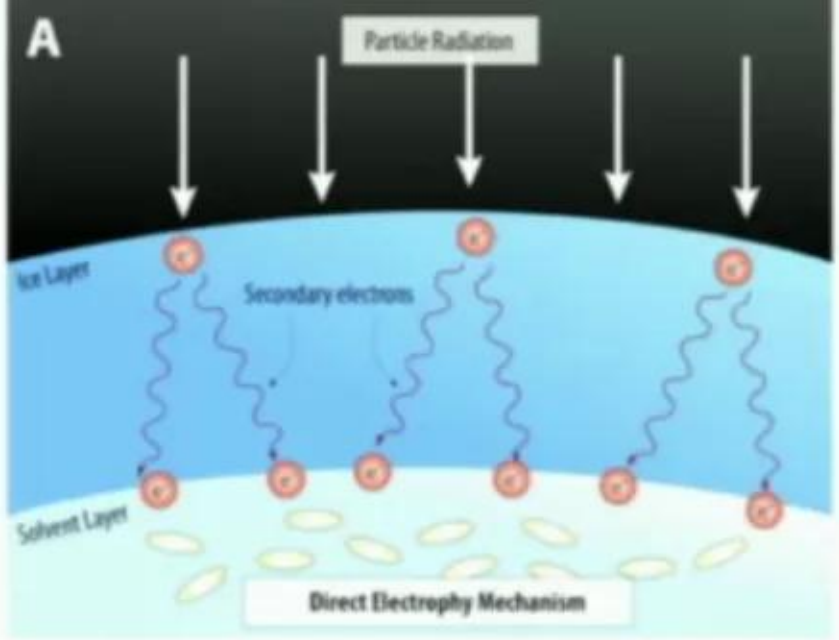
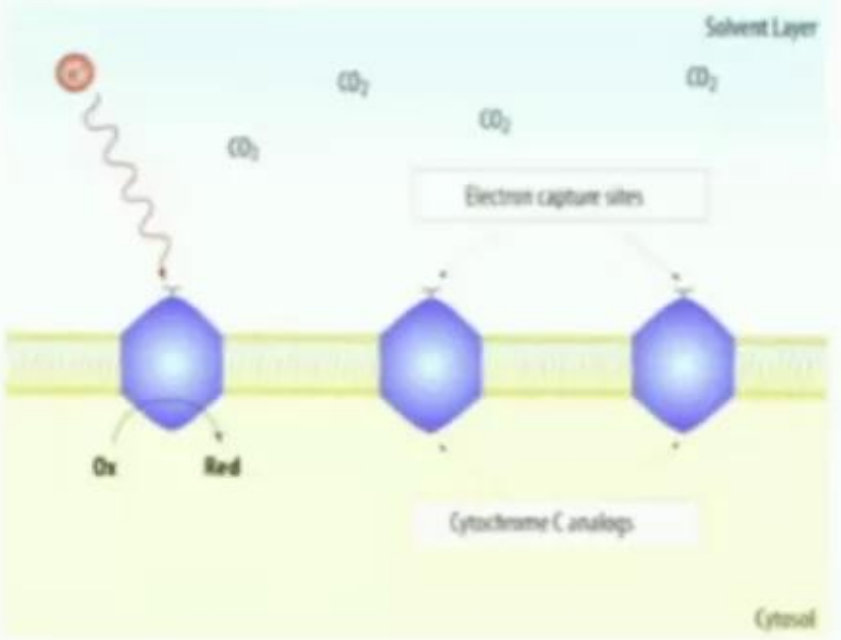
