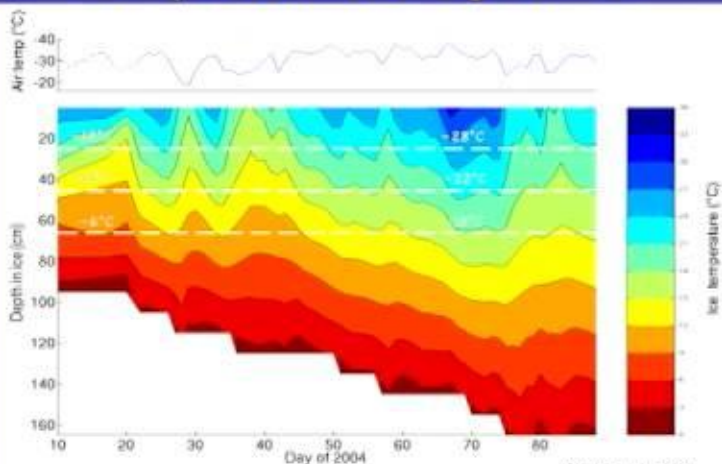




Ice temperature contours through the winter



(Collins et al., 2008)

1
00:00:04,789 --> 00:00:02,230
okay good morning or good afternoon

2
00:00:07,590 --> 00:00:04,799
depending on your time zone welcome to

3
00:00:10,629 --> 00:00:07,600
the nai director seminar uh before we

4
00:00:11,749 --> 00:00:10,639
get started i wanted to say a couple of

5
00:00:14,629 --> 00:00:11,759
things

6
00:00:17,990 --> 00:00:14,639
one is please check out the new

7
00:00:21,109 --> 00:00:18,000
integrated astrobiology program website

8
00:00:24,630 --> 00:00:21,119
the website was a labor of love by a

9
00:00:27,429 --> 00:00:24,640
number of people here at nai central and

10
00:00:28,470 --> 00:00:27,439
working with folks at nasa headquarters

11
00:00:29,509 --> 00:00:28,480
and

12
00:00:31,429 --> 00:00:29,519
we've been getting a lot of good

13
00:00:33,670 --> 00:00:31,439

feedback on it we'd love to hear more

14

00:00:38,630 --> 00:00:33,680

feedback from you all

15

00:00:44,270 --> 00:00:43,030

and the nai website url has not changed

16

00:00:46,790 --> 00:00:44,280

it's still

17

00:00:48,950 --> 00:00:46,800

nai.nasa.gov and it's been integrated

18

00:00:51,029 --> 00:00:48,960

into the large overall website so do

19

00:00:54,549 --> 00:00:51,039

check it out and there's

20

00:00:56,470 --> 00:00:54,559

uh windows at the bottom of each page

21

00:00:58,950 --> 00:00:56,480

that enable you to provide us feedback

22

00:01:01,670 --> 00:00:58,960

and so please do provide us feedback

23

00:01:02,630 --> 00:01:01,680

uh compliments criticisms corrections

24

00:01:04,469 --> 00:01:02,640

anything

25

00:01:06,390 --> 00:01:04,479

are all welcome

26

00:01:07,830 --> 00:01:06,400

one other thing i wanted to mention is

27

00:01:10,789 --> 00:01:07,840

that the

28

00:01:13,109 --> 00:01:10,799

cover story in the april issue of

29

00:01:15,350 --> 00:01:13,119

scientific american is by one of our own

30

00:01:18,390 --> 00:01:15,360

researchers nancy kang

31

00:01:21,429 --> 00:01:18,400

from the uh virtual planetary laboratory

32

00:01:23,190 --> 00:01:21,439

university of washington team she is at

33

00:01:26,230 --> 00:01:23,200

the goddard institute for space studies

34

00:01:28,550 --> 00:01:26,240

in new york and the topic of the cover

35

00:01:31,350 --> 00:01:28,560

article is the shocking colors of alien

36

00:01:33,030 --> 00:01:31,360

plants and nancy and colleagues on

37

00:01:34,230 --> 00:01:33,040

vicki's team have been working on

38

00:01:36,390 --> 00:01:34,240

understanding

39

00:01:38,390 --> 00:01:36,400

what photosynthesis might be like if it

40

00:01:40,789 --> 00:01:38,400

developed under a different stellar

41

00:01:43,670 --> 00:01:40,799

spectrum than the spectrum of the sun so

42

00:01:45,910 --> 00:01:43,680

check that out as well and she also has

43

00:01:47,670 --> 00:01:45,920

papers that have been published in

44

00:01:49,510 --> 00:01:47,680

astrobiology and the references are

45

00:01:50,630 --> 00:01:49,520

given in there

46

00:01:53,270 --> 00:01:50,640

so

47

00:01:55,350 --> 00:01:53,280

let me now take a minute to introduce

48

00:01:57,429 --> 00:01:55,360

our speakers our speakers today as you

49

00:01:59,670 --> 00:01:57,439

know are jody deming and jim staley of

50

00:02:02,389 --> 00:01:59,680

the university of washington

51
00:02:04,149 --> 00:02:02,399
jody actually began her career with nasa

52
00:02:06,630 --> 00:02:04,159
at the goddard space flight center some

53
00:02:08,469 --> 00:02:06,640
time ago and then got her phd at the

54
00:02:11,510 --> 00:02:08,479
university of maryland

55
00:02:14,070 --> 00:02:11,520
what she has been interested in is for

56
00:02:15,510 --> 00:02:14,080
her entire career are the extremes of

57
00:02:17,990 --> 00:02:15,520
life

58
00:02:20,630 --> 00:02:18,000
one of the things that she

59
00:02:24,470 --> 00:02:20,640
did was early in her career to isolate a

60
00:02:27,030 --> 00:02:24,480
novel pressure requiring bacterium

61
00:02:28,869 --> 00:02:27,040
which she then named for her research

62
00:02:29,910 --> 00:02:28,879
advisor rita caldwell

63
00:02:31,190 --> 00:02:29,920

named it

64

00:02:34,710 --> 00:02:31,200

coldwellia

65

00:02:37,670 --> 00:02:34,720

and today jody students are using one of

66

00:02:41,350 --> 00:02:37,680

these as a model organism for cold

67

00:02:44,390 --> 00:02:41,360

attack for uh cold adapted microbes

68

00:02:46,550 --> 00:02:44,400

her research has taken a turn towards

69

00:02:49,190 --> 00:02:46,560

psychrophiles and looking at low

70

00:02:51,110 --> 00:02:49,200

temperature life particularly stimulated

71

00:02:53,750 --> 00:02:51,120

by the potential for there to be such

72

00:02:57,430 --> 00:02:53,760

life on mars and europa so today she

73

00:02:59,110 --> 00:02:57,440

does a lot of work in the high arctic

74

00:03:01,030 --> 00:02:59,120

and we're going to be hearing about some

75

00:03:03,990 --> 00:03:01,040

of that today

76

00:03:05,350 --> 00:03:04,000

our other speaker is jim staley and jody

77

00:03:07,430 --> 00:03:05,360

incidentally is professor of

78

00:03:09,589 --> 00:03:07,440

oceanography jim is a professor of

79

00:03:11,430 --> 00:03:09,599

microbiology of course both at the

80

00:03:13,750 --> 00:03:11,440

university of washington

81

00:03:16,710 --> 00:03:13,760

jim's major research area is microbial

82

00:03:19,750 --> 00:03:16,720

diversity and so he studies microbial

83

00:03:22,869 --> 00:03:19,760

ecology evolution taxonomy and applies

84

00:03:25,270 --> 00:03:22,879

it to both bacteria and archaea he's

85

00:03:27,430 --> 00:03:25,280

particularly interested in the genomics

86

00:03:30,309 --> 00:03:27,440

of unusual bacteria and these include

87

00:03:32,470 --> 00:03:30,319

sea ice bacteria as well as bacteria

88

00:03:35,030 --> 00:03:32,480

that are involved in nitrogen cycling in

89

00:03:36,789 --> 00:03:35,040

the suboxic zone of the black sea and

90

00:03:38,710 --> 00:03:36,799

the black sea work is particularly

91

00:03:40,309 --> 00:03:38,720

interesting because the whole redox

92

00:03:42,390 --> 00:03:40,319

gradient in the black sea which is

93

00:03:44,470 --> 00:03:42,400

anoxic

94

00:03:46,710 --> 00:03:44,480

at its lower level serves as an analog

95

00:03:48,949 --> 00:03:46,720

both for the early earth conditions

96

00:03:51,750 --> 00:03:48,959

as well as the possible redox and

97

00:03:54,390 --> 00:03:51,760

metabolic gradients that might exist on

98

00:03:56,309 --> 00:03:54,400

other worlds that are anoxic like mars

99

00:03:57,830 --> 00:03:56,319

and europa

100

00:04:02,949 --> 00:03:57,840

so

101
00:04:05,190 --> 00:04:02,959
organisms that are trapped in sea ice

102
00:04:08,550 --> 00:04:05,200
and we're going to be hearing today

103
00:04:11,670 --> 00:04:08,560
from jody and from jim about how their

104
00:04:13,750 --> 00:04:11,680
studies of life at

105
00:04:16,150 --> 00:04:13,760
low temperature on earth might apply to

106
00:04:20,870 --> 00:04:16,160
mars and europa and i will now turn it

107
00:04:24,390 --> 00:04:22,150
thank you carl for that nice

108
00:04:27,189 --> 00:04:24,400
introduction jim and i are both pleased

109
00:04:30,230 --> 00:04:27,199
to be able to address this audience on a

110
00:04:32,550 --> 00:04:30,240
topic that we think is pretty relevant

111
00:04:37,350 --> 00:04:32,560
am i on screen with this

112
00:04:39,030 --> 00:04:37,360
because after all it is cold out there

113
00:04:41,030 --> 00:04:39,040

i have been spending a lot of time

114

00:04:43,590 --> 00:04:41,040

recently in the high arctic as carl

115

00:04:45,270 --> 00:04:43,600

alluded to in the winter time in

116

00:04:47,510 --> 00:04:45,280

particular to get the coldest ice

117

00:04:49,189 --> 00:04:47,520

formations possible but that hasn't

118

00:04:51,830 --> 00:04:49,199

always been the case

119

00:04:53,749 --> 00:04:51,840

10 years ago in 1998 i thought it was a

120

00:04:55,670 --> 00:04:53,759

pretty big deal to have organized help

121

00:04:58,230 --> 00:04:55,680

organize an international project to be

122

00:04:59,830 --> 00:04:58,240

working in open waters of the arctic

123

00:05:02,550 --> 00:04:59,840

and there we were doing traditional

124

00:05:04,629 --> 00:05:02,560

oceanography collecting water samples

125

00:05:07,029 --> 00:05:04,639

and as my graduate student likes to say

126

00:05:10,469 --> 00:05:07,039

this is not the

127

00:05:13,510 --> 00:05:10,479

night sky of the arctic but rather the

128

00:05:15,909 --> 00:05:13,520

concentration of bacteria in a tiny drop

129

00:05:18,070 --> 00:05:15,919

of sea water displayed for you on a

130

00:05:20,550 --> 00:05:18,080

black background and visualized with a

131

00:05:22,230 --> 00:05:20,560

stain specific to dna

132

00:05:25,110 --> 00:05:22,240

so we're talking about a million

133

00:05:27,430 --> 00:05:25,120

bacteria in a milliliter of seawater and

134

00:05:30,070 --> 00:05:27,440

these smaller dots are the viruses that

135

00:05:32,550 --> 00:05:30,080

are known to attack these bacteria at 10

136

00:05:34,310 --> 00:05:32,560

times the concentrations of the bacteria

137

00:05:40,230 --> 00:05:34,320

so i want you to keep this in mind when

138

00:05:44,150 --> 00:05:42,469

while i was at sea for this expedition i

139

00:05:46,950 --> 00:05:44,160

was totally

140

00:05:48,870 --> 00:05:46,960

mesmerized by all the ice formations

141

00:05:51,270 --> 00:05:48,880

here we have a glacier pouring off of

142

00:05:53,590 --> 00:05:51,280

ellesmere island the sea ice cover

143

00:05:56,310 --> 00:05:53,600

itself lots of structure and some of the

144

00:05:57,430 --> 00:05:56,320

older ice formations and when i got off

145

00:06:00,310 --> 00:05:57,440

this ship

146

00:06:02,469 --> 00:06:00,320

and came home in july of 1998 the big

147

00:06:04,950 --> 00:06:02,479

news was all europa and these images

148

00:06:07,430 --> 00:06:04,960

these fantastic images were everywhere

149

00:06:08,629 --> 00:06:07,440

that we all know so well now this one in

150

00:06:11,189 --> 00:06:08,639

particular

151
00:06:13,110 --> 00:06:11,199
was very motivating for me because it

152
00:06:16,230 --> 00:06:13,120
resembles although on a different scale

153
00:06:18,390 --> 00:06:16,240
the sorts of ice features and iceberg

154
00:06:19,670 --> 00:06:18,400
breakups that we see in the arctic on

155
00:06:20,870 --> 00:06:19,680
our planet

156
00:06:23,029 --> 00:06:20,880
so

157
00:06:24,390 --> 00:06:23,039
this did cause me to take a turn in my

158
00:06:26,070 --> 00:06:24,400
professional life

159
00:06:28,469 --> 00:06:26,080
and i joined forces with the uw

160
00:06:29,270 --> 00:06:28,479
astrobiology program that started that

161
00:06:31,670 --> 00:06:29,280
year

162
00:06:35,670 --> 00:06:31,680
with my self-appointed role of studying

163
00:06:39,510 --> 00:06:37,430

and then i proceeded to learn that

164

00:06:41,270 --> 00:06:39,520

europa isn't the only place where there

165

00:06:43,990 --> 00:06:41,280

might be another ocean in the solar

166

00:06:45,830 --> 00:06:44,000

system i was behind in my astronomy

167

00:06:49,909 --> 00:06:45,840

mars though it doesn't have one today

168

00:06:54,390 --> 00:06:51,670

and now we have all the excitement about

169

00:06:56,870 --> 00:06:54,400

enceladus which i just saw these images

170

00:06:59,189 --> 00:06:56,880

in 2006 but last week we have all this

171

00:07:01,430 --> 00:06:59,199

new excitement of eruptions of water

172

00:07:02,629 --> 00:07:01,440

with organic material in this water so

173

00:07:04,629 --> 00:07:02,639

there's a lot of

174

00:07:07,029 --> 00:07:04,639

exciting stuff going on in our solar

175

00:07:09,189 --> 00:07:07,039

system and and the question may be is

176

00:07:11,510 --> 00:07:09,199

there any life associated with the ice

177

00:07:14,550 --> 00:07:11,520

that we might be able to sample at some

178

00:07:17,749 --> 00:07:14,560

point in our students future

179

00:07:19,990 --> 00:07:17,759

here is um a depiction of following the

180

00:07:21,830 --> 00:07:20,000

water on earth following the water is

181

00:07:24,710 --> 00:07:21,840

what we're instructed to do in

182

00:07:26,550 --> 00:07:24,720

astrobiology and the blue line here is

183

00:07:28,790 --> 00:07:26,560

where we find liquid water on earth

184

00:07:30,950 --> 00:07:28,800

here's the zero to 100 degree range for

185

00:07:33,189 --> 00:07:30,960

distilled water but you can keep that

186

00:07:34,950 --> 00:07:33,199

water liquid by virtue of hydrostatic

187

00:07:35,990 --> 00:07:34,960

pressure all the way up to some very

188

00:07:37,830 --> 00:07:36,000

severe

189

00:07:40,790 --> 00:07:37,840

high temperatures at deep sea

190

00:07:42,629 --> 00:07:40,800

