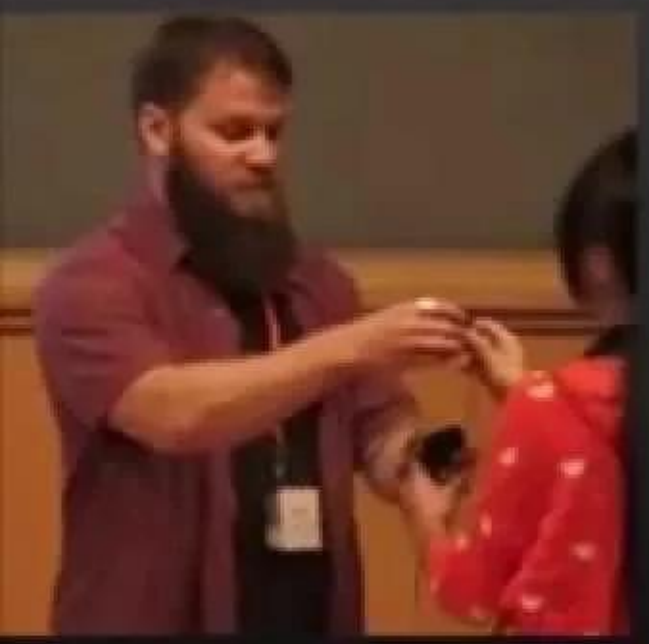

# In-situ Geochemistry contribution to mechanism of surving freezing

grind → filter → analyze concentration of Chlorophyll by spectrophotometer

Chlorophyll

Freeze

(speed:
Slow 1° C/min
Fast 4° C/min)

- Mimic geochemical condition
- In-situ geochemical condition
- Control: pure water