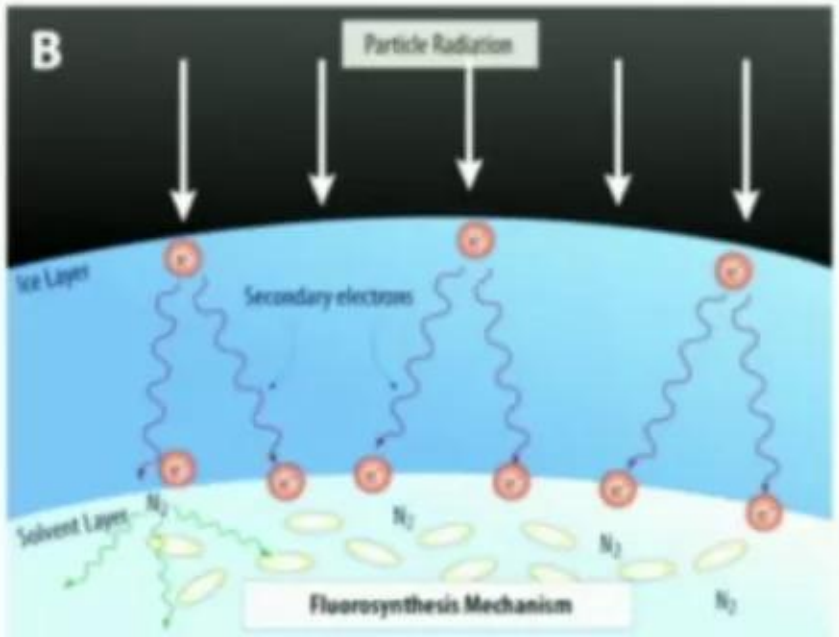
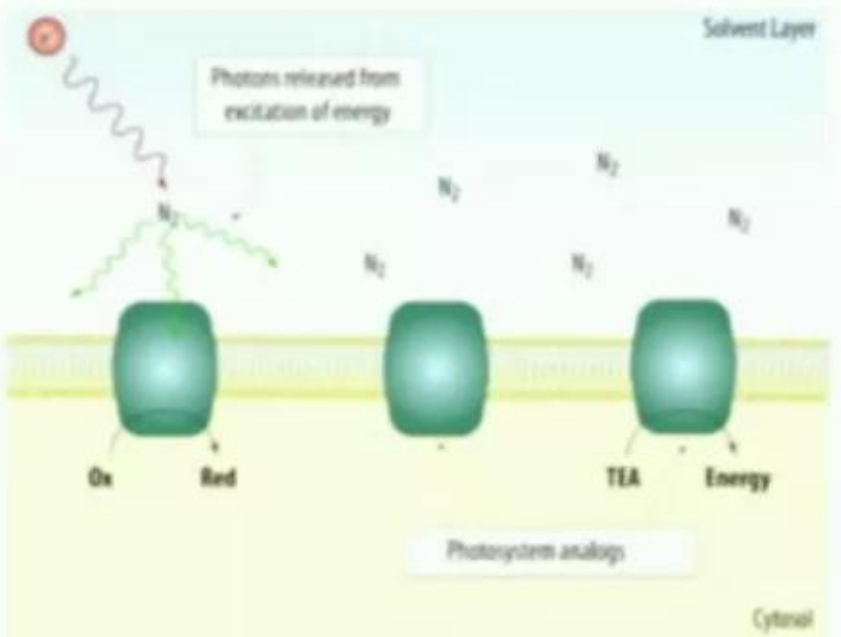