hydrothermal vents below zero you keep

191

00:07:45,749 --> 00:07:42,639

it liquid by

192

00:07:48,469 --> 00:07:45,759

its content of salt and other impurities

193

00:07:50,150 --> 00:07:48,479

so i'm after learning more about what

194

00:07:52,550 --> 00:07:50,160

happens in this zone here this

195

00:07:54,469 --> 00:07:52,560

temperature around here which brings

196

00:07:56,390 --> 00:07:54,479

relevance to the martian surface and

197

00:07:58,070 --> 00:07:56,400

subsurface

198

00:07:59,589 --> 00:07:58,080

here's the european surface but the

199

00:08:01,029 --> 00:07:59,599

european ocean

200

00:08:02,869 --> 00:08:01,039

tells us there must be a temperature

201
00:08:04,550 --> 00:08:02,879
gradient so i want to push these

202
00:08:07,909 --> 00:08:04,560
boundaries as much as possible and see

203
00:08:11,110 --> 00:08:07,919
what we know about life in very cold ice

204
00:08:12,869 --> 00:08:11,120
i'm in fact then following the ice in

205
00:08:14,550 --> 00:08:12,879
order to follow the water and i'm doing

206
00:08:17,350 --> 00:08:14,560
so in the north

207
00:08:20,550 --> 00:08:17,360
in in part because i think the original

208
00:08:22,869 --> 00:08:20,560
astrobiologists live there

209
00:08:25,110 --> 00:08:22,879
we might think of ice as frozen water

210
00:08:26,469 --> 00:08:25,120
but the native inuit think of water as

211
00:08:28,469 --> 00:08:26,479
melted ice

212
00:08:30,869 --> 00:08:28,479
and in fact ice is the natural state of

213
00:08:33,110 --> 00:08:30,879

water in our solar system so i think

214

00:08:35,110 --> 00:08:33,120

they knew something before we did it's

215

00:08:37,509 --> 00:08:35,120

it's also a perspective to bring in how

216

00:08:40,070 --> 00:08:37,519

you study ice up until recently

217

00:08:41,909 --> 00:08:40,080

microbiologists to study what was in ice

218

00:08:43,909 --> 00:08:41,919

would melt the ice return it to its

219

00:08:45,829 --> 00:08:43,919

liquid water state which completely

220

00:08:49,110 --> 00:08:45,839

changes the environment the habitat they

221

00:08:53,190 --> 00:08:49,120

were occupying so my aim is to study the

222

00:08:55,670 --> 00:08:53,200

microbes in the unaltered ice

223

00:08:56,949 --> 00:08:55,680

the north also gives us the possibility

224

00:08:58,949 --> 00:08:56,959

to study

225

00:09:01,190 --> 00:08:58,959

different types of ice formations i

226

00:09:04,310 --> 00:09:01,200

circle the arctic sea ice but we also

227

00:09:07,430 --> 00:09:04,320

have freshwater glacial ice on greenland

228

00:09:09,590 --> 00:09:07,440

and we have the permafrost siberian and

229

00:09:11,750 --> 00:09:09,600

alaskan canadian permafrost which is

230

00:09:13,269 --> 00:09:11,760

frozen soil

231

00:09:15,509 --> 00:09:13,279

if we look at

232

00:09:18,470 --> 00:09:15,519

average global tabulations of these

233

00:09:21,350 --> 00:09:18,480

types of bodies of ice on earth

234

00:09:23,269 --> 00:09:21,360

at any one time about 20 percent of the

235

00:09:25,590 --> 00:09:23,279

of the surface of our planet is covered

236

00:09:27,750 --> 00:09:25,600

with one form of ice or another

237

00:09:30,710 --> 00:09:27,760

it's the glacial ice sheets that win the

238

00:09:32,470 --> 00:09:30,720

prize for the greatest volume of ice but

239

00:09:35,030 --> 00:09:32,480

if we're following the water they have

240

00:09:36,630 --> 00:09:35,040

the smallest fraction of liquid water in

241

00:09:38,790 --> 00:09:36,640

them and this is because they have the

242

00:09:40,949 --> 00:09:38,800

least impurities to depress that

243

00:09:43,269 --> 00:09:40,959

freezing point so if we really want to

244

00:09:46,150 --> 00:09:43,279

follow the water sea ice wins the prize

245

00:09:48,150 --> 00:09:46,160

there and it's particular aspect is that

246

00:09:50,790 --> 00:09:48,160

you can get very cold temperatures and

247

00:09:52,710 --> 00:09:50,800

still have a considerable fraction of

248

00:09:54,710 --> 00:09:52,720

that's liquid in the ice

249

00:09:57,670 --> 00:09:54,720

the eutectic point or the freezing point

250

00:09:59,350 --> 00:09:57,680

for salt water is minus 55 which is

251
00:10:01,350 --> 00:09:59,360
again the average temperature of the

252
00:10:03,670 --> 00:10:01,360
surface of mars

253
00:10:04,949 --> 00:10:03,680
permafrost is also has a special

254
00:10:07,829 --> 00:10:04,959
interest

255
00:10:08,790 --> 00:10:07,839
it has the it ranks second with seasonal

256
00:10:10,710 --> 00:10:08,800
snow

257
00:10:13,750 --> 00:10:10,720
for the amount of water but it also

258
00:10:17,030 --> 00:10:13,760
brings us closer to geologic age because

259
00:10:19,509 --> 00:10:17,040
some of these permafrosts are quite old

260
00:10:22,389 --> 00:10:19,519
and one feature in permafrost that's

261
00:10:26,389 --> 00:10:22,399
understudied as an astrobiological

262
00:10:28,949 --> 00:10:26,399
habitat analog are cryopegs or lenses of

263
00:10:31,509 --> 00:10:28,959

briny liquid that are buried deeply

264

00:10:33,750 --> 00:10:31,519

in permafrost they might make nice

265

00:10:36,150 --> 00:10:33,760

analogs for future studs

266

00:10:38,230 --> 00:10:36,160

if we now look at the total number of

267

00:10:40,069 --> 00:10:38,240

microbes that are in these different ice

268

00:10:42,310 --> 00:10:40,079

formations so this is just number of

269

00:10:43,590 --> 00:10:42,320

bacteria remember that picture i showed

270

00:10:46,069 --> 00:10:43,600

you before

271

00:10:47,990 --> 00:10:46,079

freshwater ice has the lowest numbers

272

00:10:50,069 --> 00:10:48,000

and note that there's not a single

273

00:10:52,710 --> 00:10:50,079

sterile piece of ice that we know about

274

00:10:55,509 --> 00:10:52,720

they all contain some number of bacteria

275

00:10:57,269 --> 00:10:55,519

200 to 1000 in freshwater ice

276

00:10:59,829 --> 00:10:57,279

on the other end of the spectrum we have

277

00:11:02,470 --> 00:10:59,839

permafrost with over ten to the eighth

278

00:11:04,150 --> 00:11:02,480

bacteria per gram of that material and

279

00:11:06,310 --> 00:11:04,160

that isn't really a surprise to

280

00:11:08,790 --> 00:11:06,320

microbiologists because it's soil that's

281

00:11:11,430 --> 00:11:08,800

frozen and soils contain 10 of the ninth

282

00:11:13,350 --> 00:11:11,440

per per gram typically so this is not a

283

00:11:14,470 --> 00:11:13,360

surprise

284

00:11:18,550 --> 00:11:14,480

in between

285

00:11:21,670 --> 00:11:18,560

numerically are salt water forms of ice

286

00:11:23,670 --> 00:11:21,680

up to a million per ml as we saw before

287

00:11:26,470 --> 00:11:23,680

and the difference here is that in most

288

00:11:28,470 --> 00:11:26,480

cases these organisms are active they're

289

00:11:30,150 --> 00:11:28,480

doing something and it's because they

290

00:11:32,230 --> 00:11:30,160

are not restricted in terms of the

291

00:11:33,990 --> 00:11:32,240

amount of water available to them or

292

00:11:36,150 --> 00:11:34,000

nutrients

293

00:11:38,550 --> 00:11:36,160

the other interesting thing you can

294

00:11:40,790 --> 00:11:38,560

observe in this table is that

295

00:11:43,350 --> 00:11:40,800

if you're talking about particle poor

296

00:11:45,190 --> 00:11:43,360

ice you have lower numbers of bacteria

297

00:11:47,590 --> 00:11:45,200

as soon as you introduce

298

00:11:50,389 --> 00:11:47,600

particles mineral grains organic

299

00:11:53,750 --> 00:11:50,399

detritus any sort of attachment surface

300

00:11:55,509 --> 00:11:53,760

to ice your numbers zoom up

301

00:11:58,150 --> 00:11:55,519

we have plenty of examples on this

302

00:12:01,190 --> 00:11:58,160

planet of ice formations that are rich

303

00:12:02,470 --> 00:12:01,200

with mineral rains this is sea ice laden

304

00:12:06,069 --> 00:12:02,480

with sediment somewhere between

305

00:12:08,310 --> 00:12:06,079

permafrost and very clean ice

306

00:12:09,750 --> 00:12:08,320

well my first trips to the arctic and

307

00:12:12,629 --> 00:12:09,760

the dead of winter

308

00:12:14,470 --> 00:12:12,639

the march of 2001 north of barrow the

309

00:12:17,110 --> 00:12:14,480

temperature there was minus 40 at the

310

00:12:19,509 --> 00:12:17,120

time and this was work done with an nsf

311

00:12:21,350 --> 00:12:19,519

life and extreme environments award to

312

00:12:23,110 --> 00:12:21,360

meet ohio eiken who is a sea ice

313

00:12:24,550 --> 00:12:23,120

geophysicist at the university of

314

00:12:27,269 --> 00:12:24,560

fairbanks

315

00:12:29,350 --> 00:12:27,279

we went out on the rv sled the research

316

00:12:31,110 --> 00:12:29,360

vessel sled very sophisticated inuit

317

00:12:33,190 --> 00:12:31,120

device here which works perfectly to

318

00:12:35,990 --> 00:12:33,200

take you over the cold ice

319

00:12:38,069 --> 00:12:36,000

our aim was to core into the ice we had

320

00:12:39,750 --> 00:12:38,079

a little power generator because it's

321

00:12:41,829 --> 00:12:39,760

like drilling cement

322

00:12:44,069 --> 00:12:41,839

to get a temperature gradient here the

323

00:12:45,990 --> 00:12:44,079

coldest temperature we got was minus 20

324

00:12:47,670 --> 00:12:46,000

degrees because the snow overlying

325

00:12:49,750 --> 00:12:47,680

insulates

326

00:12:52,550 --> 00:12:49,760

and some of you may have heard of

327

00:12:54,389 --> 00:12:52,560

work by my graduate student karen younga

328

00:12:56,790 --> 00:12:54,399

that came from this project

329

00:12:59,110 --> 00:12:56,800

so here is a sea ice core pulled out of

330

00:13:01,030 --> 00:12:59,120

there and lying on its side here's the

331

00:13:03,509 --> 00:13:01,040

interface with the ocean so here's the

332

00:13:05,829 --> 00:13:03,519

warmest temperature and the darkness

333

00:13:07,990 --> 00:13:05,839

here is a visualization of all the

334

00:13:09,750 --> 00:13:08,000

microbes that live in it the sea ice

335

00:13:11,990 --> 00:13:09,760

microbial community which jim will talk

336

00:13:14,629 --> 00:13:12,000

about a little bit further

337

00:13:17,110 --> 00:13:14,639

i'm after again the coldest ice near the

338

00:13:18,949 --> 00:13:17,120

atmosphere the snow atmosphere interface

339

00:13:20,550 --> 00:13:18,959

there's kind of a rule of thumb in sea

340

00:13:23,030 --> 00:13:20,560

ice that once the temperature drops

341

00:13:24,870 --> 00:13:23,040

below minus five degrees the ice becomes

342

00:13:27,590 --> 00:13:24,880

impermeable

343

00:13:29,350 --> 00:13:27,600

it's mechanically strong and we think

344

00:13:32,550 --> 00:13:29,360

that little can

345

00:13:34,310 --> 00:13:32,560

squeeze out of it if you will

346

00:13:36,550 --> 00:13:34,320

and if you haven't really thought about

347

00:13:38,870 --> 00:13:36,560

fresh water versus sea ice

348

00:13:41,190 --> 00:13:38,880

here's a little kitchen demonstration

349

00:13:42,790 --> 00:13:41,200

that you can do for your own family and

350

00:13:45,430 --> 00:13:42,800

students if you like this is a

351
00:13:47,269 --> 00:13:45,440
freshwater ice cube made from tap water

352
00:13:49,670 --> 00:13:47,279
and this is an ice cube made from sea

353
00:13:52,150 --> 00:13:49,680
water with some blue stain dribbled over

354
00:13:55,110 --> 00:13:52,160
it the stain just washes off the fresh

355
00:13:57,590 --> 00:13:55,120
water ice it is not porous the sea ice

356
00:13:59,990 --> 00:13:57,600
is highly porous and soaks up the stain

357
00:14:02,629 --> 00:14:00,000
immediately that porosity is where the

358
00:14:06,389 --> 00:14:02,639
liquid phase is and that's the source of

359
00:14:08,949 --> 00:14:06,399
the habitats now this is very warm ice

360
00:14:10,550 --> 00:14:08,959
so there's a lot of porosity here

361
00:14:12,389 --> 00:14:10,560
but we're talking we want to get to the

362
00:14:14,310 --> 00:14:12,399
point of talking about very cold ice so

363
00:14:17,030 --> 00:14:14,320

let me do that more formally here for

364

00:14:18,790 --> 00:14:17,040

you this is a panel of artificially

365

00:14:21,269 --> 00:14:18,800

created sea ice

366

00:14:24,310 --> 00:14:21,279

30 millimeter square panel

367

00:14:26,150 --> 00:14:24,320

being shown here the white is where h₂o

368

00:14:28,389 --> 00:14:26,160

is moved into the solid phase and the

369

00:14:31,670 --> 00:14:28,399

black is the brine liquid phase that

370

00:14:34,069 --> 00:14:31,680

remains so you can see that the pores in

371

00:14:36,790 --> 00:14:34,079

there are quite sizable

372

00:14:38,550 --> 00:14:36,800

just drop the temperature a degree and

373

00:14:41,430 --> 00:14:38,560

everything begins to

374

00:14:44,150 --> 00:14:41,440

narrow up the pores decrease in size

375

00:14:45,990 --> 00:14:44,160

overall porosity decreases take it to

376

00:14:48,710 --> 00:14:46,000

winter temperatures

377

