381
00:15:06,860 --> 00:15:03,839
chemically interrogated and to a degree

382
00:15:09,230 --> 00:15:06,870
easily identified right this is a plot

383
00:15:12,530 --> 00:15:09,240
from some work we've done with our Peter

384
00:15:15,440 --> 00:15:12,540
Bose on photo Ferro trophic microbes in

385
00:15:17,930 --> 00:15:15,450
which we can use cyclic voltammetry to

386
00:15:19,730 --> 00:15:17,940
show the mid-point potential of some of

387
00:15:21,770 --> 00:15:19,740
the redox active compounds on their cell

388
00:15:24,800 --> 00:15:21,780

surface that they use but other living

389
00:15:27,020 --> 00:15:24,810
organisms even if they don't do eet are

390
00:15:29,820 --> 00:15:27,030
replete with redox active molecules and

391
00:15:33,200 --> 00:15:29,830
this is sort of in kind of a new area of

392
00:15:36,030 --> 00:15:33,210
of study for us and for others but all

393
00:15:37,440 --> 00:15:36,040
living organisms are susceptible to sort

394
00:15:40,590 --> 00:15:37,450
of let's call it electrochemical

395
00:15:42,090 --> 00:15:40,600
interrogation or detection how you know

396
00:15:43,710 --> 00:15:42,100
how much resolution we have are the

397
00:15:46,410 --> 00:15:43,720
specificity that all remains to be

398
00:15:48,000 --> 00:15:46,420
determined but the punchline here is

399
00:15:50,160 --> 00:15:48,010
that these kinds of electric chemical

400
00:15:51,960 --> 00:15:50,170
studies underscore this inextricable

401
00:15:54,170 --> 00:15:51,970
relationship between biological

402
00:15:57,210 --> 00:15:54,180
processes is there a biotic environment

403
00:16:00,180 --> 00:15:57,220
especially in our electrically

404
00:16:02,400 --> 00:16:00,190
conductive world whoops I did not mean

405
00:16:03,810 --> 00:16:02,410
to hit that button but um I'll end there

406
00:16:21,770 --> 00:16:03,820
I want to thank you for your time and

407
00:16:27,710 --> 00:16:24,930
provides the physical initial physical

408
00:16:30,270 --> 00:16:27,720
barrier but if they if the electrical

409
00:16:33,750 --> 00:16:30,280
current itself is detectable how far

410
00:16:35,580 --> 00:16:33,760
away from the vent is that measurable do

411
00:16:38,700 --> 00:16:35,590
these communities extend out in other

412
00:16:41,280 --> 00:16:38,710
words I'm running in general how far

413
00:16:45,510 --> 00:16:41,290

these metabolisms might build from the

414
00:16:47,850 --> 00:16:45,520
vent out and occupied the the sediments

415
00:16:49,410 --> 00:16:47,860
on the seafloor yeah that's a great

416
00:16:51,540 --> 00:16:49,420
question so so your question you're

417
00:16:55,890 --> 00:16:51,550
asking how far out can you go from a

418
00:16:57,840 --> 00:16:55,900
vent and and still sort of use this

419
00:17:00,240 --> 00:16:57,850
metabolic capacity to capitalize all

420
00:17:01,650 --> 00:17:00,250
this so that lets in the interest of

421
00:17:03,990 --> 00:17:01,660
time I'll say that the answer the

422
00:17:05,910 --> 00:17:04,000
question is really a function of the

423
00:17:10,020 --> 00:17:05,920
scale at which we're talking so for now

424
00:17:14,180 --> 00:17:10,030
I'm going to focus on the sort of

425
00:17:16,590 --> 00:17:14,190
microbial scale so this starts to become

426
00:17:18,720 --> 00:17:16,600
problematic when you move beyond the

427
00:17:20,160 --> 00:17:18,730
centimeter scale this to sort of in

428
00:17:22,949 --> 00:17:20,170
other words I don't think you should be

429
00:17:26,100 --> 00:17:22,959
imagining microorganisms a kilometer

430
00:17:28,020 --> 00:17:26,110
away being directly electrically sort of

431
00:17:30,180 --> 00:17:28,030
connected if you will to offend I think

432
00:17:34,200 --> 00:17:30,190
that's improbable and a lot of it really

433
00:17:36,000 --> 00:17:34,210
has to do with you know reasons if that

434
00:17:38,010 --> 00:17:36,010
resistivity even in a wonderfully

435
00:17:39,760 --> 00:17:38,020
conductive solution like sea water so

436
00:17:42,670 --> 00:17:39,770
this is really relevant over this

437
00:17:44,650 --> 00:17:42,680
I think centimeters maybe we're pushing

438
00:17:47,110 --> 00:17:44,660

you know tens of centimeters or a little

439
00:17:48,520 --> 00:17:47,120
bit more although I think what things

440
00:17:50,680 --> 00:17:48,530
that's important to think about is that

441
00:17:53,250 --> 00:17:50,690
this is also relevant in sediments

442
00:17:56,230 --> 00:17:53,260
because sediments themselves are

443
00:17:58,660 --> 00:17:56,240
conductive to varying degrees due to

444
00:18:00,340 --> 00:17:58,670
humans and other compounds and so in

445
00:18:02,530 --> 00:18:00,350
sediments we also see the same

446
00:18:03,760 --> 00:18:02,540
phenomenon so I don't want to leave you

447
00:18:06,480 --> 00:18:03,770
with the impression that this is only

448
00:18:08,980 --> 00:18:06,490
relevant in vent systems where you have

449
00:18:10,810 --> 00:18:08,990
semiconductive poly metallic sulfides or

450
00:18:13,300 --> 00:18:10,820
conductive polymetallic sulfides it

451
00:18:16,570 --> 00:18:13,310
matters wherever you have redox

452
00:18:18,220 --> 00:18:16,580
gradients and should it be that your

453
00:18:21,610 --> 00:18:18,230
environment is sufficiently conductive

454
00:18:23,560 --> 00:18:21,620
to support this kind of connection they

455
00:18:25,450 --> 00:18:23,570
exist and I'll end by saying it isn't

456
00:18:27,640 --> 00:18:25,460
just a microbe producing nanowires

457
00:18:31,120 --> 00:18:27,650
bear in mind that when you look at the

458
00:18:33,580 --> 00:18:31,130
potential in a sediment that the

459
00:18:35,650 --> 00:18:33,590
realized potential at any point in there

460
00:18:37,480 --> 00:18:35,660
is a function of these sort of pseudo

461
00:18:39,520 --> 00:18:37,490
oxidations that can happen so in other

462
00:18:42,160 --> 00:18:39,530
words oxygen in the overlying water

463
00:18:46,270 --> 00:18:42,170

column actually influences the realized

464
00:18:48,370 --> 00:18:46,280
potential at a point in space but

465
00:18:50,890 --> 00:18:48,380
through this conductive nature of the

466
00:18:52,030 --> 00:18:50,900
the sediment or components in it I don't

467
00:18:54,040 --> 00:18:52,040
know if that exactly answers your

468
00:18:56,200 --> 00:18:54,050
question but I hope that helps okay

469
00:18:58,060 --> 00:18:56,210
Thank You Pete we don't have time for

470
00:18:59,630 --> 00:18:58,070
any more questions for Pete but catch up