A
Particle Radiation
Ice Layer
Secondary electrons
Solvent Layer
Direct Electrophy Mechanism


Solvent Layer
CO_2
CO_2
CO_2
CO_2
Electron capture sites
Ox
Red
Cytochrome C analogs
Cytosol


B
Particle Radiation
Ice Layer
Secondary electrons
Solvent Layer
N_2
N_2
N_2
N_2
Fluorosynthesis Mechanism


Solvent Layer
Photons released from excitation of energy
N_2
N_2
N_2
N_2
N_2
N_2
Ox
Red
TEA
Energy
Photosystem analogs
Cytosol

1
00:00:07,970 --> 00:00:05,740
[Music]

2
00:00:10,520 --> 00:00:07,980
thank you very much for the introduction

3
00:00:13,190 --> 00:00:10,530
and so what I'm presenting today

4
00:00:15,350 --> 00:00:13,200
actually isn't a research that we've

5
00:00:18,800 --> 00:00:15,360
done it's a hypothesis that we put forth

6
00:00:22,310 --> 00:00:18,810
while we were at a summer astrobiology

7
00:00:25,400 --> 00:00:22,320
school so what is astrobiology summer

8
00:00:27,859 --> 00:00:25,410
school so you might have received emails

9
00:00:30,410 --> 00:00:27,869
if you're on the NASA Astrobiology

10
00:00:32,330 --> 00:00:30,420
Institute newsletter about this

11
00:00:35,750 --> 00:00:32,340
basically it's held every year in

12
00:00:39,350 --> 00:00:35,760
Santander Spain and you get three days

13
00:00:41,720 --> 00:00:39,360

of astrobiology lectures and then a

14
00:00:44,060 --> 00:00:41,730
fourth day and we go out to an excursion

15
00:00:46,040 --> 00:00:44,070
to an astrobiology related site but we

16
00:00:48,770 --> 00:00:46,050
also have these projects that we work on

17
00:00:50,930 --> 00:00:48,780
throughout the week and then our project

18
00:00:51,889 --> 00:00:50,940
eventually kind of progressed to

19
00:00:53,810 --> 00:00:51,899
something a little bit more that we

20
00:00:55,840 --> 00:00:53,820
continued working on after the

21
00:00:59,029 --> 00:00:55,850
astrobiology summary school and then

22
00:01:01,479 --> 00:00:59,039
something cool about astrobiology summer

23
00:01:04,759 --> 00:01:01,489
schools outside of learning things about

24
00:01:07,789 --> 00:01:04,769
astrobiology you make awesome friends as

25
00:01:10,490 --> 00:01:07,799
shown here and these three guys helped

26
00:01:16,070 --> 00:01:10,500
me escape Spain I was a little bit stuck

27
00:01:21,910 --> 00:01:16,080
and a Peterloo Divya helped me catch a

28
00:01:25,780 --> 00:01:21,920
train back to the airport in Madrid but

29
00:01:29,120 --> 00:01:25,790
what was the basic idea here during our

30
00:01:31,760 --> 00:01:29,130
astrobiology summary school so it

31
00:01:35,600 --> 00:01:31,770
focused if you could simplify everything

32
00:01:38,920 --> 00:01:35,610
here we basically discussed what life

33
00:01:41,960 --> 00:01:38,930
neat what life actually needed and

34
00:01:44,749 --> 00:01:41,970
simple components so first thing is a

35
00:01:46,910 --> 00:01:44,759
liquid solvent so most people think of

36
00:01:50,120 --> 00:01:46,920
water but it doesn't necessarily have to

37
00:01:52,580 --> 00:01:50,130
be water according to some people so a

38
00:01:55,600 --> 00:01:52,590

source of nutrients and then of course

39
00:01:57,859 --> 00:01:55,610
energy don't have energy iron

40
00:02:00,999 --> 00:01:57,869
thermodynamic equilibrium just like

41
00:02:04,240 --> 00:02:01,009
nessie here entered back in Memorial Day

42
00:02:11,270 --> 00:02:04,250
so it definitely is a source of energy

43
00:02:12,510 --> 00:02:11,280
to power life and then our group was the

44
00:02:15,530 --> 00:02:12,520
energy group and

45
00:02:20,580 --> 00:02:15,540
so we discussed about how life might

46
00:02:24,120 --> 00:02:20,590
utilize beta decay or a protocol

47
00:02:27,570 --> 00:02:24,130
radiation of the planet planetary

48
00:02:29,130 --> 00:02:27,580
magnetospheres and one of our advisors

49
00:02:30,690 --> 00:02:29,140
came up to us and she's like hey you

50
00:02:33,060 --> 00:02:30,700
guys should write a hypothesis paper

51
00:02:35,190 --> 00:02:33,070
about this and so what's a hypothesis

52
00:02:36,360 --> 00:02:35,200
paper well it's exactly what it sounds

53
00:02:38,640 --> 00:02:36,370
like and I'm just going to go through

54
00:02:40,070 --> 00:02:38,650