→ Thaw

1
00:00:12,709 --> 00:00:08,790
so right now we have a special talk in

2
00:00:14,390 --> 00:00:12,719
the schedule uh from the rfg that just

3
00:00:16,710 --> 00:00:14,400
happened this last weekend

4
00:00:18,070 --> 00:00:16,720
and so this is uh for you guys that

5
00:00:20,390 --> 00:00:18,080
don't know

6
00:00:22,710 --> 00:00:20,400
part of abroad con every year we have

7
00:00:24,310 --> 00:00:22,720
hosted this research focus group in

8
00:00:27,269 --> 00:00:24,320
which it's sort of a

9
00:00:29,509 --> 00:00:27,279
very intense uh two to three day writing

10
00:00:30,470 --> 00:00:29,519
proposal writing boot camp

11
00:00:33,430 --> 00:00:30,480
where

12
00:00:35,830 --> 00:00:33,440
a bunch of you guys show up

13
00:00:37,270 --> 00:00:35,840

just write furiously for two days

14
00:00:39,190 --> 00:00:37,280
straight

15
00:00:42,310 --> 00:00:39,200
and then we have this whole proposal

16
00:00:44,310 --> 00:00:42,320
review process you present your work and

17
00:00:45,670 --> 00:00:44,320
everybody just gets together votes on it

18
00:00:47,590 --> 00:00:45,680
and has a good time writing the

19
00:00:49,510 --> 00:00:47,600
proposals talking about the proposals

20
00:00:51,830 --> 00:00:49,520
and just getting used to

21
00:00:53,590 --> 00:00:51,840
the entire proposal writing process

22
00:00:55,590 --> 00:00:53,600
so if it's it's something very important

23
00:00:57,270 --> 00:00:55,600
for early career astrobiologists to take

24
00:00:59,750 --> 00:00:57,280
a part of and it's something that if

25
00:01:01,670 --> 00:00:59,760
you're going to future ab grad cons that

26
00:01:03,349 --> 00:01:01,680
you should consider it's very helpful

27
00:01:05,910 --> 00:01:03,359
not only for writing proposals but

28
00:01:07,830 --> 00:01:05,920
getting prepared for your candidacy

29
00:01:09,429 --> 00:01:07,840
even getting prepared for your defense

30
00:01:11,190 --> 00:01:09,439
but something as scientists that we

31
00:01:12,950 --> 00:01:11,200
typically have to do a lot of is this

32
00:01:14,789 --> 00:01:12,960
proposal writing stuff

33
00:01:17,109 --> 00:01:14,799
and so

34
00:01:19,749 --> 00:01:17,119
from this last weekend

35
00:01:23,910 --> 00:01:19,759
this is the winning proposal that was

36
00:01:25,910 --> 00:01:23,920
chosen and so you can see a highlight of

37
00:01:27,990 --> 00:01:25,920
the work that is done over this weekend

38
00:01:30,870 --> 00:01:28,000

and can see what can come out of this

39
00:01:33,270 --> 00:01:30,880
and how awesome the projects can be

40
00:01:35,749 --> 00:01:33,280
so group a

41
00:01:42,950 --> 00:01:35,759
go and present

42
00:01:46,469 --> 00:01:44,069
all right well thank you very much

43
00:01:47,910 --> 00:01:46,479
bradley thanks everyone for coming

44
00:01:50,469 --> 00:01:47,920
we're going to completely jump ship from

45
00:01:53,190 --> 00:01:50,479
what the first session was about and go

46
00:01:55,670 --> 00:01:53,200
to some talks about biology

47
00:01:57,910 --> 00:01:55,680
life on earth has come to fill almost

48
00:01:59,990 --> 00:01:57,920
every niche we can imagine

49
00:02:02,630 --> 00:02:00,000
living in marginal environments and

50
00:02:04,149 --> 00:02:02,640
extreme environments as well as well

51
00:02:07,429 --> 00:02:04,159
extremes of

52
00:02:09,190 --> 00:02:07,439
things like pressure ph salinity as well

53
00:02:11,270 --> 00:02:09,200
as temperature

54
00:02:12,710 --> 00:02:11,280
finding out how life can survive in

55
00:02:15,190 --> 00:02:12,720
these various extremes is really

56
00:02:17,350 --> 00:02:15,200
important for astrobiology to understand

57
00:02:19,510 --> 00:02:17,360
the origins and evolution of life

58
00:02:21,110 --> 00:02:19,520
but also how life might thrive elsewhere

59
00:02:23,350 --> 00:02:21,120
in the universe

60
00:02:25,350 --> 00:02:23,360
and so for our research we were studying

61
00:02:27,750 --> 00:02:25,360
or proposing to study

62
00:02:29,510 --> 00:02:27,760
an algal strain that has the capability

63
00:02:30,710 --> 00:02:29,520

of surviving at extremely cold