00:14:50,790 --> 00:14:48,720

and boy you've moved all the h₂o pretty

378

00:14:52,629 --> 00:14:50,800

much into the solid phase and

379

00:14:54,790 --> 00:14:52,639

conventional thinking at this time was

380

00:14:57,829 --> 00:14:54,800

that the pores were all closed up as i

381

00:14:59,509 --> 00:14:57,839

said an impermeable ice mass bad news

382

00:15:01,509 --> 00:14:59,519

for microbial life

383

00:15:03,189 --> 00:15:01,519

maybe you can be preserved in here but

384

00:15:04,230 --> 00:15:03,199

not much is going to happen as long as

385

00:15:06,230 --> 00:15:04,240

you are

386

00:15:08,069 --> 00:15:06,240

squished into

387

00:15:10,389 --> 00:15:08,079

impermeable zones here

388

00:15:12,870 --> 00:15:10,399

the problem with this or let me also say

389

00:15:14,389 --> 00:15:12,880

that you can see the brine concentrating

390

00:15:17,110 --> 00:15:14,399

factor here because

391

00:15:19,910 --> 00:15:17,120

as this closes up as i said drops below

392

00:15:21,430 --> 00:15:19,920

-5 the salt and the other impurities

393

00:15:23,350 --> 00:15:21,440

have no place to go so they get

394

00:15:24,389 --> 00:15:23,360

concentrated into these small pore

395

00:15:26,230 --> 00:15:24,399

spaces

396

00:15:29,590 --> 00:15:26,240

and it's not just the salt but we've

397

00:15:30,949 --> 00:15:29,600

learned that it's also the microbes

398

00:15:33,590 --> 00:15:30,959

but the problem here is that we're at

399

00:15:36,310 --> 00:15:33,600

the millimeter scale and a bacterium is

400

00:15:38,629 --> 00:15:36,320

on the order of one micrometer in size

401

00:15:41,110 --> 00:15:38,639

so we're way out of

402

00:15:43,750 --> 00:15:41,120

out of sync here in terms of size for

403

00:15:46,389 --> 00:15:43,760

examining a habitat for a microbe we

404

00:15:48,389 --> 00:15:46,399

wanted to get to the micrometer scale

405

00:15:50,470 --> 00:15:48,399

so we set up a laboratory a freezer

406

00:15:53,189 --> 00:15:50,480

laboratory with a factory modified

407

00:15:56,230 --> 00:15:53,199

epifluorescence microscope with computer

408

00:15:57,749 --> 00:15:56,240

image analysis next to it and a graduate

409

00:15:59,030 --> 00:15:57,759

student willing to spend her life in

410

00:16:01,829 --> 00:15:59,040

that freezer

411

00:16:03,590 --> 00:16:01,839

and she developed a way to take a slice

412

00:16:04,870 --> 00:16:03,600

of natural sea ice from the from the

413

00:16:06,870 --> 00:16:04,880

winter

414

00:16:10,230 --> 00:16:06,880

carefully cut it across the top to

415

00:16:12,629 --> 00:16:10,240

expose the to open up some of the pores

416

00:16:15,189 --> 00:16:12,639

with these are exaggerated pore spaces

417

00:16:17,269 --> 00:16:15,199

she had to develop a dappy stain or a

418

00:16:18,389 --> 00:16:17,279

dna specific stain so that when you

419

00:16:21,269 --> 00:16:18,399

dropped it on there it wouldn't

420

00:16:23,430 --> 00:16:21,279

immediatly freeze but instead would

421

00:16:25,670 --> 00:16:23,440

diffuse into the brine pores so it had

422

00:16:26,710 --> 00:16:25,680

to be isothermal isohalene that took a

423

00:16:28,629 --> 00:16:26,720

while

424

00:16:31,430 --> 00:16:28,639

but once we figured out how to do that

425

00:16:33,590 --> 00:16:31,440

then we could peer into the ice without

426

00:16:36,389 --> 00:16:33,600

having melted it to see

427

00:16:39,590 --> 00:16:36,399

what kind of a habitat that was like

428

00:16:42,790 --> 00:16:39,600

the first image that i'll show you is

429

00:16:45,749 --> 00:16:42,800

unstained just transmit transmission

430

00:16:47,749 --> 00:16:45,759

light to look directly into the ice and

431

00:16:49,189 --> 00:16:47,759

what can we see at the scale of

432

00:16:51,110 --> 00:16:49,199

micrometers

433

00:16:53,110 --> 00:16:51,120

this was a very exciting image when we

434

00:16:55,030 --> 00:16:53,120

first saw it

435

00:16:57,670 --> 00:16:55,040

this is the solid phase of ice and these

436

00:17:00,230 --> 00:16:57,680

are the brine pores 50 micrometers

437

00:17:02,230 --> 00:17:00,240

scaled here what you're seeing what i

438

00:17:05,029 --> 00:17:02,240

want you to see is that these pores are

439

00:17:06,949 --> 00:17:05,039

not isolated they are all connected

440

00:17:09,350 --> 00:17:06,959

it's an interconnected system on the

441

00:17:11,990 --> 00:17:09,360

scale of the microbe

442

00:17:14,069 --> 00:17:12,000

and since this ice sea ice on our planet

443

00:17:14,949 --> 00:17:14,079

anyway has a temperature gradient across

444

00:17:20,390 --> 00:17:14,959

it

445

00:17:22,710 --> 00:17:20,400

convection and advection of fluids

446

00:17:27,510 --> 00:17:22,720

through this matrix through this network

447

00:17:32,390 --> 00:17:30,549

now this is also an unstained panel and

448

00:17:34,549 --> 00:17:32,400

what you're seeing are two pairs of

449

00:17:36,870 --> 00:17:34,559

diatoms sea ice algae that have been

450

00:17:39,669 --> 00:17:36,880

trapped in the ice and they are not

451

00:17:41,990 --> 00:17:39,679

frozen into the solid part of the ice

452

00:17:43,830 --> 00:17:42,000

they are excluded into the liquid phase

453

00:17:45,909 --> 00:17:43,840

this is the brine phase and they're

454

00:17:47,510 --> 00:17:45,919

fluorescing green not because of a stain

455

00:17:49,669 --> 00:17:47,520

but because they're chloroplasts are

456

00:17:51,590 --> 00:17:49,679

naturally autofluorescent and they're

457

00:17:53,430 --> 00:17:51,600

very healthy looking there's no cell

458

00:17:55,029 --> 00:17:53,440

damage that's visible we're not doing

459

00:17:56,950 --> 00:17:55,039

anything in the winter in the arctic

460

00:17:59,190 --> 00:17:56,960

because there's no sunlight but

461

00:18:01,190 --> 00:17:59,200

they appear undamaged we have to go to

462

00:18:03,430 --> 00:18:01,200

the epi fluorescent light and the dna

463

00:18:05,350 --> 00:18:03,440

stain to see the bacteria that they are

464

00:18:07,990 --> 00:18:05,360

plentiful and concentrated in these

465

00:18:10,310 --> 00:18:08,000

liquid phases

466

00:18:12,630 --> 00:18:10,320

using another stain a postdoc with me at

467

00:18:14,789 --> 00:18:12,640

the time christopher kremz

468

00:18:16,789 --> 00:18:14,799

he discovered that these sea ice algae

469

00:18:18,470 --> 00:18:16,799

were coating themselves with what we

470

00:18:21,029 --> 00:18:18,480

call eps

471

00:18:23,110 --> 00:18:21,039

extracellular polysaccharide substances

472

00:18:24,070 --> 00:18:23,120

or exopolymers these are basically

473

00:18:25,669 --> 00:18:24,080

sugars

474

00:18:29,029 --> 00:18:25,679

that take the form of gelatinous

475

00:18:32,470 --> 00:18:29,039

material or literally mucus and it turns

476

00:18:35,830 --> 00:18:32,480

out that the ice pores of

477

00:18:37,990 --> 00:18:35,840

sea ice pores the liquid phase is filled

478

00:18:40,310 --> 00:18:38,000

with this mucous material this is

479

00:18:42,470 --> 00:18:40,320

unstained even unstained you can see the

480

00:18:44,549 --> 00:18:42,480

model the appearance of what's in there

481

00:18:46,549 --> 00:18:44,559

the gelatinous material

482

00:18:49,590 --> 00:18:46,559

so the cells are coating themselves up

483

00:18:51,510 --> 00:18:49,600

to survive the winter

484

00:18:53,510 --> 00:18:51,520

well christopher did some very detailed

485

00:18:54,830 --> 00:18:53,520

analyses of

486

00:18:57,990 --> 00:18:54,840

artificially

487

00:18:59,510 --> 00:18:58,000

created sea ice with and without these

488

00:19:03,990 --> 00:18:59,520

exopolymers

489

00:19:06,310 --> 00:19:04,000

completely abiotic system you get these

490

00:19:10,549 --> 00:19:06,320

euclidean pores that appear to be

491

00:19:12,310 --> 00:19:10,559

disconnected with eps produced by life

492

00:19:14,870 --> 00:19:12,320

you've now got a completely altered

493

00:19:17,029 --> 00:19:14,880

habitat with fractal dimensions to the

494

00:19:20,070 --> 00:19:17,039

pores faces greater surface area to

495

00:19:23,270 --> 00:19:20,080

colonize in interiorly the ice holds

496

00:19:25,750 --> 00:19:23,280

more salt it stays holds more liquid at

497

00:19:28,950 --> 00:19:25,760

lower temperatures it's a remarkable

498

00:19:30,950 --> 00:19:28,960

example of microbes altering the physics

499

00:19:34,230 --> 00:19:30,960

of their environment to enhance its

500

00:19:38,150 --> 00:19:36,230

well what about the bacteria and here's

501
00:19:40,230 --> 00:19:38,160
a panel from the coldest ice we had at

502
00:19:41,750 --> 00:19:40,240
that time you're seeing three ice

503
00:19:43,830 --> 00:19:41,760
crystals together

504
00:19:46,710 --> 00:19:43,840
a triple point juncture and we blow up a

505
00:19:49,190 --> 00:19:46,720
little pour in here and voila there

506
00:19:51,110 --> 00:19:49,200
there's bacteria in there

507
00:19:53,350 --> 00:19:51,120
and this is my favorite slide at minus

508
00:19:54,710 --> 00:19:53,360
15 degrees we captured a bacterium in

509
00:19:56,870 --> 00:19:54,720
the act

510
00:19:58,789 --> 00:19:56,880
we can't really prove that but as you

511
00:20:01,029 --> 00:19:58,799
focused up and down on

512
00:20:06,710 --> 00:20:01,039
that you can see the break point in the

513
00:20:10,310 --> 00:20:08,310

which raises the question of what are

514

00:20:12,230 --> 00:20:10,320

these organisms doing in there okay

515

00:20:13,669 --> 00:20:12,240

they've altered the habitat to make it

516

00:20:15,510 --> 00:20:13,679

more habitable

517

00:20:16,870 --> 00:20:15,520

but are they able to do anything in

518

00:20:18,549 --> 00:20:16,880

there and

519

00:20:20,549 --> 00:20:18,559

in the interest of time i won't explain

520

00:20:21,669 --> 00:20:20,559

the methodology here but i'm happy to

521

00:20:23,350 --> 00:20:21,679

later

522

00:20:25,430 --> 00:20:23,360

what you're seeing here are sections of

523

00:20:27,190 --> 00:20:25,440

the ice from near the ocean to the

524

00:20:28,310 --> 00:20:27,200

atmosphere so the coldest section is

525

00:20:30,230 --> 00:20:28,320

here

526
00:20:32,470 --> 00:20:30,240
and 100

527
00:20:34,870 --> 00:20:32,480
of the cells that were active were

528
00:20:36,950 --> 00:20:34,880
attached to something

529
00:20:40,310 --> 00:20:36,960
to make a long story short short the

530
00:20:42,390 --> 00:20:40,320
bacteria were are also embedded in eps

531
00:20:44,950 --> 00:20:42,400
in this exopolymer material it's not

532
00:20:47,190 --> 00:20:44,960
just the sea ice algae all the microbes

533
00:20:49,029 --> 00:20:47,200
in there are embedded in this material

534
00:20:51,750 --> 00:20:49,039
that is facilitating their ability to

535
00:20:54,470 --> 00:20:51,760
metabolize and we think it's because the

536
00:20:56,870 --> 00:20:54,480
these gels are highly hydrated

537
00:20:59,190 --> 00:20:56,880
so they're providing greater water

538
00:21:00,870 --> 00:20:59,200

around the cell even while there's this

539

00:21:05,909 --> 00:21:00,880

serious brine

540

00:21:09,909 --> 00:21:07,990

since that project we've

541

00:21:12,950 --> 00:21:09,919

not been satisfied with just being able

542

00:21:15,029 --> 00:21:12,960

to get a single ice core or a set of ice

543

00:21:16,789 --> 00:21:15,039

cores from one trip so we've been

544

00:21:18,070 --> 00:21:16,799

overwintering in the arctic we've had

545

00:21:20,470 --> 00:21:18,080

two of these

546

00:21:22,230 --> 00:21:20,480

remarkable expeditions

547

00:21:24,070 --> 00:21:22,240

which are under the guise of canadian

548

00:21:26,710 --> 00:21:24,080

leadership especially during the

549

00:21:28,470 --> 00:21:26,720

international polar year and we froze in

550

00:21:30,549 --> 00:21:28,480

in the north

551
00:21:32,950 --> 00:21:30,559
and got to work with our

552
00:21:35,430 --> 00:21:32,960
astrobiology friends up there

553
00:21:37,830 --> 00:21:35,440
and as we're asking the question is this

554
00:21:39,990 --> 00:21:37,840
sea ice that we're standing on that the

555
00:21:41,750 --> 00:21:40,000
ship is immobilized in that you can land

556
00:21:44,149 --> 00:21:41,760
a plane on

557
00:21:45,990 --> 00:21:44,159
is this a museum for all the microbes in

558
00:21:49,669 --> 00:21:46,000
there or is there something going on

559
00:21:54,870 --> 00:21:51,750
so here is a

560
00:21:57,110 --> 00:21:54,880
contour map that shows you temperature

561
00:21:59,350 --> 00:21:57,120
cool colors are for cold warm colors for

562
00:22:00,789 --> 00:21:59,360
warm the sea ice grows at the bottom

563
00:22:02,390 --> 00:22:00,799

into the ocean if you haven't thought

564

00:22:04,310 --> 00:22:02,400

about that before

565

00:22:06,870 --> 00:22:04,320

so you can see the ice growth during the

566

00:22:09,510 --> 00:22:06,880

course of the winter we sampled

567

00:22:11,510 --> 00:22:09,520