some examples of what other people have

55
00:02:45,120 --> 00:02:40,080
done so

56
00:02:49,350 --> 00:02:45,130
Raynald at all in 1983 their hypothesis

57
00:02:51,570 --> 00:02:49,360
was that life might utilize the planet

58
00:02:54,990 --> 00:02:51,580
planetary magnetospheres Jupiter as a

59
00:02:57,810 --> 00:02:55,000
source of life basically having the

60
00:03:01,140 --> 00:02:57,820
particle radiation hit the surface of

61
00:03:05,130 --> 00:03:01,150
the ice on one side and having that

62
00:03:08,430 --> 00:03:05,140
current go go down through subsurface

63
00:03:11,220 --> 00:03:08,440

ocean forming hydrogen and oxygen

64
00:03:13,590 --> 00:03:11,230
basically splitting water apart that

65
00:03:16,920 --> 00:03:13,600
that would then be able to power life

66
00:03:20,430 --> 00:03:16,930
and then Hitler and Phillips and 2001

67
00:03:23,280 --> 00:03:20,440
also using our particle radiation at

68
00:03:26,699 --> 00:03:23,290
this time talking about how organics

69
00:03:29,100 --> 00:03:26,709
might form on the surface of Europa and

70
00:03:30,920 --> 00:03:29,110
then that getting cycled into the

71
00:03:34,920 --> 00:03:30,930
subsurface ocean that can then be

72
00:03:38,910 --> 00:03:34,930
utilized by life more recently a John

73
00:03:40,949 --> 00:03:38,920
Johnson at all in 2014 discussed out of

74
00:03:45,680 --> 00:03:40,959
the workman Reynolds effect basically

75
00:03:50,210 --> 00:03:45,690
what that is is when ice freezes it

76
00:03:52,710 --> 00:03:50,220
freezes in some cations or anions

77
00:03:57,810 --> 00:03:52,720
preferentially depending on the

78
00:03:59,250 --> 00:03:57,820
conditions so you can form a voltage

79
00:04:01,440 --> 00:03:59,260
there that where you can also split

80
00:04:06,750 --> 00:04:01,450
water and form hydrogen and oxygen and

81
00:04:08,699 --> 00:04:06,760
then recently here actually in 2015

82
00:04:12,180 --> 00:04:08,709
discussed how you can use a particle

83
00:04:15,510 --> 00:04:12,190
radiation on Mars basically forming a

84
00:04:18,140 --> 00:04:15,520
secondary particles I can then go down

85
00:04:23,330 --> 00:04:18,150
to the surface

86
00:04:27,710 --> 00:04:23,340
and help power subsurface microbes on

87
00:04:31,909 --> 00:04:27,720
Mars so our hypothesis paper kind of

88
00:04:35,980 --> 00:04:31,919

adult with the idea of organisms using a

89
00:04:37,999 --> 00:04:35,990
current directly so this isn't a

90
00:04:39,950 --> 00:04:38,009
completely crazy concept because

91
00:04:43,790 --> 00:04:39,960
terrestrial organisms go ahead and do

92
00:04:47,120 --> 00:04:43,800
that so we have shelwyn ella and geo

93
00:04:49,969 --> 00:04:47,130
vector as being the first couple

94
00:04:53,600 --> 00:04:49,979
organisms that can use an electric

95
00:04:56,330 --> 00:04:53,610
current directly from a cathode and then

96
00:04:58,909 --> 00:04:56,340
basically take oxidized products to

97
00:05:01,629 --> 00:04:58,919
create reduce products and then somatic

98
00:05:07,460 --> 00:05:01,639
and Frank's here is a good review paper

99
00:05:09,200 --> 00:05:07,470
on that topic and so with this

100
00:05:13,580 --> 00:05:09,210
hypothesis we kind of need a head

101
00:05:19,370 --> 00:05:13,590
everything that we needed to basically

102
00:05:22,820 --> 00:05:19,380
propose organisms using current on icy

103
00:05:25,040 --> 00:05:22,830
world so we do have a liquid solvent and

104
00:05:28,730 --> 00:05:25,050
some of them in the case of europa you

105
00:05:33,800 --> 00:05:28,740
know a kilometers down or within the

106
00:05:36,290 --> 00:05:33,810
surface just because you know it's so

107
00:05:38,420 --> 00:05:36,300
cold at a 150 Kelvin on water is

108
00:05:40,100 --> 00:05:38,430
definitely frozen on the surface here

109
00:05:42,680 --> 00:05:40,110
but if you're not utilizing water as a

110
00:05:45,290 --> 00:05:42,690
solvent that becomes less of an issue

111
00:05:47,689 --> 00:05:45,300
definitely have your source of nutrients

112
00:05:49,460 --> 00:05:47,699
on a number of icy worlds and then the

113
00:05:52,670 --> 00:05:49,470

source of energy that we were using was

114