64
00:02:31,990 --> 00:02:30,720
temperatures

65
00:02:35,670 --> 00:02:32,000
this alga

66
00:02:37,750 --> 00:02:35,680
a species of the genus klebsormidium has

67
00:02:39,589 --> 00:02:37,760
been found in environments across the

68
00:02:42,390 --> 00:02:39,599
planet some of those marginal some of

69
00:02:43,750 --> 00:02:42,400
those extreme in extremes of extremely

70
00:02:46,550 --> 00:02:43,760
low ph

71
00:02:49,110 --> 00:02:46,560
high contaminant metal abundances

72
00:02:51,509 --> 00:02:49,120
extremes of desiccation and extremely

73
00:02:53,350 --> 00:02:51,519
low temperatures they've been found in

74
00:02:55,190 --> 00:02:53,360
some cases to survive down to negative

75
00:02:56,869 --> 00:02:55,200
40 degrees celsius

76
00:03:00,070 --> 00:02:56,879
and so we're going to talk to you about

77
00:03:01,830 --> 00:03:00,080
one strain that jessica has isolated and

78
00:03:04,390 --> 00:03:01,840
the mechanisms we're searching for in

79
00:03:05,750 --> 00:03:04,400
this organism that allow it to survive

80
00:03:06,949 --> 00:03:05,760
in the cold

81
00:03:11,830 --> 00:03:06,959
and with that jessica will tell you

82
00:03:16,550 --> 00:03:14,070
so i'll be talking a little bit about

83
00:03:20,790 --> 00:03:16,560
our where we found this alga

84
00:03:23,589 --> 00:03:20,800
and that would be in colorado so

85
00:03:25,350 --> 00:03:23,599
we have this region of hydrothermal

86
00:03:29,030 --> 00:03:25,360
alteration that's rich with sulfide

87
00:03:31,030 --> 00:03:29,040
minerals to include iron copper

88
00:03:32,789 --> 00:03:31,040

silver

89
00:03:34,789 --> 00:03:32,799
and gold so these are traditionally

90
00:03:36,949 --> 00:03:34,799
mined and they have been traditionally

91
00:03:38,630 --> 00:03:36,959
mined and this a lot all along this

92
00:03:40,869 --> 00:03:38,640
region of the

93
00:03:42,550 --> 00:03:40,879
rocky mountains so the field site where

94
00:03:44,789 --> 00:03:42,560
i collected this alga was in the

95
00:03:51,910 --> 00:03:44,799
silverton caldera

96
00:03:53,910 --> 00:03:51,920
san juan mountains in southern colorado

97
00:03:56,070 --> 00:03:53,920
and that region is also characterized by

98
00:03:58,630 --> 00:03:56,080
the heavy mining activity historically

99
00:04:00,710 --> 00:03:58,640
it's been mined so it's been about 150

100
00:04:02,550 --> 00:04:00,720
years 200 years that it's been mined

101
00:04:05,190 --> 00:04:02,560
this is the red mountain where you can

102
00:04:08,949 --> 00:04:05,200
see all the sulfide weathering so when

103
00:04:11,990 --> 00:04:08,959
sulfide minerals weather they whether to

104
00:04:13,830 --> 00:04:12,000
oxidize sulfur to sulfate and oxidize

105
00:04:17,030 --> 00:04:13,840
the metals like iron 2 goes to iron

106
00:04:19,990 --> 00:04:17,040
three which you see as the rust color

107
00:04:21,830 --> 00:04:20,000
and what happens when uh the ore is

108
00:04:24,070 --> 00:04:21,840
extracted from these sulfide minerals

109
00:04:26,550 --> 00:04:24,080
from the from the mountains

110
00:04:29,990 --> 00:04:26,560
you get mine tailing so mine waste so

111
00:04:33,110 --> 00:04:30,000
you get rock piles that are upstream of

112
00:04:35,909 --> 00:04:33,120
hydrogeologic features so what happens

113
00:04:38,150 --> 00:04:35,919

is we get groundwater runoff from

114
00:04:40,310 --> 00:04:38,160
underneath from groundwater and

115
00:04:42,150 --> 00:04:40,320
precipitation so what we end up getting

116
00:04:44,230 --> 00:04:42,160
is this runoff that's toxic to aquatic

117
00:04:47,110 --> 00:04:44,240
life and it's rich in metals here you

118
00:04:49,990 --> 00:04:47,120
see there's nothing growing where we get

119
00:04:52,070 --> 00:04:50,000
the runoff from the acidic mine drainage

120
00:04:53,430 --> 00:04:52,080
and this is the overall equation for

121
00:04:55,510 --> 00:04:53,440
acid mine

122
00:04:58,070 --> 00:04:55,520
runoff so there are four equations

123
00:05:00,629 --> 00:04:58,080
stepwise equations so where we get iron

124
00:05:01,830 --> 00:05:00,639