periodically throughout the winter

568

00:22:13,350 --> 00:22:11,520

three different ice horizons to look at

569

00:22:15,029 --> 00:22:13,360

the microbes that were trapped in there

570

00:22:16,950 --> 00:22:15,039

when we started when we got there was

571

00:22:19,909 --> 00:22:16,960

already pretty cold for them

572

00:22:21,510 --> 00:22:19,919

and we got some colder temperatures here

573

00:22:23,190 --> 00:22:21,520

again in the interest of time i'm just

574

00:22:26,149 --> 00:22:23,200

going to summarize what we found from

575

00:22:28,390 --> 00:22:26,159

that first overwintering expedition

576

00:22:30,630 --> 00:22:28,400

graduate student thesis work here we

577

00:22:33,270 --> 00:22:30,640

found that in in the case of both

578

00:22:35,350 --> 00:22:33,280

bacteria and archaea which we confirmed

579

00:22:37,830 --> 00:22:35,360

are really present in sea ice

580

00:22:39,510 --> 00:22:37,840

they persist in numbers and diversity

581

00:22:41,510 --> 00:22:39,520

throughout the winter there's no

582

00:22:43,630 --> 00:22:41,520

die off of one group or another they're

583

00:22:46,070 --> 00:22:43,640

persisting and we can see that the

584

00:22:47,430 --> 00:22:46,080

exopolymeric content of that ice

585

00:22:49,110 --> 00:22:47,440

increases during the course of the

586

00:22:50,870 --> 00:22:49,120

winter so we obviously think those two

587

00:22:52,710 --> 00:22:50,880

things are connected

588

00:22:55,430 --> 00:22:52,720

this is a mechanism for

589

00:22:57,029 --> 00:22:55,440

surviving the winter but then my other

590

00:22:59,350 --> 00:22:57,039

student lead

591

00:23:01,510 --> 00:22:59,360

was fascinated by these viruses that

592

00:23:02,870 --> 00:23:01,520

were present at high concentrations we

593

00:23:05,190 --> 00:23:02,880

already knew they were present at high

594

00:23:06,950 --> 00:23:05,200

concentrations in summer ice but we

595

00:23:09,430 --> 00:23:06,960

didn't know for winter ice and here they

596

00:23:10,950 --> 00:23:09,440

are at very high concentrations what

597

00:23:12,710 --> 00:23:10,960

that means is that the viruses and

598

00:23:15,110 --> 00:23:12,720

bacteria have been brought together for

599

00:23:18,310 --> 00:23:15,120

some super high contact rates in these

600

00:23:20,549 --> 00:23:18,320

brine pores 600 times the rate at which

601
00:23:21,750 --> 00:23:20,559
they'd encounter each other in normal

602
00:23:23,909 --> 00:23:21,760
seawater

603
00:23:25,590 --> 00:23:23,919
so this is a dynamite situation for an

604
00:23:29,430 --> 00:23:25,600
interaction between a bacterium and a

605
00:23:31,990 --> 00:23:29,440
virus if you can do that positively

606
00:23:34,390 --> 00:23:32,000
and lee did some short-term experiments

607
00:23:37,750 --> 00:23:34,400
at the coldest conditions we could get

608
00:23:38,789 --> 00:23:37,760
stably on the ship minus 12 degrees 16

609
00:23:40,390 --> 00:23:38,799
salt

610
00:23:42,549 --> 00:23:40,400
and he was able to show that bacterial

611
00:23:45,590 --> 00:23:42,559
and viral numbers are not static they're

612
00:23:47,830 --> 00:23:45,600
changing bacteria are growing dying

613
00:23:49,990 --> 00:23:47,840

being hit by viruses viruses are

614

00:23:52,789 --> 00:23:50,000

increasing dropping it's a very dynamic

615

00:23:56,789 --> 00:23:54,470

when we're not at sea

616

00:23:59,350 --> 00:23:56,799

we're working with koelia our model

617

00:24:02,310 --> 00:23:59,360

organism that carl alluded to it holds a

618

00:24:04,630 --> 00:24:02,320

number of records its growth record is

619

00:24:07,430 --> 00:24:04,640

jim's bug got to it first he'll tell you

620

00:24:10,230 --> 00:24:07,440

about that one but they both grow at -12

621

00:24:13,830 --> 00:24:10,240

swims at -10 produces enzymes produces

622

00:24:16,230 --> 00:24:13,840

these excessive exopolymers as you move

623

00:24:19,110 --> 00:24:16,240

into frozen temperatures so we're going

624

00:24:22,230 --> 00:24:19,120

from seawater into ice here and zoom it

625

00:24:24,870 --> 00:24:22,240

over produces eps

626

00:24:27,909 --> 00:24:24,880

what we're pursuing now with this model

627

00:24:31,190 --> 00:24:27,919

system we're pursuing the physics of how

628

00:24:33,350 --> 00:24:31,200

ice grows this is an abiotic situation

629

00:24:34,789 --> 00:24:33,360

here with lamellae they're called of ice

630

00:24:37,190 --> 00:24:34,799

growing let me

631

00:24:39,750 --> 00:24:37,200

show you real sea ice growing this is a

632

00:24:42,149 --> 00:24:39,760

scale of one millimeter my newest

633

00:24:44,310 --> 00:24:42,159

graduate student is working on this

634

00:24:47,190 --> 00:24:44,320

where after understanding how these

635

00:24:49,750 --> 00:24:47,200

growing physical lamellae actually trap

636

00:24:51,909 --> 00:24:49,760

organics and microbes how that process

637

00:24:54,149 --> 00:24:51,919

works

638

00:24:56,870 --> 00:24:54,159

and we're um working

639

00:25:00,070 --> 00:24:56,880

further with the virus that we

640

00:25:02,549 --> 00:25:00,080

obtained that attacks coelia

641

00:25:05,190 --> 00:25:02,559

and does so at a record low of minus 12

642

00:25:07,350 --> 00:25:05,200

degrees and 16 percent salt so we have a

643

00:25:09,110 --> 00:25:07,360

model system of this microbe with its

644

00:25:10,149 --> 00:25:09,120

attacking virus

645

00:25:12,070 --> 00:25:10,159

so that

646

00:25:14,630 --> 00:25:12,080

presents the potential in the

647

00:25:16,789 --> 00:25:14,640

microbiology community being able to

648

00:25:18,710 --> 00:25:16,799

have what's called a genetic system

649

00:25:21,110 --> 00:25:18,720

where you can

650

00:25:22,870 --> 00:25:21,120

move genes about if we can get this to

651
00:25:24,230 --> 00:25:22,880
work out

652
00:25:26,630 --> 00:25:24,240
and that's what we're ultimately

653
00:25:28,470 --> 00:25:26,640
interested in is the concept of lateral

654
00:25:30,789 --> 00:25:28,480
gene transfer

655
00:25:33,269 --> 00:25:30,799
usually we think of inheriting genes by

656
00:25:35,590 --> 00:25:33,279
reproducing you inherit genes from your

657
00:25:37,430 --> 00:25:35,600
parents from from the daughter cells

658
00:25:39,029 --> 00:25:37,440
from the parents but lateral gene

659
00:25:41,190 --> 00:25:39,039
transfer is a case

660
00:25:43,909 --> 00:25:41,200
where a bacterium being attacked by

661
00:25:47,110 --> 00:25:43,919
viruses here's a close-up showing the

662
00:25:49,029 --> 00:25:47,120
virus actually injecting some dna into

663
00:25:52,070 --> 00:25:49,039

the cell

664

00:25:54,470 --> 00:25:52,080

that dna normally normally

665

00:25:56,789 --> 00:25:54,480

would take over the bacterial host and

666

00:25:58,950 --> 00:25:56,799

reproduce hundreds of viruses

667

00:26:01,110 --> 00:25:58,960

kill the host and that's the way viruses

668

00:26:04,390 --> 00:26:01,120

reproduce themselves but sometimes the

669

00:26:06,710 --> 00:26:04,400

virus moves into the cell and joins the

670

00:26:09,110 --> 00:26:06,720

bacterial genome and lives benignly with

671

00:26:11,669 --> 00:26:09,120

it generation after generation and in

672

00:26:13,669 --> 00:26:11,679

the process it can bring in a new gene

673

00:26:15,510 --> 00:26:13,679

that it picked up by mistake when it was

674

00:26:17,909 --> 00:26:15,520

killing another bacterium

675

00:26:20,310 --> 00:26:17,919

it's a different way of evolving and it

676
00:26:21,990 --> 00:26:20,320
has the potential of a more rapid way of

677
00:26:23,669 --> 00:26:22,000
evolving

678
00:26:25,590 --> 00:26:23,679
we have some clues from the genome

679
00:26:27,909 --> 00:26:25,600
sequence of coelia

680
00:26:29,510 --> 00:26:27,919
not only that the genome sequence told

681
00:26:32,149 --> 00:26:29,520
us what we already knew which is that it

682
00:26:34,710 --> 00:26:32,159
likes to release a lot of stuff

683
00:26:37,029 --> 00:26:34,720
but it also tells us potential for

684
00:26:38,390 --> 00:26:37,039
lateral gene transfer there's a gene

685
00:26:41,190 --> 00:26:38,400
that's involved in archaeal

686
00:26:42,549 --> 00:26:41,200
methanogenesis in our bug and our bug

687
00:26:45,430 --> 00:26:42,559
doesn't

688
00:26:47,190 --> 00:26:45,440

it's a bacterium that lights organics so

689

00:26:49,750 --> 00:26:47,200

it's not a methanogen

690

00:26:51,350 --> 00:26:49,760

and we have two viruses

691

00:26:53,350 --> 00:26:51,360

whole genomes of viruses that are

692

00:26:55,510 --> 00:26:53,360

sitting in here benignly

693

00:26:58,630 --> 00:26:55,520

so we think we're on to something and i

694

00:27:01,669 --> 00:26:58,640

want to leave you with the idea that

695

00:27:04,549 --> 00:27:01,679

these poor spaces and very cold

696

00:27:06,950 --> 00:27:04,559

ices especially saline ices

697

00:27:09,830 --> 00:27:06,960

are not museums but some very exciting

698

00:27:12,470 --> 00:27:09,840

things may be going on in there that

699

00:27:14,630 --> 00:27:12,480

touch upon the evolution of life at very

700

00:27:16,870 --> 00:27:14,640

cold temperatures and we'd like to make

701
00:27:19,669 --> 00:27:16,880
some more progress on this concept of

702
00:27:21,909 --> 00:27:19,679
lateral gene transfer as a very potent

703
00:27:23,590 --> 00:27:21,919
mechanism for adapting to an extreme

704
00:27:25,830 --> 00:27:23,600
environment

705
00:27:27,590 --> 00:27:25,840
to have just a couple minutes for

706
00:27:29,510 --> 00:27:27,600
pretty pictures from our last

707
00:27:31,110 --> 00:27:29,520
overwintering expedition we just got off

708
00:27:33,190 --> 00:27:31,120
the ship uh

709
00:27:35,190 --> 00:27:33,200
i guess a month or so ago

710
00:27:37,350 --> 00:27:35,200
so we don't have a lot of results yet

711
00:27:39,510 --> 00:27:37,360
but most westerners are not up in the

712
00:27:42,630 --> 00:27:39,520
arctic when the ice begins to freeze to

713
00:27:44,310 --> 00:27:42,640

witness this scene of frost flowers

714

00:27:46,630 --> 00:27:44,320

this is where the ice on the ocean is

715

00:27:49,110 --> 00:27:46,640

just beginning to freeze and instead of

716

00:27:51,430 --> 00:27:49,120

all of the brine rejecting downwards

717

00:27:52,950 --> 00:27:51,440

into the ocean as as the when the water

718

00:27:53,990 --> 00:27:52,960

when the ice is still

719

00:27:56,710 --> 00:27:54,000

warm

720

00:27:58,310 --> 00:27:56,720

some of it ejects upwards

721

00:28:01,110 --> 00:27:58,320

and the atmosphere is now getting cold

722

00:28:03,590 --> 00:28:01,120

so it freezes and you have frost flowers

723

00:28:06,230 --> 00:28:03,600

so this is a field of frost flowers

724

00:28:08,950 --> 00:28:06,240

not studied before by microbiologists

725

00:28:10,789 --> 00:28:08,960

studied by the physicists for issues of

726

00:28:13,590 --> 00:28:10,799

convection of brine

727

00:28:16,149 --> 00:28:13,600

well guess what's in those frost flowers

728

00:28:19,110 --> 00:28:16,159

again this is not the night scene there

729

00:28:20,789 --> 00:28:19,120

but but the many millions of viruses

730

00:28:23,029 --> 00:28:20,799

that are in those

731

00:28:25,029 --> 00:28:23,039

frost flowers being ejected into the

732

00:28:27,350 --> 00:28:25,039

atmosphere now that's something to think

733

00:28:32,310 --> 00:28:29,350

and at this point i'll transfer the

734

00:28:38,950 --> 00:28:32,320

torch or the ice as the case may be to

735

00:28:44,470 --> 00:28:41,269

jody thanks a lot and carl also thank

736

00:28:46,389 --> 00:28:44,480

you for inviting us to do this this is

737

00:29:09,590 --> 00:28:46,399

a

738

00:29:10,710 --> 00:29:09,600

get there

739

00:29:12,310 --> 00:29:10,720

and

740

00:29:13,669 --> 00:29:12,320

so it's a search for low temperature

741

00:29:15,909 --> 00:29:13,679

growth

742

00:29:17,750 --> 00:29:15,919

i want to say a few words

743

00:29:20,230 --> 00:29:17,760

here about the discovery and

744

00:29:22,789 --> 00:29:20,240

significance of marine gas vacuolate

745

00:29:25,269 --> 00:29:22,799

bacteria which seems perhaps somewhat

746

00:29:27,510 --> 00:29:25,279

bizarre to you but it's related here i

747

00:29:29,830 --> 00:29:27,520

think to our topic i'm actually going to

748

00:29:32,070 --> 00:29:29,840

skip this second copy because of time

749

00:29:33,750 --> 00:29:32,080

limitations

750

00:29:35,510 --> 00:29:33,760

then i want to talk most importantly

751
00:29:38,470 --> 00:29:35,520
about the low temperature growth and

752
00:29:41,190 --> 00:29:38,480
then finish it up with the genomics of

753
00:29:43,669 --> 00:29:41,200
an extreme psychophile

754
00:29:45,430 --> 00:29:43,679
so our work began in the antarctic we

755
00:29:47,029 --> 00:29:45,440
weren't looking for low temperature

756
00:29:49,830 --> 00:29:47,039
growth at all we were looking for

757
00:29:51,510 --> 00:29:49,840
bacteria that degraded chitin