00:05:55,820 --> 00:05:52,680
particle radiation but there's an issue

115
00:06:00,980 --> 00:05:55,830
with particle radiation because most of

116
00:06:03,129 --> 00:06:00,990
it is so energetic enough that it you

117
00:06:07,760 --> 00:06:03,139
know as mentioned ionizes everything and

118
00:06:12,339 --> 00:06:07,770
destroys molecules that you're using so

119
00:06:15,830 --> 00:06:12,349
what we proposed was that energy can be

120
00:06:18,200 --> 00:06:15,840
dissipated here by having the electrons

121
00:06:20,240 --> 00:06:18,210
come in and forming secondary electrons

122
00:06:23,899 --> 00:06:20,250
which would be lower in energy then

123
00:06:25,670 --> 00:06:23,909
eventually going so low in the energy of

124
00:06:28,210 --> 00:06:25,680
1 to 10 electron volts where you're no

125
00:06:31,630 --> 00:06:28,220
longer ionizing

126
00:06:35,370 --> 00:06:31,640
anything and so we propose the same

127
00:06:38,230 --> 00:06:35,380
thing as what trust really organisms do

128
00:06:42,760 --> 00:06:38,240
basically having a cytochrome C analog

129
00:06:47,260 --> 00:06:42,770
which is what geo vector uses to capture

130
00:06:52,120 --> 00:06:47,270
electrons having the electrons come in

131
00:06:55,210 --> 00:06:52,130
and reducing your compounds that way we

132
00:06:58,300 --> 00:06:55,220
also had a secondary hypothesis that we

133
00:07:00,940 --> 00:06:58,310
worked on if we called in direct electro

134
00:07:03,700 --> 00:07:00,950
fiol so we gave it another name floor

135
00:07:07,420 --> 00:07:03,710
synthesis and meaning will become clear

136
00:07:10,390 --> 00:07:07,430
in just a second here so with the

137
00:07:13,210 --> 00:07:10,400
particle radiation coming in and forming

138
00:07:16,570 --> 00:07:13,220

secondary electrons we also proposed

139
00:07:19,360 --> 00:07:16,580
that the electrons might cause another

140
00:07:22,750 --> 00:07:19,370
molecule to Flores or release photons

141
00:07:24,760 --> 00:07:22,760
and then that case you would just have a

142
00:07:27,240 --> 00:07:24,770
process directly analogous to a

143
00:07:31,710 --> 00:07:27,250
traditional photosynthesis with the

144
00:07:36,250 --> 00:07:31,720
organisms using the fluorescent photons

145
00:07:38,890 --> 00:07:36,260
to power life and so this is kind of a

146
00:07:41,620 --> 00:07:38,900
diagram of what happens here so you have

147
00:07:43,719 --> 00:07:41,630
an electron or another particle that

148
00:07:46,890 --> 00:07:43,729
comes in and there's a basically a

149
00:07:50,650 --> 00:07:46,900
cascade of electrons that comes through

150
00:07:53,380 --> 00:07:50,660
and then each lower in energy than that

151
00:07:54,880 --> 00:07:53,390
first initial one you've got most going

152
00:07:58,360 --> 00:07:54,890
further down into the eyes but you have

153
00:08:00,340 --> 00:07:58,370
some escaping but we needed a way to

154
00:08:02,710 --> 00:08:00,350
quantify the number of secondary

155
00:08:06,850 --> 00:08:02,720
electrons produced so we could come up

156
00:08:10,750 --> 00:08:06,860
with a current and determine how much

157
00:08:13,300 --> 00:08:10,760
biomass we could expect to form so we

158
00:08:16,300 --> 00:08:13,310
start off with this equation here with

159
00:08:21,610 --> 00:08:16,310
this little epsilon here basically being

160
00:08:25,000 --> 00:08:21,620
how much energy is being transferred to

161
00:08:27,490 --> 00:08:25,010
the ice with each secondary electron

162
00:08:29,770 --> 00:08:27,500
that's produced and this just describes

163
00:08:32,709 --> 00:08:29,780

how much energy is being lost here as

164
00:08:36,730 --> 00:08:32,719
the electrons going through the eyes so

165
00:08:40,540 --> 00:08:36,740
what are these two values this one comes

166
00:08:45,040 --> 00:08:40,550
out to about 25 electron volts

167
00:08:48,610 --> 00:08:45,050
and then here we can estimate this value

168
00:08:51,520 --> 00:08:48,620
here by using this equation this energy

169
00:08:56,530 --> 00:08:51,530
is the energy of this initial electron

170
00:09:00,280 --> 00:08:56,540
right here and then R is just this

171
00:09:04,320 --> 00:09:00,290