oxidizing to iron iron two oxidizing to

125
00:05:04,710 --> 00:05:01,840
iron three

126
00:05:07,510 --> 00:05:04,720
uh the sulfur oxidizing into sulfate we

127
00:05:10,710 --> 00:05:07,520
also uh get hydrolysis and we get a lot

128
00:05:13,189 --> 00:05:10,720
of protons uh as the iron three

129
00:05:15,029 --> 00:05:13,199
precipitates into the solid we get hype

130
00:05:17,909 --> 00:05:15,039
you know it scavenges the hydroxides so

131
00:05:20,469 --> 00:05:17,919
we get very acidic runoff uh combining

132
00:05:22,550 --> 00:05:20,479
with with the um

133
00:05:24,230 --> 00:05:22,560
with the groundwater sources

134
00:05:27,270 --> 00:05:24,240
so these are the types of environments

135
00:05:29,430 --> 00:05:27,280
where we found the alga and it's quite

136
00:05:31,430 --> 00:05:29,440
it's it makes the alga unique for a

137
00:05:34,230 --> 00:05:31,440
couple of reasons and one is being in

138
00:05:35,029 --> 00:05:34,240

sub-alpine colorado it's very resistant

139
00:05:41,590 --> 00:05:35,039
to

140
00:05:45,189 --> 00:05:44,230
in culture collections because they're

141
00:05:46,950 --> 00:05:45,199
not

142
00:05:48,950 --> 00:05:46,960
they don't freeze well if you freeze an

143
00:05:50,230 --> 00:05:48,960
elgat then we can't bring it back so

144
00:05:52,469 --> 00:05:50,240
it's very they're

145
00:05:54,790 --> 00:05:52,479
difficult to maintain so these guys are

146
00:05:57,350 --> 00:05:54,800
resistant to freezing as well as

147
00:05:59,990 --> 00:05:57,360
all this very rich metal runoff

148
00:06:01,990 --> 00:06:00,000
they are also very uh

149
00:06:04,469 --> 00:06:02,000
they're very sensitive to copper so this

150
00:06:06,550 --> 00:06:04,479
runoff also has a lot of copper in it

151
00:06:08,469 --> 00:06:06,560
and actually we use copper sulfate to

152
00:06:12,070 --> 00:06:08,479
keep algae algae out of our swimming

153
00:06:14,629 --> 00:06:12,080
pools so i we took this culture uh

154
00:06:16,550 --> 00:06:14,639
cultured it in a fish tank with its

155
00:06:19,510 --> 00:06:16,560
native conditions so with under a lot of

156
00:06:22,710 --> 00:06:19,520
metals and low ph water which was ph3

157
00:06:25,029 --> 00:06:22,720
and with this algo we can

158
00:06:26,710 --> 00:06:25,039
do our downstream experiments

159
00:06:29,510 --> 00:06:26,720
so what i proposed

160
00:06:32,150 --> 00:06:29,520
my my approach to identifying the

161
00:06:34,550 --> 00:06:32,160
mechanisms that allow it to survive

162
00:06:36,550 --> 00:06:34,560
freezing is to first we can do a

163
00:06:39,189 --> 00:06:36,560

bioinformatics approach so the genome

164
00:06:41,029 --> 00:06:39,199
has been sequenced so you can do some

165
00:06:43,749 --> 00:06:41,039
bioinformatics take some

166
00:06:47,189 --> 00:06:43,759
statistics or find open reading frames

167
00:06:48,390 --> 00:06:47,199
that would presumably encode for genes

168
00:06:50,230 --> 00:06:48,400
and

169
00:06:52,629 --> 00:06:50,240
find the ones that are similar to other

170
00:06:54,710 --> 00:06:52,639
organisms so you find homologous

171
00:06:56,870 --> 00:06:54,720
sequences and other organisms that are

172
00:06:58,870 --> 00:06:56,880
tolerant to freezing and then you can

173
00:07:01,430 --> 00:06:58,880
take that gene

174
00:07:12,390 --> 00:07:01,440
so you want to switch to the lab maybe

175
00:07:17,189 --> 00:07:15,029
okay so

176
00:07:19,350 --> 00:07:17,199
we can take the genes put it in an e

177
00:07:22,070 --> 00:07:19,360
coli host which is that's what we use in

178
00:07:25,350 --> 00:07:22,080
the lab to screen for functions

179
00:07:26,870 --> 00:07:25,360
and a positive result would uh

180
00:07:28,309 --> 00:07:26,880
be the e coli that we introduced that

181
00:07:31,110 --> 00:07:28,319
gene to would be more resistant to

182
00:07:34,629 --> 00:07:31,120
freezing so that's one approach that

183
00:07:36,870 --> 00:07:34,639
also assumes or is dependent on having

184
00:07:38,230 --> 00:07:36,880
other organisms with the mechanisms

185
00:07:40,230 --> 00:07:38,240
already have been having been

186