758
00:29:54,070 --> 00:29:51,520
and we were working off the antarctic

759
00:29:57,110 --> 00:29:54,080
peninsula which is the peninsula just

760
00:29:58,149 --> 00:29:57,120
south of south america there

761
00:30:03,830 --> 00:29:58,159
and

762
00:30:06,470 --> 00:30:03,840
we came across some of bacteria that

763
00:30:08,389 --> 00:30:06,480

were growing in the water

764

00:30:09,510 --> 00:30:08,399

that had gas vacuoles and the way we

765

00:30:11,590 --> 00:30:09,520

told this

766

00:30:12,789 --> 00:30:11,600

was that you can see on the lower left

767

00:30:15,269 --> 00:30:12,799

plate here

768

00:30:18,149 --> 00:30:15,279

colonies that are quite uh chalky white

769

00:30:20,149 --> 00:30:18,159

in appearance in contrast organisms over

770

00:30:21,750 --> 00:30:20,159

here the same species

771

00:30:24,470 --> 00:30:21,760

are not that way and the difference is

772

00:30:25,909 --> 00:30:24,480

that these organisms have gas vacuoles

773

00:30:27,350 --> 00:30:25,919

inside of them

774

00:30:29,269 --> 00:30:27,360

and so you can sort of tell just by

775

00:30:31,669 --> 00:30:29,279

looking at the colony type whether or

776

00:30:33,190 --> 00:30:31,679

not they have these gas vacuoles

777

00:30:34,870 --> 00:30:33,200

and then when you look at them under the

778

00:30:36,950 --> 00:30:34,880

microscope you can see these bright

779

00:30:41,110 --> 00:30:36,960

areas inside the cells which are

780

00:30:42,789 --> 00:30:41,120

indicative of gas vacuoles

781

00:30:44,470 --> 00:30:42,799

the real proof of whether they have gas

782

00:30:47,110 --> 00:30:44,480

vacuoles is to look in the electron

783

00:30:49,590 --> 00:30:47,120

microscope and you can see these doesn't

784

00:30:53,269 --> 00:30:49,600

drop too well but these little vesicles

785

00:30:55,190 --> 00:30:53,279

are the subunits of the gas vacuum

786

00:30:57,590 --> 00:30:55,200

when these are isolated

787

00:30:59,909 --> 00:30:57,600

they look like this they're cylindrical

788

00:31:02,389 --> 00:30:59,919

and they have conical tips on them

789

00:31:05,510 --> 00:31:02,399

and they consist of a protein it's just

790

00:31:10,070 --> 00:31:05,520

a single protein uh that forms this

791

00:31:13,430 --> 00:31:10,080

membrane around the uh the gas vesicle

792

00:31:15,909 --> 00:31:13,440

and that protein is hydrophobic

793

00:31:18,870 --> 00:31:15,919

so in the cell cytoplasm water cannot

794

00:31:20,950 --> 00:31:18,880

get into the vesicle but gases whatever

795

00:31:22,230 --> 00:31:20,960

the gas is in the environment pretty

796

00:31:24,070 --> 00:31:22,240

diffuses

797

00:31:26,149 --> 00:31:24,080

into the vesicle

798

00:31:28,630 --> 00:31:26,159

result is these little vesicles are

799

00:31:30,310 --> 00:31:28,640

hollow spots in the cell they allow the

800

00:31:34,389 --> 00:31:30,320

organism to rise

801
00:31:35,750 --> 00:31:34,399
or to fall in a gradient

802
00:31:38,230 --> 00:31:35,760
um

803
00:31:40,710 --> 00:31:38,240
ecologically they're important then in

804
00:31:43,830 --> 00:31:40,720
buoyancy or motion

805
00:31:46,470 --> 00:31:43,840
these are enabling organisms to rise i

806
00:31:47,750 --> 00:31:46,480
said or to fall depending upon how many

807
00:31:49,830 --> 00:31:47,760
they need to produce to be at the

808
00:31:52,630 --> 00:31:49,840
location they wish to be

809
00:31:54,470 --> 00:31:52,640
and this is a simple organelle

810
00:31:58,149 --> 00:31:54,480
of motility

811
00:32:00,710 --> 00:31:58,159
it's made with a 7 500 molecular weight

812
00:32:02,950 --> 00:32:00,720
protein very small protein and it's a

813
00:32:04,870 --> 00:32:02,960

repeating subunit that forms the

814

00:32:06,310 --> 00:32:04,880

membrane

815

00:32:08,870 --> 00:32:06,320

because of the simplicity of this

816

00:32:11,269 --> 00:32:08,880

structure i argue that these are likely

817

00:32:13,830 --> 00:32:11,279

an early evolutionarily speaking

818

00:32:15,269 --> 00:32:13,840

organelle of prokaryotic motility very

819

00:32:16,710 --> 00:32:15,279

simple to form

820

00:32:19,269 --> 00:32:16,720

some of you may be aware of the

821

00:32:20,549 --> 00:32:19,279

creationist argument about the bacterial

822

00:32:22,070 --> 00:32:20,559

flagellum

823

00:32:24,149 --> 00:32:22,080

which is of course the organelle

824

00:32:26,630 --> 00:32:24,159

motility most people know about

825

00:32:29,029 --> 00:32:26,640

being so complex it must have been

826

00:32:30,789 --> 00:32:29,039

designed by intelligent design well

827

00:32:31,509 --> 00:32:30,799

here's a very simple structure

828

00:32:33,269 --> 00:32:31,519

that

829

00:32:37,350 --> 00:32:33,279

could be designed by unintelligent

830

00:32:38,630 --> 00:32:37,360

design or what we call evolution

831

00:32:40,950 --> 00:32:38,640

anyway

832

00:32:43,590 --> 00:32:40,960

seeing that these organisms were in the

833

00:32:45,509 --> 00:32:43,600

water here made us think that since they

834

00:32:47,909 --> 00:32:45,519

are organelles of motility that allow

835

00:32:50,630 --> 00:32:47,919

you to rise or fall on a gradient that

836

00:32:52,230 --> 00:32:50,640

perhaps they're associated with the sea

837

00:32:55,029 --> 00:32:52,240

ice microbial community which is a

838

00:32:56,950 --> 00:32:55,039

stratified community

839

00:32:58,389 --> 00:32:56,960

and uh this is the evidence that we had

840

00:33:00,950 --> 00:32:58,399

from that cruise

841

00:33:03,669 --> 00:33:00,960

looking at the depth samples that were

842

00:33:05,830 --> 00:33:03,679

taken in samples in which were positive

843

00:33:07,990 --> 00:33:05,840

over here for the gas vacuolate

844

00:33:11,350 --> 00:33:08,000

organisms were all collected in the

845

00:33:14,870 --> 00:33:11,360

upper zone of the marine habitat 10

846

00:33:17,509 --> 00:33:14,880

meters a few at 25 meters

847

00:33:19,909 --> 00:33:17,519

but absolutely none of them had 100 200

848

00:33:22,710 --> 00:33:19,919

and 500 meters this suggests that these

849

00:33:24,389 --> 00:33:22,720

were floating the bacteria up toward the

850

00:33:26,870 --> 00:33:24,399

surface

851
00:33:28,310 --> 00:33:26,880
of the water now at the time we had our

852
00:33:30,310 --> 00:33:28,320
hypothesis

853
00:33:32,149 --> 00:33:30,320
we were at the palmer station there was

854
00:33:34,470 --> 00:33:32,159
no sea ice left

855
00:33:36,070 --> 00:33:34,480
so what we proposed to nsf was to go the

856
00:33:38,230 --> 00:33:36,080
next year

857
00:33:40,630 --> 00:33:38,240
to mcmurdo to actually look in the sea

858
00:33:43,509 --> 00:33:40,640
ice microbial community to see whether

859
00:33:44,789 --> 00:33:43,519
or not these gas vacuum bacteria were

860
00:33:46,950 --> 00:33:44,799
there

861
00:33:48,389 --> 00:33:46,960
so we sampled off mcmurdo station

862
00:33:50,549 --> 00:33:48,399
there's a nice

863
00:33:52,149 --> 00:33:50,559

a bunch of sea ice over here it's

864

00:33:54,149 --> 00:33:52,159

actually

865

00:33:57,269 --> 00:33:54,159

used to land airplanes on part of the

866

00:33:59,269 --> 00:33:57,279

year it's two meters thick typically uh

867

00:34:00,710 --> 00:33:59,279

and of course as the season progresses

868

00:34:02,710 --> 00:34:00,720

the summer season this will eventually

869

00:34:04,470 --> 00:34:02,720

melt off and they closely monitor this

870

00:34:06,630 --> 00:34:04,480

to make sure the planes are all right

871

00:34:08,869 --> 00:34:06,640

these are c130s on it

872

00:34:10,869 --> 00:34:08,879

we collected samples uh

873

00:34:13,190 --> 00:34:10,879

near the airstrip here at this macro

874

00:34:15,829 --> 00:34:13,200

station here some samples here but also

875

00:34:17,589 --> 00:34:15,839

we went across the sound but sound

876

00:34:19,349 --> 00:34:17,599

and collected some samples over there as

877

00:34:21,510 --> 00:34:19,359

well

878

00:34:23,030 --> 00:34:21,520

and uh jody's already sort of explained

879

00:34:25,109 --> 00:34:23,040

this and of course i got a polar bear in

880

00:34:26,470 --> 00:34:25,119

there just to keep you guys alert we're

881

00:34:28,069 --> 00:34:26,480

going to go to the arctic but we're not

882

00:34:29,990 --> 00:34:28,079

there yet

883

00:34:32,069 --> 00:34:30,000

anyway the sea ice community is sort of

884

00:34:34,389 --> 00:34:32,079

at the interface here between the water

885

00:34:37,190 --> 00:34:34,399

and and it's in the ice but at that

886

00:34:41,909 --> 00:34:39,669

and this just shows a cord sample which

887

00:34:43,829 --> 00:34:41,919

has the black here not black but the

888

00:34:46,149 --> 00:34:43,839

dark amount of

889

00:34:48,790 --> 00:34:46,159

sea ice microbial community in it due to

890

00:34:50,790 --> 00:34:48,800

the diatoms primarily that

891

00:34:52,710 --> 00:34:50,800

are the primary producers

892

00:34:54,790 --> 00:34:52,720

and then this shows a completely

893

00:34:57,109 --> 00:34:54,800

extruded and full-length

894

00:34:59,109 --> 00:34:57,119

uh sea ice column with the sea ice

895

00:35:01,349 --> 00:34:59,119

community at the bottom as jody has

896

00:35:03,190 --> 00:35:01,359

shown also

897

00:35:04,790 --> 00:35:03,200

and so we sampled in that sea ice

898

00:35:06,710 --> 00:35:04,800

community

899

00:35:08,390 --> 00:35:06,720

and what we found were a lot of colonies

900

00:35:09,750 --> 00:35:08,400

that were like this

901
00:35:11,270 --> 00:35:09,760
and you can see there are pigmented

902
00:35:12,710 --> 00:35:11,280
colonies

903
00:35:14,790 --> 00:35:12,720
many of the sea ice bacteria are

904
00:35:16,550 --> 00:35:14,800
pigmented but they have a

905
00:35:19,510 --> 00:35:16,560
white fringe around the colonies and

906
00:35:21,270 --> 00:35:19,520
this is the chalkiness of gas vesicles

907
00:35:22,710 --> 00:35:21,280
and we verified these things for gas

908
00:35:25,109 --> 00:35:22,720
vacuums we went ahead and surveyed and

909
00:35:27,510 --> 00:35:25,119
sure enough you we did find the gas

910
00:35:29,829 --> 00:35:27,520
calculate bacteria in the sea ice

911
00:35:31,670 --> 00:35:29,839
so in this particular sample at site 4

912
00:35:33,270 --> 00:35:31,680
83

913
00:35:36,550 --> 00:35:33,280

of the bacteria in this sample which was

914

00:35:38,630 --> 00:35:36,560

in the ice 20 centimeters above the uh

915

00:35:40,069 --> 00:35:38,640

sea ice interface

916

00:35:42,390 --> 00:35:40,079

so there were a lot of them there not so

917

00:35:44,630 --> 00:35:42,400

many most of the sites but the point was

918

00:35:47,430 --> 00:35:44,640

they are in the ice and they are

919

00:35:49,190 --> 00:35:47,440

associated with that

920

00:35:50,950 --> 00:35:49,200

gradient of the ice

921

00:35:52,470 --> 00:35:50,960

and i'm going to skip this part because

922

00:35:55,270 --> 00:35:52,480

it's not so

923

00:35:58,230 --> 00:35:55,280

relevant to us except i wanted to

924

00:36:00,950 --> 00:35:58,240

point out we did go then to the north

925

00:36:02,310 --> 00:36:00,960

polar area and we sampled off point

926
00:36:04,150 --> 00:36:02,320
barrel

927
00:36:06,310 --> 00:36:04,160
there are several sites here and the

928
00:36:07,589 --> 00:36:06,320
site i want to talk about mostly is site

929
00:36:10,630 --> 00:36:07,599
number two

930
00:36:12,390 --> 00:36:10,640
which was in the elson lagoon

931
00:36:14,470 --> 00:36:12,400
and this is a different sort of habitat

932
00:36:15,589 --> 00:36:14,480
from the open marine habitat because as

933
00:36:17,589 --> 00:36:15,599
a lagoon

934
00:36:19,270 --> 00:36:17,599
there's a little more evaporation and

935
00:36:21,349 --> 00:36:19,280
concentration of salt

936
00:36:24,310 --> 00:36:21,359
so it's a sort of higher salt

937
00:36:29,190 --> 00:36:24,320
uh environment than the typical sea ice

938
00:36:29,200 --> 00:36:34,630

and i don't want to talk about this now

939

00:36:38,950 --> 00:36:36,950

so the question is

940

00:36:41,109 --> 00:36:38,960

are these sea ice bacteria good

941

00:36:43,510 --> 00:36:41,119

psychophiles we weren't set out

942

00:36:45,670 --> 00:36:43,520

initially to answer this question but

943

00:36:47,190 --> 00:36:45,680

and became of interest to us

944

00:36:49,349 --> 00:36:47,200

as we went along

945

00:36:52,829 --> 00:36:49,359

and so you might just ask yourself what

946

00:36:55,190 --> 00:36:52,839

would be the features of a psychophile

947

00:36:57,190 --> 00:36:55,200

um that's living

948

00:36:59,190 --> 00:36:57,200

that you want to believe is a very good

949

00:37:02,150 --> 00:36:59,200

psychophile one would be of course its

950

00:37:04,870 --> 00:37:02,160

ability to grow at zero degrees or below

951

00:37:08,390 --> 00:37:04,880

another possibility would that be uh

952

00:37:12,150 --> 00:37:08,400

have a low gc ratio

953

00:37:14,870 --> 00:37:12,160