equation here with this just being the

172
00:09:07,990 --> 00:09:04,330
density and this also being the initial

173
00:09:11,560 --> 00:09:08,000
electron energy here so we can recombine

174
00:09:13,990 --> 00:09:11,570
these equations to get derive a number

175
00:09:14,680 --> 00:09:14,000
of the secondary electrons coming

176
00:09:18,850 --> 00:09:14,690
through here

177
00:09:22,600 --> 00:09:18,860
so we made some estimates are using this

178
00:09:24,550 --> 00:09:22,610
and so we already have here the

179
00:09:28,120 --> 00:09:24,560
secondary electron flux how we

180
00:09:30,520 --> 00:09:28,130
calculated that so I just started off by

181
00:09:33,250 --> 00:09:30,530
looking at okay let's say we have a

182
00:09:35,970 --> 00:09:33,260
hundred particles coming in looking at

183
00:09:38,800 --> 00:09:35,980
on both a water and nitrogen Isis both

184
00:09:41,460 --> 00:09:38,810
common in the outer solar system

185
00:09:45,340 --> 00:09:41,470
Europa being an example of a water ice

186
00:09:48,430 --> 00:09:45,350
Pluto and Triton Neptune's moon being

187
00:09:50,650 --> 00:09:48,440
examples of nitrogen Isis calculating

188
00:09:54,850 --> 00:09:50,660

the penetration death using a program

189
00:09:56,920 --> 00:09:54,860
called East R which is of usually

190
00:09:58,600 --> 00:09:56,930
available unless the government's going

191
00:10:03,820 --> 00:09:58,610
down through a shutdown like it was a

192
00:10:05,920 --> 00:10:03,830
couple years ago and are using this

193
00:10:09,760 --> 00:10:05,930
secondary electron flux and this

194
00:10:12,480 --> 00:10:09,770
penetration adept or we can come up with

195
00:10:16,150 --> 00:10:12,490
the number of electrons flowing through

196
00:10:18,910 --> 00:10:16,160
and we can convert this to a current

197
00:10:22,030 --> 00:10:18,920
using the definition of what an ampere

198
00:10:23,860 --> 00:10:22,040
is so it's six point two four one times

199
00:10:28,780 --> 00:10:23,870
ten eighteenth particle charged

200
00:10:31,000 --> 00:10:28,790
particles moving per second and then we

201
00:10:35,860 --> 00:10:31,010
had we had to come up with a conversion

202
00:10:38,650 --> 00:10:35,870
factor for converting the movement of

203
00:10:42,720 --> 00:10:38,660
electrons to our grams of biomass we did

204
00:10:46,450 --> 00:10:42,730
that by basically just looking at

205
00:10:49,030 --> 00:10:46,460
photosynthesis and treating it as a

206
00:10:51,069 --> 00:10:49,040
transfer of electrons that's essentially

207
00:10:54,160 --> 00:10:51,079
what life is after all just

208
00:10:59,920 --> 00:10:54,170
transfer of electrons that we just used

209
00:11:01,949 --> 00:10:59,930
the wavelengths of light converting it

210
00:11:03,850 --> 00:11:01,959
that to how many electrons were being

211
00:11:08,769 --> 00:11:03,860
transferred within the photosynthetic

212
00:11:12,009 --> 00:11:08,779
process and coming up with the biomass

213
00:11:17,639 --> 00:11:12,019

this way and then the estimated number

214
00:11:20,859 --> 00:11:17,649
of cells is just based off how much the

215
00:11:24,359 --> 00:11:20,869
based off the weight of an e coli so

216
00:11:28,840 --> 00:11:24,369
coming up with this conversion factor

217
00:11:31,059 --> 00:11:28,850
and then this is a letter shown here

218
00:11:35,460 --> 00:11:31,069
with a graph here so just starting off

219
00:11:37,419 --> 00:11:35,470
with how many particles we had and just

220
00:11:39,910 --> 00:11:37,429
starting off with our initial or

221
00:11:43,419 --> 00:11:39,920
radiation flux and just moving forward

222
00:11:46,689 --> 00:11:43,429
we can come up with an estimated biomass

223
00:11:49,449 --> 00:11:46,699
so definitely probably overshooting here

224
00:11:52,749 --> 00:11:49,459
if the average surface of Io density on

225
00:11:59,220 --> 00:11:52,759
earth is being exceeded by Europa and

226
00:12:04,419 --> 00:11:59,230
Ganymede but and so here are we showing

227
00:12:08,860 --> 00:12:04,429
the two different types of Isis but both

228
00:12:12,910 --> 00:12:08,870
pretty comparable here so we didn't

229
00:12:17,650 --> 00:12:12,920