00:07:42,710 --> 00:07:40,240
characterized so that's not always the

187
00:07:45,990 --> 00:07:42,720
case and uh so an alternative approach

188
00:07:48,790 --> 00:07:46,000

is to do a functional screen where we

189
00:07:51,029 --> 00:07:48,800
take the we stress out the mrn of the

190
00:07:54,070 --> 00:07:51,039
algae we stress out the alga we freeze

191
00:07:55,749 --> 00:07:54,080
it bring it back harvest the mrna which

192
00:08:00,230 --> 00:07:55,759
is or all the messages so this is the

193
00:08:01,430 --> 00:08:00,240
rna is run on a polyacrylamide gel

194
00:08:03,670 --> 00:08:01,440
we run a current through it and we

195
00:08:06,150 --> 00:08:03,680
separate the rna by size so here we have

196
00:08:08,629 --> 00:08:06,160
the ribosomal rna in between the light

197
00:08:10,710 --> 00:08:08,639
gray areas those are all the messages so

198
00:08:13,830 --> 00:08:10,720
it's only two to five percent of the

199
00:08:15,589 --> 00:08:13,840
total rna the messenger rna so what we

200
00:08:17,110 --> 00:08:15,599
can do is we can harvest that and

201
00:08:20,950 --> 00:08:17,120
convert it to c

202
00:08:22,150 --> 00:08:20,960
complementary dna using a viral

203
00:08:24,150 --> 00:08:22,160
enzyme

204
00:08:26,710 --> 00:08:24,160
and we can amplify it and turn it into

205
00:08:30,469 --> 00:08:26,720
dna so that we can use it as a gene

206
00:08:33,190 --> 00:08:30,479
so what we can do is take all the cdna

207
00:08:34,230 --> 00:08:33,200
that we have made from the rna

208
00:08:35,829 --> 00:08:34,240
and

209
00:08:37,990 --> 00:08:35,839
here we see that here's a ladder that

210
00:08:39,670 --> 00:08:38,000
will tell you the size of all this dna

211
00:08:41,269 --> 00:08:39,680
that's been run on a gel

212
00:08:43,829 --> 00:08:41,279
so all of these are the different

213
00:08:45,190 --> 00:08:43,839

transcripts different sized messages

214
00:08:47,590 --> 00:08:45,200
from all the genes that it's been

215
00:08:49,670 --> 00:08:47,600
transcribing while it's stressed for

216
00:08:51,829 --> 00:08:49,680
during stress during during freeze

217
00:08:52,790 --> 00:08:51,839
stress as well as a bunch of other stuff

218
00:08:55,030 --> 00:08:52,800
that we don't know what they are we

219
00:08:57,030 --> 00:08:55,040
don't know what the transcripts are so

220
00:08:59,750 --> 00:08:57,040
we take these bits of dna put them into

221
00:09:02,389 --> 00:08:59,760
a vector a little piece of dna that we

222
00:09:04,470 --> 00:09:02,399
can introduce to an e coli cell so this

223
00:09:06,550 --> 00:09:04,480
is the chromosomal dna that the e coli

224
00:09:08,389 --> 00:09:06,560
needs to live it also has extracellular

225
00:09:10,310 --> 00:09:08,399
pieces of dna that we can introduce

226
00:09:13,190 --> 00:09:10,320
and we can introduce the functions that

227
00:09:15,590 --> 00:09:13,200
these genes encode for

228
00:09:17,350 --> 00:09:15,600
now what we can do with e coli to select

229
00:09:20,150 --> 00:09:17,360
for the genes that confer resistance is

230
00:09:22,389 --> 00:09:20,160
we can freeze these cells and the cells

231
00:09:25,110 --> 00:09:22,399
that don't survive are the ones that

232
00:09:26,870 --> 00:09:25,120
don't have any uh dna from the algae

233
00:09:28,870 --> 00:09:26,880
that allow resistance

234
00:09:31,670 --> 00:09:28,880
so the ones that do survive will have

235
00:09:34,710 --> 00:09:31,680
presumably have the inserts that confer

236
00:09:37,030 --> 00:09:34,720
resistance and then we can take those

237
00:09:38,870 --> 00:09:37,040
separate them on a gel find the one of

238
00:09:40,389 --> 00:09:38,880

interest send it for sequencing and map

239
00:09:42,949 --> 00:09:40,399
it to the

240
00:09:45,670 --> 00:09:42,959
gene that uh on the genome because it's

241
00:09:48,150 --> 00:09:45,680
been sequenced and then follow with uh

242
00:09:52,550 --> 00:09:48,160
characterizing the gene product and uh

243
00:09:54,630 --> 00:09:52,560
the mechanism so that's one approach and

244
00:09:56,070 --> 00:09:54,640
that leads us to the protein

245