and this relates to the dna the gc bond

954

00:37:18,310 --> 00:37:14,880

is a triple hydrogen bond the a t bond

955

00:37:20,550 --> 00:37:18,320

in contrast is a double hydrogen bond

956

00:37:22,230 --> 00:37:20,560

so if you think about replication

957

00:37:23,589 --> 00:37:22,240

it might be better to have double

958

00:37:25,510 --> 00:37:23,599

hydrogen bonds rather than triple

959

00:37:28,550 --> 00:37:25,520

hydrogen bonds to break

960

00:37:31,990 --> 00:37:28,560

uh so maybe a low gc organism is good

961

00:37:34,790 --> 00:37:32,000

ours is a 40 gc organism

962

00:37:37,670 --> 00:37:34,800

so that's pretty low in gc content by

963

00:37:39,990 --> 00:37:37,680

the way this argument does not apply to

964

00:37:41,829 --> 00:37:40,000

thermophilic bacteria we know this

965

00:37:42,950 --> 00:37:41,839

you can have low gc organs you might

966

00:37:44,230 --> 00:37:42,960

expect

967

00:37:45,750 --> 00:37:44,240

in the case of thermophiles that they

968

00:37:47,109 --> 00:37:45,760

would have more gc

969

00:37:49,589 --> 00:37:47,119

than at

970

00:37:51,990 --> 00:37:49,599

and that's not always the case

971

00:37:53,510 --> 00:37:52,000

so but i think uh evidence so far for

972

00:37:54,790 --> 00:37:53,520

the low temperature thing may indicate

973

00:37:56,230 --> 00:37:54,800

that this history

974

00:37:58,310 --> 00:37:56,240

we're not sure yet

975

00:37:59,270 --> 00:37:58,320

another thing is a habitat as jody's

976
00:38:02,950 --> 00:37:59,280
mentioned

977
00:38:05,670 --> 00:38:02,960
the coldest temperatures at the air

978
00:38:09,030 --> 00:38:05,680
interface with the ice so the father of

979
00:38:11,750 --> 00:38:09,040
the uh ice column for the surface

980
00:38:13,589 --> 00:38:11,760
is where you'd expect maybe to find your

981
00:38:15,670 --> 00:38:13,599
low temperature organisms

982
00:38:17,430 --> 00:38:15,680
you'd also like an organism and that's

983
00:38:19,750 --> 00:38:17,440
by the way where we did find it we found

984
00:38:22,630 --> 00:38:19,760
it in the upper

985
00:38:25,030 --> 00:38:22,640
50 centimeters of a 180 centimeter ice

986
00:38:27,910 --> 00:38:25,040
core near the surface

987
00:38:29,589 --> 00:38:27,920
of the toward the air

988
00:38:32,710 --> 00:38:29,599

also a toleration of freezing point

989

00:38:34,710 --> 00:38:32,720

depressants in the medium salt our bug

990

00:38:36,950 --> 00:38:34,720

grows at 12 percent salt i think joey's

991

00:38:39,030 --> 00:38:36,960

does at least that as well

992

00:38:40,870 --> 00:38:39,040

and and glycerol we find that this

993

00:38:42,870 --> 00:38:40,880

organism that we're growing

994

00:38:44,150 --> 00:38:42,880

can grow in glycerol utilizes glycerol

995

00:38:45,589 --> 00:38:44,160

as a carbon source that's a freezing

996

00:38:48,150 --> 00:38:45,599

point depressant it'll grow in the

997

00:38:50,150 --> 00:38:48,160

presence of five percent glycerol

998

00:38:52,710 --> 00:38:50,160

the other thing is that we would hope an

999

00:38:54,710 --> 00:38:52,720

organism would have a low maximum

1000

00:38:57,510 --> 00:38:54,720

temperature or growth

1001
00:39:00,310 --> 00:38:57,520
and i'll explain that in just a second

1002
00:39:02,310 --> 00:39:00,320
uh here is the ice column that we got

1003
00:39:03,829 --> 00:39:02,320
these organisms out of

1004
00:39:07,109 --> 00:39:03,839
this is a very different ice column the

1005
00:39:09,829 --> 00:39:07,119
dark areas in this ice column

1006
00:39:11,829 --> 00:39:09,839
are not sea ice microbial community

1007
00:39:14,150 --> 00:39:11,839
they are sediment

1008
00:39:16,310 --> 00:39:14,160
so in elsin lagoon

1009
00:39:19,109 --> 00:39:16,320
you have the phenomenon of anchor ice

1010
00:39:20,710 --> 00:39:19,119
formation the ice freezes on the bottom

1011
00:39:22,230 --> 00:39:20,720
and then it floats up and carries

1012
00:39:23,670 --> 00:39:22,240
sediment with it and then that gets

1013
00:39:25,910 --> 00:39:23,680

entrapped in the ice column so it's a

1014

00:39:27,910 --> 00:39:25,920

little bit different environment

1015

00:39:30,230 --> 00:39:27,920

and our bug was isolated near the

1016

00:39:33,990 --> 00:39:30,240

surface here in this sediment

1017

00:39:37,430 --> 00:39:35,589

so i wanted to say a little bit here

1018

00:39:38,710 --> 00:39:37,440

about growth rate of bacteria versus

1019

00:39:40,550 --> 00:39:38,720

temperature

1020

00:39:42,710 --> 00:39:40,560

we have e coli that you're all quite

1021

00:39:45,589 --> 00:39:42,720

familiar with its high temperature for

1022

00:39:47,670 --> 00:39:45,599

growth is 44 degrees its low temperature

1023

00:39:51,109 --> 00:39:47,680

for growth is 8 degrees

1024

00:39:52,710 --> 00:39:51,119

so that span is about 35 36 degrees

1025

00:39:54,390 --> 00:39:52,720

in temperature and that's typical for

1026

00:39:56,390 --> 00:39:54,400

bacteria

1027

00:39:59,990 --> 00:39:56,400

hyperthermophiles they can grow as high

1028

00:40:02,870 --> 00:40:00,000

as 121 and down in the upper 80s as

1029

00:40:06,230 --> 00:40:02,880

their minimum growth temperature

1030

00:40:07,990 --> 00:40:06,240

and in the case of our bug

1031

00:40:10,710 --> 00:40:08,000

it has a low

1032

00:40:13,589 --> 00:40:10,720

maximum temperature for growth it grows

1033

00:40:16,790 --> 00:40:13,599

at 10 degrees and not higher

1034

00:40:19,030 --> 00:40:16,800

so if you sort of superimpose a growth

1035

00:40:21,990 --> 00:40:19,040

situation on this organism you would

1036

00:40:24,950 --> 00:40:22,000

expect that it could grow perhaps as low

1037

00:40:26,870 --> 00:40:24,960

temperatures at minus 20 or so

1038

00:40:28,710 --> 00:40:26,880

we don't know that that's the case

1039

00:40:29,670 --> 00:40:28,720

but we have shown growth at minus 12

1040

00:40:31,190 --> 00:40:29,680

degrees

1041

00:40:33,990 --> 00:40:31,200

so

1042

00:40:36,069 --> 00:40:34,000

the problem with the minus 20 thing is a

1043

00:40:38,790 --> 00:40:36,079

technical problem it's difficult to

1044

00:40:41,190 --> 00:40:38,800

provide conditions where you have liquid

1045

00:40:42,790 --> 00:40:41,200

water available in an experiment in the

1046

00:40:45,670 --> 00:40:42,800

laboratory

1047

00:40:48,390 --> 00:40:45,680

but that's something that i think can be

1048

00:40:50,470 --> 00:40:48,400

addressed in the future

1049

00:40:52,790 --> 00:40:50,480

here are the bacteria

1050

00:40:54,710 --> 00:40:52,800

and unlike uh what you might expect from

1051
00:40:56,870 --> 00:40:54,720
something from a cold environment these

1052
00:41:00,230 --> 00:40:56,880
are quite large bacteria about a

1053
00:41:03,109 --> 00:41:00,240
micrometer in diameter and they're 10 to

1054
00:41:05,750 --> 00:41:03,119
i think about 16 or 17 micrometers in

1055
00:41:08,630 --> 00:41:05,760
length that's a big big bacterium

1056
00:41:10,390 --> 00:41:08,640
and they have gas vesicles in them

1057
00:41:11,270 --> 00:41:10,400
which are the bright areas that you see

1058
00:41:12,710 --> 00:41:11,280
here

1059
00:41:14,470 --> 00:41:12,720
and i don't think this shows up very

1060
00:41:16,069 --> 00:41:14,480
well i didn't think it would have been

1061
00:41:18,390 --> 00:41:16,079
but you actually have

1062
00:41:21,430 --> 00:41:18,400
two types of gas vesicles here this is

1063
00:41:23,589 --> 00:41:21,440

an electron micrograph showing the cell

1064

00:41:25,670 --> 00:41:23,599

and there is a larger gas vesicle that

1065

00:41:27,670 --> 00:41:25,680

you can see somewhat and i'm afraid the

1066

00:41:30,309 --> 00:41:27,680

smaller one because of the layer and

1067

00:41:33,510 --> 00:41:30,319

such it doesn't show but there's one

1068

00:41:35,750 --> 00:41:33,520

very thin long vesicle type so it forms

1069

00:41:38,230 --> 00:41:35,760

two different types of gas vesicles

1070

00:41:40,230 --> 00:41:38,240

and we think that this may be important

1071

00:41:42,150 --> 00:41:40,240

perhaps in the brain pocket somewhere

1072

00:41:44,230 --> 00:41:42,160

along the way they have a reason for

1073

00:41:45,910 --> 00:41:44,240

producing these two different types this

1074

00:41:48,470 --> 00:41:45,920

organism actually also produces a

1075

00:41:49,430 --> 00:41:48,480

flagellum but we've never seen

1076

00:41:50,550 --> 00:41:49,440

yet

1077

00:41:52,390 --> 00:41:50,560

in our

1078

00:41:53,829 --> 00:41:52,400

we've never seen flagellar motility in

1079

00:41:55,510 --> 00:41:53,839

our cultures

1080

00:41:56,630 --> 00:41:55,520

and so this is your organism in the

1081

00:41:58,790 --> 00:41:56,640

upper

1082

00:42:00,870 --> 00:41:58,800

cluster here is the psychomonas group

1083

00:42:03,829 --> 00:42:00,880

aren't our bug is cyclomonase ingrid

1084

00:42:05,510 --> 00:42:03,839

hamiah

1085

00:42:07,510 --> 00:42:05,520

and

1086

00:42:08,950 --> 00:42:07,520

i want to point out here that we've done

1087

00:42:09,829 --> 00:42:08,960

some comparison with the genome work

1088

00:42:12,550 --> 00:42:09,839

with

1089

00:42:15,510 --> 00:42:12,560

closely related organisms the idiomarina

1090

00:42:17,910 --> 00:42:15,520

lohinsis from hawaii

1091

00:42:20,550 --> 00:42:17,920

and also with the colwellia group

1092

00:42:22,230 --> 00:42:20,560

calwellia psychiatria

1093

00:42:25,349 --> 00:42:22,240

please note that joey's organism is

1094

00:42:30,470 --> 00:42:27,190

and then some other organisms as well

1095

00:42:33,510 --> 00:42:30,480

with the genome work

1096

00:42:35,349 --> 00:42:33,520

and this is a growth curve here

1097

00:42:36,309 --> 00:42:35,359

the organism

1098

00:42:38,790 --> 00:42:36,319

grows

1099

00:42:40,550 --> 00:42:38,800

at -12 as we've said now the way we did

1100

00:42:42,950 --> 00:42:40,560

this was to make a medium up with the

1101

00:42:44,870 --> 00:42:42,960

glycerol and i think the salinity was

1102

00:42:45,910 --> 00:42:44,880

that of green water

1103

00:42:48,870 --> 00:42:45,920

and

1104

00:42:51,270 --> 00:42:48,880

we set up 25 pre-cooled tubes

1105

00:42:52,870 --> 00:42:51,280

and we inoculated these tubes

1106

00:42:54,870 --> 00:42:52,880

and

1107

00:42:56,390 --> 00:42:54,880

incubated them in a

1108

00:42:58,470 --> 00:42:56,400

very

1109

00:43:00,550 --> 00:42:58,480

a good incubator one of these hocks that

1110

00:43:02,309 --> 00:43:00,560

keeps the temperature at -12 we have

1111

00:43:04,470 --> 00:43:02,319

maximum minimum thermometer in there to

1112

00:43:05,990 --> 00:43:04,480

make sure that it never got higher than

1113

00:43:08,630 --> 00:43:06,000

the -12

1114

00:43:10,710 --> 00:43:08,640

and then we incubated these for weeks

1115

00:43:12,950 --> 00:43:10,720

now it's a very long-term experiment for

1116

00:43:15,270 --> 00:43:12,960

bacterial growth

1117

00:43:17,670 --> 00:43:15,280

and within the first week about six or

1118

00:43:19,829 --> 00:43:17,680

seven of the tubes froze

1119

00:43:22,069 --> 00:43:19,839

um

1120

00:43:23,109 --> 00:43:22,079

this is not made necessarily unexpected

1121

00:43:24,950 --> 00:43:23,119

but this is the sort of thing you

1122

00:43:27,750 --> 00:43:24,960

encounter

1123

00:43:29,190 --> 00:43:27,760

and interestingly enough after that none

1124

00:43:30,710 --> 00:43:29,200

of the tube strokes

1125

00:43:31,589 --> 00:43:30,720

and the organisms were continuing to

1126

00:43:33,910 --> 00:43:31,599

grow

1127

00:43:36,150 --> 00:43:33,920

so we think the eps that these bacteria

1128

00:43:38,630 --> 00:43:36,160

produce may have something to do

1129

00:43:41,030 --> 00:43:38,640

with lowering the freezing point of the

1130

00:43:44,309 --> 00:43:41,040

water but we're not uh positive about

1131

00:43:46,069 --> 00:43:44,319

that yet to be easily tested though

1132

00:43:49,270 --> 00:43:46,079

uh so anyway this is a growth curve we

1133

00:43:50,230 --> 00:43:49,280

got the generation time here was 240

1134

00:43:52,870 --> 00:43:50,240

hours

1135

00:43:55,349 --> 00:43:52,880

or 10 days for a generation time so it's

1136

00:43:57,990 --> 00:43:55,359

pretty slow growing

1137

00:43:59,670 --> 00:43:58,000

but it is growing nonetheless

1138

00:44:02,550 --> 00:43:59,680

so here are the features of the genome

1139

00:44:07,430 --> 00:44:05,030

first of all i think what's interesting

1140

00:44:10,150 --> 00:44:07,440

perhaps maybe the most interesting thing

1141

00:44:13,589 --> 00:44:10,160

is that the cell membrane proteins

1142

00:44:16,150 --> 00:44:13,599

are not as hydrophobic as typical cell

1143

00:44:17,829 --> 00:44:16,160

membrane proteins of bacteria

1144

00:44:20,870 --> 00:44:17,839

they're more hydrophilic

1145

00:44:22,870 --> 00:44:20,880

and this would give the bacterium

1146

00:44:23,670 --> 00:44:22,880

more fluidity in the cell membrane and

1147