account for of course nutrient sources

230
00:12:19,269 --> 00:12:17,660
or anything like that but I'm going to

231
00:12:22,030 --> 00:12:19,279
move on to the relevance of the

232
00:12:25,600 --> 00:12:22,040
calculations and just a little bit and

233
00:12:27,970 --> 00:12:25,610
then same thing here estimating the

234
00:12:30,400 --> 00:12:27,980
biomass from indirect Electrify so this

235
00:12:33,309 --> 00:12:30,410
again being what we also termed as

236
00:12:36,220 --> 00:12:33,319
florist synthesis so it turns out that

237
00:12:39,369 --> 00:12:36,230
ice fluoresce is when you irradiate it

238
00:12:43,689 --> 00:12:39,379

with electrons when the wave numbers

239
00:12:47,439 --> 00:12:43,699
that comes out is or photons that comes

240
00:12:50,949 --> 00:12:47,449
out is 306 it is that found at 306

241
00:12:53,590 --> 00:12:50,959
nanometers so there was already some

242
00:12:56,340 --> 00:12:53,600
work done with the photon yield was from

243
00:13:00,380 --> 00:12:56,350
that we also converted that to its

244
00:13:04,590 --> 00:13:00,390
energy value in electron volts and

245
00:13:08,310 --> 00:13:04,600
created an electron yield based off of

246
00:13:09,600 --> 00:13:08,320
that and then did same calculations here

247
00:13:11,880 --> 00:13:09,610
when just based off the amount of

248
00:13:15,030 --> 00:13:11,890
photons of being our producer just

249
00:13:22,550 --> 00:13:15,040
assuming that one of these photons would

250
00:13:25,170 --> 00:13:22,560
be equivalent to when terrestrial photon

251
00:13:27,650 --> 00:13:25,180
that's used sir that's used in

252
00:13:30,810 --> 00:13:27,660
terrestrial photosynthesis but also used

253
00:13:34,920 --> 00:13:30,820
one based off the energy flux from those

254
00:13:37,680 --> 00:13:34,930
photons are higher in energy being

255
00:13:39,210 --> 00:13:37,690
supplied with a little more but in terms

256
00:13:42,449 --> 00:13:39,220
of an order of magnitude doesn't really

257
00:13:45,690 --> 00:13:42,459
make much of a difference in terms of

258
00:13:49,160 --> 00:13:45,700
how much IU form so it shows the same

259
00:13:53,759 --> 00:13:49,170
thing here with the radiation flux I

260
00:13:57,030 --> 00:13:53,769
just going out here showing how much you

261
00:14:00,660 --> 00:13:57,040
would expect in terms of biomass and

262
00:14:03,180 --> 00:14:00,670
again lower than the average surface

263
00:14:05,939 --> 00:14:03,190

biomass density on earth but still

264
00:14:09,060 --> 00:14:05,949
fairly high here again not accounting

265
00:14:09,769 --> 00:14:09,070
for on your nutrients or anything like

266
00:14:12,210 --> 00:14:09,779
that

267
00:14:17,340 --> 00:14:12,220
so these estimates are definitely high

268
00:14:19,650 --> 00:14:17,350
so how reliable are these so one of the

269
00:14:21,720 --> 00:14:19,660
things that we first things that we did

270
00:14:25,310 --> 00:14:21,730
in Spain was we were actually looking at

271
00:14:29,310 --> 00:14:25,320
beta decay first and with beta decay

272
00:14:32,790 --> 00:14:29,320
when we applied these same calculations

273
00:14:35,519 --> 00:14:32,800
here didn't really get substantial

274
00:14:38,730 --> 00:14:35,529
amounts of biomass that were able to be

275
00:14:40,889 --> 00:14:38,740
supported until we looked at these guys

276
00:14:45,090 --> 00:14:40,899
here and these are waste products from

277
00:14:48,269 --> 00:14:45,100
on nuclear reactors and so we also see

278
00:14:50,790 --> 00:14:48,279
high biomass estimates based off those

279
00:14:56,850 --> 00:14:50,800
and it's interesting because just

280
00:14:59,130 --> 00:14:56,860
recently and they found a fun guy in a

281
00:15:05,100 --> 00:14:59,140
Chernobyl Ukraine that are able to

282
00:15:07,800 --> 00:15:05,110
utilize a radiation coming off from

283
00:15:10,290 --> 00:15:07,810
there the exact mechanism is still

284
00:15:12,600 --> 00:15:10,300
unknown but even though these

285
00:15:16,220 --> 00:15:12,610
calculations you know

286
00:15:19,559 --> 00:15:16,230
aren't giving probably aren't giving us

287
00:15:22,799 --> 00:15:19,569
the exact biomass readings here they

288
00:15:25,259 --> 00:15:22,809