00:09:57,750 --> 00:09:56,080
characterization and the types of

246
00:09:59,430 --> 00:09:57,760
mechanisms that we can

247
00:10:04,470 --> 00:09:59,440
possibly screen for that graham will go

248
00:10:07,990 --> 00:10:06,550
okay thank you jessica uh there are

249
00:10:09,269 --> 00:10:08,000
various mechanisms that have been

250
00:10:11,990 --> 00:10:09,279
discovered already through which

251
00:10:14,550 --> 00:10:12,000
organisms survive extremes of cold these

252
00:10:17,269 --> 00:10:14,560
include increased uh solutes inside the

253
00:10:18,550 --> 00:10:17,279
cell in the cytoplasm like sugars like

254
00:10:20,710 --> 00:10:18,560
glucose

255
00:10:23,269 --> 00:10:20,720
and sucrose to help the cell survive in

256
00:10:24,949 --> 00:10:23,279
lower temperatures but one really

257
00:10:26,389 --> 00:10:24,959
interesting way that cells have learned

258
00:10:28,630 --> 00:10:26,399
to survive these kinds of low

259
00:10:30,710 --> 00:10:28,640
temperatures is by creating novel

260
00:10:32,710 --> 00:10:30,720
proteins in the case of this picture

261
00:10:35,430 --> 00:10:32,720
here they've created anti-freeze

262
00:10:38,230 --> 00:10:35,440
proteins that effectively create ice

263
00:10:40,470 --> 00:10:38,240

cages that bind around ice crystals and

264
00:10:42,630 --> 00:10:40,480
stop them from forming large structures

265
00:10:44,829 --> 00:10:42,640
to allow the cell to survive a lot of

266
00:10:46,389 --> 00:10:44,839
small ice crystals inside the cell next

267
00:10:48,389 --> 00:10:46,399
slide

268
00:10:50,630 --> 00:10:48,399
so to continue our characterization of

269
00:10:52,790 --> 00:10:50,640
this algal strain this is kind of a

270
00:10:55,509 --> 00:10:52,800
quick and easy way doing some lab work

271
00:10:58,150 --> 00:10:55,519
to assess what temperatures this these

272
00:10:59,670 --> 00:10:58,160
cells can survive down to how fast they

273
00:11:00,790 --> 00:10:59,680
can be cooled without without dying

274
00:11:02,790 --> 00:11:00,800
completely

275
00:11:04,470 --> 00:11:02,800
how fast it can be heated back up and

276
00:11:07,590 --> 00:11:04,480
the duration of time they can withstand

277
00:11:10,230 --> 00:11:07,600
freezing from days to months seasonally

278
00:11:12,069 --> 00:11:10,240
or even yearly next slide please

279
00:11:13,509 --> 00:11:12,079
and in doing our characterizations

280
00:11:15,190 --> 00:11:13,519
looking at proteins there's a lot of

281
00:11:17,509 --> 00:11:15,200
things you can do in molecular biology

282
00:11:19,269 --> 00:11:17,519
to understand proteins it's a very wide

283
00:11:21,430 --> 00:11:19,279
field but we would start off with

284
00:11:23,910 --> 00:11:21,440
something really easy doing an assay

285
00:11:25,670 --> 00:11:23,920
just to quantify the amount of protein

286
00:11:27,670 --> 00:11:25,680
within a stressed cell in the cold

287
00:11:30,069 --> 00:11:27,680
versus a non-stressed cell to see if

288
00:11:31,269 --> 00:11:30,079

there's a difference and then after that

289
00:11:32,870 --> 00:11:31,279
if we wanted to we could use other

290
00:11:35,110 --> 00:11:32,880
techniques like this image i have behind

291
00:11:36,949 --> 00:11:35,120
but can't explain through the time

292
00:11:41,350 --> 00:11:36,959
that we could use to characterize these

293
00:11:46,230 --> 00:11:43,670
so my job is to

294
00:11:49,910 --> 00:11:46,240
test the geochemistry

295
00:11:51,430 --> 00:11:49,920
condition in the water where the algae

296
00:11:55,110 --> 00:11:51,440
is will

297
00:11:57,670 --> 00:11:55,120
help or inhibit the algae to survive

298
00:11:59,750 --> 00:11:57,680
freezing so this is a picture of the

299
00:12:03,190 --> 00:11:59,760
algae we have and

300
00:12:05,350 --> 00:12:03,200
the um we are testing the concentration

301
00:12:07,430 --> 00:12:05,360
of chlorophyll um

302
00:12:08,710 --> 00:12:07,440
before freezing and after freezing they

303
00:12:12,150 --> 00:12:08,720
are the green

304
00:12:14,069 --> 00:12:12,160
pigment in those cells and the process

305
00:12:17,509 --> 00:12:14,079