00:44:24,470 --> 00:44:23,680

this is

1148

00:44:26,710 --> 00:44:24,480

uh

1149

00:44:28,069 --> 00:44:26,720

what what normally happens is the it's

1150

00:44:30,630 --> 00:44:28,079

thought that the cell membrane sort of

1151
00:44:32,309 --> 00:44:30,640
freezes up or rigidifies and then you

1152
00:44:34,470 --> 00:44:32,319
lose your ability to

1153
00:44:35,750 --> 00:44:34,480
uh to grow and transport nutrients and

1154
00:44:37,910 --> 00:44:35,760
so forth

1155
00:44:39,349 --> 00:44:37,920
and we found six different classes of

1156
00:44:41,750 --> 00:44:39,359
proteins here

1157
00:44:43,990 --> 00:44:41,760
a typical bacterium has four classes

1158
00:44:45,430 --> 00:44:44,000
there's one bacterium that has five

1159
00:44:47,630 --> 00:44:45,440
classes

1160
00:44:50,470 --> 00:44:47,640
and that's also psychophile called

1161
00:44:52,390 --> 00:44:50,480
pseudoalteromonas haloplanctus

1162
00:44:54,550 --> 00:44:52,400
this organism has actually six classes

1163
00:44:56,470 --> 00:44:54,560

of proteins so it's quite unusual

1164

00:44:59,109 --> 00:44:56,480

in that regard and this is based upon

1165

00:45:00,870 --> 00:44:59,119

correspondence analysis

1166

00:45:03,430 --> 00:45:00,880

one of these classes has many unique

1167

00:45:05,109 --> 00:45:03,440

orphan genes that may be related to low

1168

00:45:06,550 --> 00:45:05,119

temperature growth

1169

00:45:08,790 --> 00:45:06,560

and we don't know what these are are

1170

00:45:10,550 --> 00:45:08,800

doing but again express arrays would be

1171

00:45:13,910 --> 00:45:10,560

very interesting to try

1172

00:45:15,349 --> 00:45:13,920

uh to see what is perhaps going on here

1173

00:45:17,109 --> 00:45:15,359

which ones are expressed under low

1174

00:45:18,630 --> 00:45:17,119

temperatures

1175

00:45:21,510 --> 00:45:18,640

there's another interesting feature here

1176
00:45:24,390 --> 00:45:21,520
and that is that these organisms have

1177
00:45:26,150 --> 00:45:24,400
quite a bit of asparagine

1178
00:45:27,589 --> 00:45:26,160
this is amino acid that they have in

1179
00:45:29,829 --> 00:45:27,599
their proteins

1180
00:45:31,829 --> 00:45:29,839
now asparagine is interesting in that at

1181
00:45:33,430 --> 00:45:31,839
higher temperatures it breaks down to

1182
00:45:35,910 --> 00:45:33,440
aspartic acid

1183
00:45:38,230 --> 00:45:35,920
so you don't see so much in mesophiles

1184
00:45:40,870 --> 00:45:38,240
and certainly thermophiles but in this

1185
00:45:42,550 --> 00:45:40,880
psychophile you see a lot of it

1186
00:45:45,510 --> 00:45:42,560
and there's less of things like

1187
00:45:48,630 --> 00:45:45,520
methionine cysteine and histamine

1188
00:45:50,309 --> 00:45:48,640

and these are sensitive to oxygen and at

1189

00:45:52,550 --> 00:45:50,319

low temperatures of course the

1190

00:45:54,550 --> 00:45:52,560

environment is going to have a lot more

1191

00:45:55,829 --> 00:45:54,560

oxygen in it

1192

00:45:58,150 --> 00:45:55,839

so we think these things may be

1193

00:45:58,829 --> 00:45:58,160

important whoops

1194

00:46:07,510 --> 00:45:58,839

to

1195

00:46:08,710 --> 00:46:07,520

there we go

1196

00:46:10,870 --> 00:46:08,720

uh so

1197

00:46:12,870 --> 00:46:10,880

this is the correspondence analysis

1198

00:46:14,790 --> 00:46:12,880

plotting against the most informative

1199

00:46:17,030 --> 00:46:14,800

axes that they found

1200

00:46:18,790 --> 00:46:17,040

one is the asparagine concentration and

1201
00:46:20,390 --> 00:46:18,800
you can see they have generally quite a

1202
00:46:22,790 --> 00:46:20,400
bit of asparagine they're the six

1203
00:46:25,190 --> 00:46:22,800
different classes of protein illustrated

1204
00:46:29,270 --> 00:46:26,790
aromaticity

1205
00:46:30,870 --> 00:46:29,280
they don't have so many aromatic amino

1206
00:46:33,349 --> 00:46:30,880
acids in them

1207
00:46:36,390 --> 00:46:33,359
and hydrophobicity they have a low

1208
00:46:38,150 --> 00:46:36,400
hydrophobicity in the proteins so we

1209
00:46:40,150 --> 00:46:38,160
think these are probably important

1210
00:46:42,069 --> 00:46:40,160
aspects of low temperature growth this

1211
00:46:44,309 --> 00:46:42,079
is just the amino acid composition of

1212
00:46:46,870 --> 00:46:44,319
total proteins and i want to just point

1213
00:46:48,390 --> 00:46:46,880

out here is the asparagine here you can

1214

00:46:51,190 --> 00:46:48,400

see it's quite a bit higher than you

1215

00:46:53,030 --> 00:46:51,200

have an e coli shoe and alanine denses

1216

00:46:54,309 --> 00:46:53,040

and vibrio cholera

1217

00:46:55,670 --> 00:46:54,319

so there's something going on here at

1218

00:46:57,349 --> 00:46:55,680

low temperature that's consistent with

1219

00:47:01,510 --> 00:46:57,359

that

1220

00:47:03,030 --> 00:47:01,520

methionine here compared to these other

1221

00:47:05,270 --> 00:47:03,040

bacteria

1222

00:47:07,030 --> 00:47:05,280

less of the histidine

1223

00:47:09,349 --> 00:47:07,040

and less of the

1224

00:47:10,950 --> 00:47:09,359

arginine and there are other features

1225

00:47:13,109 --> 00:47:10,960

i'm not going to point out here but the

1226

00:47:16,550 --> 00:47:13,119

proteins are somewhat different in terms

1227

00:47:19,030 --> 00:47:16,560

of their amino acid composition

1228

00:47:21,990 --> 00:47:19,040

so to summarize

1229

00:47:25,109 --> 00:47:22,000

uh we have a large number of cyclic gdp

1230

00:47:25,119 --> 00:47:27,510

that

1231

00:47:34,069 --> 00:47:31,349

are important in eps production

1232

00:47:35,589 --> 00:47:34,079

there are also chaperones and stress

1233

00:47:37,990 --> 00:47:35,599

proteins that we think are very

1234

00:47:40,390 --> 00:47:38,000

important in in terms of low temperature

1235

00:47:42,309 --> 00:47:40,400

growth refolding proteins so that

1236

00:47:44,630 --> 00:47:42,319

they're more able to

1237

00:47:46,069 --> 00:47:44,640

work at lower temperatures

1238

00:47:49,510 --> 00:47:46,079

there's also

1239

00:47:52,870 --> 00:47:49,520

uh betaine choline and betaine choline

1240

00:47:54,950 --> 00:47:52,880

is an osmolite as the

1241

00:47:56,950 --> 00:47:54,960

salt concentrations in brine pockets

1242

00:47:59,750 --> 00:47:56,960

increases this osmo light would be

1243

00:48:02,870 --> 00:47:59,760

produced by the cell inside the cell to

1244

00:48:03,910 --> 00:48:02,880

counterbalance the external osmotic

1245

00:48:04,870 --> 00:48:03,920

pressure

1246

00:48:07,109 --> 00:48:04,880

from the

1247

00:48:09,190 --> 00:48:07,119

salt

1248

00:48:11,430 --> 00:48:09,200

and then it has these two different gas

1249

00:48:13,030 --> 00:48:11,440

vessel proteins inside the genome as

1250

00:48:14,470 --> 00:48:13,040

well

1251

00:48:16,470 --> 00:48:14,480

curiously

1252

00:48:17,589 --> 00:48:16,480

the most closely related organism to

1253

00:48:19,589 --> 00:48:17,599

this

1254

00:48:22,390 --> 00:48:19,599

is is not of

1255

00:48:25,109 --> 00:48:22,400

these others that were in the same group

1256

00:48:27,270 --> 00:48:25,119

uh on the basis of proteins it's vibrio

1257

00:48:28,790 --> 00:48:27,280

cholera now vibrio cholera

1258

00:48:30,790 --> 00:48:28,800

is um

1259

00:48:32,870 --> 00:48:30,800

not only a pathogen but it's in a

1260

00:48:35,270 --> 00:48:32,880

different family and it's in fact in a

1261

00:48:37,430 --> 00:48:35,280

different order of the bacteria

1262

00:48:38,790 --> 00:48:37,440

so this was really quite a surprise to

1263

00:48:39,670 --> 00:48:38,800

us

1264

00:48:41,589 --> 00:48:39,680

but

1265

00:48:42,710 --> 00:48:41,599

in looking at the types of proteins that

1266

00:48:44,950 --> 00:48:42,720

are similar

1267

00:48:47,430 --> 00:48:44,960

it turns out it's basic

1268

00:48:51,109 --> 00:48:47,440

core metabolism proteins

1269

00:48:53,910 --> 00:48:51,119

things that give the organism energy

1270

00:48:55,349 --> 00:48:53,920

they have a glycolytic system which they

1271

00:48:58,470 --> 00:48:55,359

share in common

1272

00:49:00,950 --> 00:48:58,480

they have the tca cycle for example

1273

00:49:03,109 --> 00:49:00,960

they carry out fermentation so these

1274

00:49:06,309 --> 00:49:03,119

genes are the ones that are shared

1275

00:49:08,069 --> 00:49:06,319

uh with these uh with the vibrio cholera

1276

00:49:10,870 --> 00:49:08,079

and then these are the other organisms

1277

00:49:13,670 --> 00:49:10,880

uh here that we've showed shown and

1278

00:49:15,910 --> 00:49:13,680

psycho psycho three here is is not as

1279

00:49:18,630 --> 00:49:15,920

similar as chunella yes it's kind of

1280

00:49:20,309 --> 00:49:18,640

fascinating there are these differences

1281

00:49:22,390 --> 00:49:20,319

on this

1282

00:49:23,109 --> 00:49:22,400

comparison with other bacteria

1283

00:49:23,990 --> 00:49:23,119

so

1284

00:49:25,910 --> 00:49:24,000

the

1285

00:49:27,430 --> 00:49:25,920

vibrio cholera thing as i mentioned it's

1286

00:49:29,670 --> 00:49:27,440

surprising

1287

00:49:31,430 --> 00:49:29,680

we don't think it's a horizontal gene

1288

00:49:33,430 --> 00:49:31,440

transfer julia talked about lateral gene

1289

00:49:35,270 --> 00:49:33,440

transfer horizontal gene transfer is the

1290

00:49:37,270 --> 00:49:35,280

same thing a different word for it where

1291

00:49:39,270 --> 00:49:37,280

you're getting transfer perhaps of the

1292

00:49:42,950 --> 00:49:39,280

16s gene

1293

00:49:44,549 --> 00:49:42,960

into an unrelated group namely the

1294

00:49:46,309 --> 00:49:44,559

psychomonas group we don't think that

1295

00:49:48,790 --> 00:49:46,319

that's the case because it's just these

1296

00:49:50,630 --> 00:49:48,800

poor metabolic genes we think that is

1297

00:49:52,710 --> 00:49:50,640

they share an evolutionary history with

1298

00:49:56,549 --> 00:49:52,720

vibrio but that's an ancient history and

1299

00:50:02,069 --> 00:49:59,190

they also uh we in comparing with

1300

00:50:04,549 --> 00:50:02,079

psychoarithmetic uh secretary's minus 12

1301
00:50:06,790 --> 00:50:04,559
to 19 degree bug idiom arena is not

1302
00:50:08,630 --> 00:50:06,800
really a psychophile uh but this is

1303
00:50:11,109 --> 00:50:08,640
another organization comparison as i

1304
00:50:14,390 --> 00:50:11,119
said it was quite closely related but it

1305
00:50:17,030 --> 00:50:14,400
grows from 4 degrees to 46 degrees

1306
00:50:18,790 --> 00:50:17,040
at somewhat higher growth temperatures

1307
00:50:20,549 --> 00:50:18,800
nonetheless they share

1308
00:50:22,309 --> 00:50:20,559
many proteins in common these close

1309
00:50:24,630 --> 00:50:22,319
relatives and these proteins are

1310
00:50:26,710 --> 00:50:24,640
probably the most important ones for low

1311
00:50:28,790 --> 00:50:26,720
temperature growth they include things

1312
00:50:30,710 --> 00:50:28,800
involved with rna

1313
00:50:32,790 --> 00:50:30,720

and dna uh

1314

00:50:34,309 --> 00:50:32,800

synthesis and so your dna polymerase is

1315

00:50:36,790 --> 00:50:34,319

one for example

1316

00:50:38,950 --> 00:50:36,800

rna helicases and so forth so we think

1317

00:50:41,109 --> 00:50:38,960

these are the types of enzymes that are

1318

00:50:44,710 --> 00:50:41,119

really important for

1319

00:50:46,950 --> 00:50:44,720

cyclophilic bacterial growth

1320

00:50:49,430 --> 00:50:46,960

summary here

1321

00:50:51,589 --> 00:50:49,440

gas vacuole bacteria are indigenous to

1322

00:50:55,109 --> 00:50:51,599

the sea ice community

1323

00:50:57,109 --> 00:50:55,119

sea ice bacteria are superb psychophiles

1324

00:50:59,510 --> 00:50:57,119

psychomonas ingrahamian grows at minus

1325

00:51:01,270 --> 00:50:59,520

12 or lower

1326
00:51:03,910 --> 00:51:01,280
genomic peaches that are adventurous

1327
00:51:05,990 --> 00:51:03,920
unusual membranes ludicry six glasses of

1328
00:51:09,270 --> 00:51:06,000
protein very high asparagine

1329
00:51:11,670 --> 00:51:09,280
concentrations production of eps

1330
00:51:13,030 --> 00:51:11,680
and the two types of gas festivals that

1331
00:51:15,829 --> 00:51:13,040
they have

1332
00:51:17,589 --> 00:51:15,839
so i will leave it at that and uh

1333
00:51:19,510 --> 00:51:17,599
well i should mention i wanted is

1334
00:51:21,589 --> 00:51:19,520
especially mentioned only graduate

1335
00:51:24,470 --> 00:51:21,599
students and so forth from the lab

1336
00:51:26,790 --> 00:51:24,480
monica riley she was the

1337
00:51:28,309 --> 00:51:26,800
the power behind the genome sequence and

1338
00:51:29,910 --> 00:51:28,319

i have to give her special credit here

1339

00:51:31,910 --> 00:51:29,920

because i've talked a lot about that

1340

00:51:34,230 --> 00:51:31,920

work

1341

00:51:36,069 --> 00:51:34,240

okay i guess jody are we ready for

1342

00:51:38,470 --> 00:51:36,079

questions or what's the procedure at

1343

00:51:39,829 --> 00:51:38,480