might be indicative of they might still

289
00:15:27,840 --> 00:15:25,269
be helpful in determining and telling

290
00:15:32,759 --> 00:15:27,850
you you know like a pointer like hey

291
00:15:39,119 --> 00:15:32,769
life might exist here or not and so how

292
00:15:41,160 --> 00:15:39,129
would life survive on subsurface moon so

293
00:15:43,579 --> 00:15:41,170
I already talked about the particle

294
00:15:47,179 --> 00:15:43,589
radiation here forming secondary

295
00:15:51,900 --> 00:15:47,189
electrons and that energy just being

296
00:15:55,679 --> 00:15:51,910
dissipated here into a smaller or more

297
00:15:58,619 --> 00:15:55,689
electrons but with smaller packets of

298
00:16:02,879 --> 00:15:58,629
energy that wouldn't be involved in

299
00:16:06,389 --> 00:16:02,889
ionizing chemistry okay sorry

300
00:16:09,119 --> 00:16:06,399
so also forming spores here on the

301
00:16:12,869 --> 00:16:09,129
surface so if ice gets sublimated and

302
00:16:15,420 --> 00:16:12,879
you can't form secondary electrons you

303
00:16:22,499 --> 00:16:15,430
can go into a spore mode ice nucleation

304
00:16:24,150 --> 00:16:22,509
proteins that basically help form ice

305
00:16:27,739 --> 00:16:24,160
outside the cell instead of the inside

306
00:16:32,519 --> 00:16:27,749
and then antifreeze proteins that

307
00:16:35,009 --> 00:16:32,529
basically don't keep your organism from

308
00:16:37,949 --> 00:16:35,019
freezing and in terms of testing the

309
00:16:39,809 --> 00:16:37,959
hypothesis the easiest way right now

310
00:16:43,799 --> 00:16:39,819
would be to use one of the terrestrial

311
00:16:46,259 --> 00:16:43,809
electrophilic organisms and then using

312
00:16:48,720 --> 00:16:46,269
these secondary electrons to power them

313
00:16:50,910 --> 00:16:48,730

and so basically just went over the kind

314
00:16:53,699 --> 00:16:50,920
of back of the envelope estimates that

315
00:16:55,860 --> 00:16:53,709
we had for direct and indirect electro

316
00:17:00,379 --> 00:16:55,870
fee and now we're just revising our

317
00:17:03,019 --> 00:17:00,389
biomass estimates and putting in some

318
00:17:05,750 --> 00:17:03,029
electrochemistry thermodynamics before

319
00:17:12,210 --> 00:17:05,760
finishing everything off and just some

320
00:17:21,159 --> 00:17:14,350
it's time for one quick question before

321
00:17:23,289 --> 00:17:21,169
we run oh you're closer sorry hi I'm

322
00:17:25,990 --> 00:17:23,299
great talk so what I was curious was

323
00:17:28,659 --> 00:17:26,000
what I guess ratio or metric did you use

324
00:17:30,580 --> 00:17:28,669
to determine the translation from the

325
00:17:36,400 --> 00:17:30,590
electron volts to the amount of biomass

326
00:17:38,440 --> 00:17:36,410
produced okay so that was okay so the

327
00:17:41,980 --> 00:17:38,450
electron volts in terms of the initial

328
00:17:46,620 --> 00:17:41,990
particle energy I'll back up here so

329
00:17:50,169 --> 00:17:46,630
it's not the energy of the electron here

330
00:17:54,580 --> 00:17:50,179
that determines how much energy the

331
00:17:58,570 --> 00:17:54,590
organism unnecessarily gets the electron

332
00:18:00,909 --> 00:17:58,580
volts here are important because they

333
00:18:04,690 --> 00:18:00,919
decide how many secondary electrons are

334
00:18:06,669 --> 00:18:04,700
produced and then that in itself

335
00:18:10,450 --> 00:18:06,679
produces a current here and then we use

336
00:18:12,970 --> 00:18:10,460
that current then to determine how much

337
00:18:14,590 --> 00:18:12,980
biomass and was that from the previous

338
00:18:16,840 --> 00:18:14,600

values of electrophilic organizing

339
00:18:18,909 --> 00:18:16,850
organisms on earth I know so with

340
00:18:21,760 --> 00:18:18,919
electrophilic organisms it's a little

341
00:18:26,950 --> 00:18:21,770
bit more straightforward because you're

342
00:18:32,020 --> 00:18:26,960
using cells so you can come up with the

343
00:18:34,840 --> 00:18:32,030
exact energy here more directly but with

344
00:18:37,270 --> 00:18:34,850
the plasma here it's a little bit

345
00:18:42,240 --> 00:18:37,280
different so we decided to use the