is we grind it and

306
00:12:19,750 --> 00:12:17,519
we use a filter to get the juice

307
00:12:22,030 --> 00:12:19,760
and then analyze the concentration of

308
00:12:25,110 --> 00:12:22,040
chlorophyll by the

309
00:12:28,710 --> 00:12:25,120
spectrophotometer and then we

310
00:12:30,230 --> 00:12:28,720
we freeze the algae under

311
00:12:33,350 --> 00:12:30,240
three different

312
00:12:37,750 --> 00:12:33,360
geochemical conditions first is to

313
00:12:40,629 --> 00:12:37,760

mimic the real environment and then use

314
00:12:42,870 --> 00:12:40,639
the real environment then on the third

315
00:12:45,670 --> 00:12:42,880
one is the control using the pure water

316
00:12:49,350 --> 00:12:45,680
and we then defreeze it

317
00:12:51,430 --> 00:12:49,360
saw and to continue the grind filter and

318
00:12:54,710 --> 00:12:51,440
analyze it again

319
00:12:55,750 --> 00:12:54,720
so the there are three results we expect

320
00:12:57,670 --> 00:12:55,760
to see

321
00:13:00,470 --> 00:12:57,680
uh not three more than three but i'm

322
00:13:02,790 --> 00:13:00,480
listing these three simple ones and on

323
00:13:05,590 --> 00:13:02,800
the x-axis you can see

324
00:13:07,670 --> 00:13:05,600
under different conditions um

325
00:13:11,030 --> 00:13:07,680
the y-axis is the concentration of

326
00:13:12,150 --> 00:13:11,040
chlorophyll and if it looks like image

327
00:13:15,030 --> 00:13:12,160
one

328
00:13:17,990 --> 00:13:15,040
means the they are um the chemical

329
00:13:21,030 --> 00:13:18,000
conditions are helping them to

330
00:13:25,110 --> 00:13:21,040
survive freezing and second one

331
00:13:27,190 --> 00:13:25,120
means they um inhibit them to survive

332
00:13:28,550 --> 00:13:27,200
freezing and the third one means they

333
00:13:29,509 --> 00:13:28,560
have no effect

334
00:13:30,949 --> 00:13:29,519
for that

335
00:13:32,470 --> 00:13:30,959
and water

336
00:13:34,150 --> 00:13:32,480
or what if there are minerals

337
00:13:36,230 --> 00:13:34,160
participate

338
00:13:39,590 --> 00:13:36,240

in the solution

339
00:13:43,110 --> 00:13:39,600
so there comes our technology xrd so

340
00:13:45,670 --> 00:13:43,120
this is a image of xrd in my lab and

341
00:13:48,389 --> 00:13:45,680
that's a geochemistry

342
00:13:52,230 --> 00:13:48,399
geometry and that's a principle behind

343
00:13:54,710 --> 00:13:52,240
it i have no time to explain

344
00:13:57,189 --> 00:13:54,720
so just super quickly um we're talking

345
00:13:59,030 --> 00:13:57,199
about this in the context of guiding

346
00:14:01,750 --> 00:13:59,040
exploration of other planets like

347
00:14:03,189 --> 00:14:01,760
particularly mars and europa

348
00:14:04,470 --> 00:14:03,199
on the on the right i just have a plot

349
00:14:07,030 --> 00:14:04,480
here of the daily temperature

350
00:14:08,230 --> 00:14:07,040
fluctuations on mars

351
00:14:09,110 --> 00:14:08,240
but i'm just going to skip to the next

352
00:14:11,189 --> 00:14:09,120
slide

353
00:14:12,710 --> 00:14:11,199
and talk about the relevance to nasa

354
00:14:14,550 --> 00:14:12,720
objectives so the reason that we picked

355
00:14:16,470 --> 00:14:14,560
mars in europa is because

356
00:14:17,670 --> 00:14:16,480
for the planetary decadal survey for one

357
00:14:19,110 --> 00:14:17,680
reason they're the two highest priority

358
00:14:20,150 --> 00:14:19,120
flagship missions are to those two

359
00:14:21,910 --> 00:14:20,160
planets

360
00:14:23,430 --> 00:14:21,920
but also as applications to the mars

361
00:14:25,430 --> 00:14:23,440
exploration program which is explore

362
00:14:27,189 --> 00:14:25,440
habitability and also the nasa

363
00:14:28,710 --> 00:14:27,199

astrobiology roadmap

364
00:14:30,550 --> 00:14:28,720
in the last slide i just have

365
00:14:32,150 --> 00:14:30,560
description of the two goals that our

366
00:14:33,829 --> 00:14:32,160
project meets towards astrobiology

367
00:14:35,590 --> 00:14:33,839
roadmap

368
00:14:37,910 --> 00:14:35,600
including biochemical adaptation to

369
00:14:39,509 --> 00:14:37,920
extreme environments so with that thank