this point

1344

00:51:41,750 --> 00:51:39,839

well the first

1345

00:51:48,710 --> 00:51:41,760

thing is for all of us to thank our

1346

00:51:54,710 --> 00:51:52,630

yeah the process here is for folks with

1347

00:51:57,349 --> 00:51:54,720

questions out there to raise their hands

1348

00:52:00,150 --> 00:51:57,359

on webex is the preferred way although

1349

00:52:02,069 --> 00:52:00,160

folks can also jump in uh while you're

1350

00:52:04,470 --> 00:52:02,079

raising your hands on webex let me just

1351

00:52:07,349 --> 00:52:04,480

put in a plug for the next director

1352

00:52:09,349 --> 00:52:07,359

seminar which is four weeks from today

1353

00:52:11,510 --> 00:52:09,359

by steve benner

1354

00:52:12,950 --> 00:52:11,520

so i hope you'll all tune in then and

1355

00:52:15,270 --> 00:52:12,960

maybe i'll

1356

00:52:17,910 --> 00:52:15,280

take the chair's prerogative here to ask

1357

00:52:19,670 --> 00:52:17,920

a question which may actually be more

1358

00:52:21,750 --> 00:52:19,680

appropriately directed to somebody in

1359

00:52:24,309 --> 00:52:21,760

the audience because it's not so much

1360

00:52:26,790 --> 00:52:24,319

directly on on what you talked about but

1361

00:52:29,190 --> 00:52:26,800

on the application of what you've talked

1362

00:52:30,870 --> 00:52:29,200

about particularly to europa and jody

1363

00:52:32,710 --> 00:52:30,880

i'm thinking of

1364

00:52:34,390 --> 00:52:32,720

your discussion of the microphysics of

1365

00:52:37,030 --> 00:52:34,400

the ice and i'm just wondering if

1366

00:52:39,670 --> 00:52:37,040

anybody has done modeling

1367

00:52:42,870 --> 00:52:39,680

that you know of of the

1368

00:52:45,190 --> 00:52:42,880

frozen ice above the european ocean to

1369

00:52:46,710 --> 00:52:45,200

understand at the bottom of that ice

1370

00:52:48,470 --> 00:52:46,720

where the ice in the ocean are in

1371

00:52:50,390 --> 00:52:48,480

contact

1372

00:52:53,109 --> 00:52:50,400

what kind of thickness

1373

00:52:54,710 --> 00:52:53,119

of ice might have the kind of

1374

00:52:57,829 --> 00:52:54,720

microstructure

1375

00:52:58,870 --> 00:52:57,839

with interconnected brine pores that you

1376

00:53:02,069 --> 00:52:58,880

find

1377

00:53:03,910 --> 00:53:02,079

in the sea ice that you're looking at

1378

00:53:06,230 --> 00:53:03,920

and just you know how might that

1379

00:53:10,630 --> 00:53:06,240

microphysics be reproduced

1380

00:53:12,069 --> 00:53:10,640

at the bottom of a european ice layer

1381

00:53:13,670 --> 00:53:12,079

well i don't think anybody's done that

1382

00:53:15,750 --> 00:53:13,680

modeling work yet i think they're still

1383

00:53:19,030 --> 00:53:15,760

debating how thick the ice cover is if

1384

00:53:20,549 --> 00:53:19,040

there is a an ocean what its salinity is

1385

00:53:22,309 --> 00:53:20,559

but there's plenty of modeling work

1386

00:53:24,870 --> 00:53:22,319

that's been done with regards to earth

1387

00:53:27,190 --> 00:53:24,880

sea ice and we know that temperature and

1388

00:53:30,630 --> 00:53:27,200

the salt concentration of the source

1389

00:53:32,870 --> 00:53:30,640

liquid control the final product of the

1390

00:53:34,069 --> 00:53:32,880

ice and its interconnectivity of pore

1391

00:53:37,030 --> 00:53:34,079

space

1392

00:53:37,990 --> 00:53:37,040

so if we knew the salinity of a european

1393

00:53:40,630 --> 00:53:38,000

ocean

1394

00:53:42,309 --> 00:53:40,640

and if we knew the temperature gradient

1395

00:53:43,910 --> 00:53:42,319

then we have ways to immediately

1396

00:53:46,069 --> 00:53:43,920

calculate and model

1397

00:53:48,710 --> 00:53:46,079

where you could expect to find enough

1398

00:53:50,710 --> 00:53:48,720

liquid porosity to support

1399

00:53:52,870 --> 00:53:50,720

microbes

1400

00:53:54,790 --> 00:53:52,880

well if there are some european modelers

1401

00:53:57,349 --> 00:53:54,800

out there i hope you take that as

1402

00:54:00,150 --> 00:53:57,359

something of a challenge from jody and

1403

00:54:02,470 --> 00:54:00,160

try to take a crack at that

1404

00:54:04,390 --> 00:54:02,480

so uh let's see do we have any hands

1405

00:54:06,549 --> 00:54:04,400

raised marco there are no hands raised

1406

00:54:08,870 --> 00:54:06,559

yet in webex so let me encourage you to

1407

00:54:11,030 --> 00:54:08,880

do so if you can otherwise if somebody

1408

00:54:13,829 --> 00:54:11,040

has a question out there or a comment

1409

00:54:16,549 --> 00:54:13,839

please just jump in at this point

1410

00:54:21,990 --> 00:54:19,190

this is gene brentley at penn state

1411

00:54:23,190 --> 00:54:22,000

and can you hear me yes we sure can

1412

00:54:25,750 --> 00:54:23,200

go ahead gene

1413

00:54:28,150 --> 00:54:25,760

apparently you couldn't see us

1414

00:54:30,549 --> 00:54:28,160

anyway i wanted to ask jim staley

1415

00:54:32,870 --> 00:54:30,559

towards the end of his talk he was

1416

00:54:35,270 --> 00:54:32,880

mentioning protein similarities with

1417

00:54:37,109 --> 00:54:35,280

other organisms and unfortunately we got

1418

00:54:38,510 --> 00:54:37,119

disconnected but i was trying to figure

1419

00:54:41,589 --> 00:54:38,520

out did you mean that it was

1420

00:54:43,910 --> 00:54:41,599

phylogenetically related by rna to

1421

00:54:47,030 --> 00:54:43,920

vibrio calorie or were those just

1422

00:54:49,349 --> 00:54:47,040

protein homologies that were related

1423

00:54:51,589 --> 00:54:49,359

yeah it was protein homologies it was

1424

00:54:54,230 --> 00:54:51,599

surprising because it's not so closely

1425

00:54:56,230 --> 00:54:54,240

related on the basis of 16s phylogeny

1426

00:54:58,710 --> 00:54:56,240

and that's sort of the disparity there

1427

00:55:00,870 --> 00:54:58,720

how does one explain it but i i would

1428

00:55:05,030 --> 00:55:00,880

argue that since we're talking about

1429

00:55:07,670 --> 00:55:05,040

core metabolic genes of being in common

1430

00:55:09,750 --> 00:55:07,680

between vibrio and cyclone synchronomei

1431

00:55:12,069 --> 00:55:09,760

that that's what they share

1432

00:55:14,230 --> 00:55:12,079

and those genes one wouldn't expect to

1433

00:55:15,829 --> 00:55:14,240

necessarily be involved in this sort of

1434

00:55:18,069 --> 00:55:15,839

peripheral activity that has to do with

1435

00:55:19,589 --> 00:55:18,079

cyclophilic so i think the 16s is

1436

00:55:21,670 --> 00:55:19,599

actually true here i don't think that's

1437

00:55:22,630 --> 00:55:21,680

a 16 s transfer that's happened that

1438

00:55:23,589 --> 00:55:22,640

would be my

1439

00:55:26,150 --> 00:55:23,599

argument

1440

00:55:32,069 --> 00:55:28,069

that makes sense

1441

00:55:36,069 --> 00:55:34,230

i think somebody else was also trying to

1442

00:55:38,630 --> 00:55:36,079

break in perhaps just about the same

1443

00:55:39,510 --> 00:55:38,640

time as jeans so if uh you were please

1444

00:55:41,349 --> 00:55:39,520

go ahead

1445

00:55:45,510 --> 00:55:41,359

the vicky meadows i think yeah it was

1446

00:55:50,630 --> 00:55:48,150

jim actually about um you talk about the

1447

00:55:52,630 --> 00:55:50,640

buoyancy control for these microbes does

1448

00:55:54,630 --> 00:55:52,640

anybody know or is anybody speculated as

1449

00:55:55,829 --> 00:55:54,640

to why they might need disbuoyancy

1450

00:55:58,309 --> 00:55:55,839

control are they trying to get to

1451

00:56:00,069 --> 00:55:58,319

optimum temperatures or insulation

1452

00:56:01,750 --> 00:56:00,079

that's a very good question

1453

00:56:03,510 --> 00:56:01,760

and i didn't have time to tell you but

1454

00:56:05,190 --> 00:56:03,520

these gas vacuoles are found on all

1455

00:56:07,670 --> 00:56:05,200

sorts of bacteria especially freshwater

1456

00:56:09,750 --> 00:56:07,680

bacteria so the cyanobacteria have them

1457

00:56:11,109 --> 00:56:09,760

they want to be up to the top where the

1458

00:56:13,430 --> 00:56:11,119

well the light is coming in for

1459

00:56:15,190 --> 00:56:13,440

photosynthesis but you also have

1460

00:56:17,109 --> 00:56:15,200

photosynthetic bacteria that are in

1461

00:56:19,430 --> 00:56:17,119

oxygenic photosynthetic bacteria that

1462

00:56:20,950 --> 00:56:19,440

grow in the anaerobic zone of these very

1463

00:56:21,829 --> 00:56:20,960

same lakes where the cyanobacteria are

1464

00:56:23,430 --> 00:56:21,839

so they're

1465

00:56:25,270 --> 00:56:23,440

trying to fight beneath that there are

1466

00:56:27,270 --> 00:56:25,280

even some methanogens that produce gas

1467

00:56:28,630 --> 00:56:27,280

fractals in the archaea the same

1468

00:56:30,309 --> 00:56:28,640

structure

1469

00:56:33,270 --> 00:56:30,319

and they would be found in the sediments

1470

00:56:34,870 --> 00:56:33,280

or near to the sediments in lakes so

1471

00:56:36,230 --> 00:56:34,880

more or less depending upon the need of

1472

00:56:38,390 --> 00:56:36,240

the organism

1473

00:56:40,950 --> 00:56:38,400

any habitat that has a vertical gradient

1474

00:56:43,270 --> 00:56:40,960

like this could have gas vacuum so a

1475

00:56:44,950 --> 00:56:43,280

place like europa that would be a simple

1476

00:56:47,750 --> 00:56:44,960

organelle motility that might have

1477

00:56:52,950 --> 00:56:47,760

evolved early on and could be there yet

1478

00:56:52,960 --> 00:56:57,270

we have a question from ames

1479

00:57:01,349 --> 00:56:59,670

oh hi carl this is orlando santos over

1480

00:57:03,190 --> 00:57:01,359

in 239 and i had a question that was

1481

00:57:05,430 --> 00:57:03,200

similar to yours

1482

00:57:08,309 --> 00:57:05,440

about the physical structure of the ice

1483

00:57:10,309 --> 00:57:08,319

that contains microbes and what i'm

1484

00:57:12,870 --> 00:57:10,319

thinking about that is using it as a bio

1485

00:57:14,309 --> 00:57:12,880

signature so i'm wondering if anybody's

1486

00:57:17,270 --> 00:57:14,319

looked to see

1487

00:57:19,109 --> 00:57:17,280

how that structure changes like for

1488

00:57:22,069 --> 00:57:19,119

example say the

1489

00:57:24,390 --> 00:57:22,079

electrical conductivity of the ice or

1490

00:57:26,630 --> 00:57:24,400

the conductivity of the ice to radar for

1491

00:57:28,630 --> 00:57:26,640

example and if that could be used to

1492

00:57:29,750 --> 00:57:28,640

look to see if that structure exists on

1493

00:57:33,190 --> 00:57:29,760

europa

1494

00:57:35,589 --> 00:57:33,200

and then kind of a related question is

1495

00:57:37,190 --> 00:57:35,599

how does that structure develop under

1496

00:57:40,309 --> 00:57:37,200

different gravity conditions does

1497

00:57:42,230 --> 00:57:40,319

anybody look to see if if for example

1498

00:57:45,270 --> 00:57:42,240

hyper gravity conditions affects that

1499

00:57:50,710 --> 00:57:48,230

well those are excellent questions

1500

00:57:52,950 --> 00:57:50,720

as far as i know only proposals have

1501

00:57:55,750 --> 00:57:52,960

been written to do that sort of work

1502

00:57:58,230 --> 00:57:55,760

no work has gone forward with that

1503

00:58:01,589 --> 00:57:58,240

it keep in mind that it's fairly new

1504

00:58:03,030 --> 00:58:01,599

information that exopolymers alter the

1505

00:58:04,950 --> 00:58:03,040

physics of ice

1506

00:58:06,309 --> 00:58:04,960

so we're

1507

00:58:08,150 --> 00:58:06,319

like i said we've written a couple of

1508

00:58:10,470 --> 00:58:08,160

proposals with no success yet but we'd

1509

00:58:12,470 --> 00:58:10,480

love to look at the concept of

1510

00:58:14,470 --> 00:58:12,480

altered physics of ice as a bio

1511

00:58:17,430 --> 00:58:14,480

signature i think the problem is going

1512

00:58:19,670 --> 00:58:17,440

to be one of scale we can all already

1513

00:58:22,630 --> 00:58:19,680

recognize on a small scale that you you

1514

00:58:25,190 --> 00:58:22,640

could detect these differences both

1515

00:58:27,030 --> 00:58:25,200

visually and by the mechanical strength

1516

00:58:29,030 --> 00:58:27,040

of the ice the more porous and

1517

00:58:29,750 --> 00:58:29,040

liquid-filled it is the less strong it

1518

00:58:32,549 --> 00:58:29,760

is

1519

00:58:34,870 --> 00:58:32,559

but to detect a biosignature remotely

1520

00:58:37,670 --> 00:58:34,880

with a spacecraft you're talking about a

1521

00:58:39,910 --> 00:58:37,680

different scale of evaluating the ice

1522

00:58:42,309 --> 00:58:39,920

with lots of different issues to deal

1523

00:58:44,150 --> 00:58:42,319

with so i think that's a big challenge i

1524

00:58:47,510 --> 00:58:44,160

think conceptually we've got a

1525

00:58:49,349 --> 00:58:47,520

biosignature but to translate that into

1526

00:58:51,589 --> 00:58:49,359

one that we can use in the search for

1527

00:58:55,990 --> 00:58:51,599

life that's

1528

00:59:07,829 --> 00:58:57,829

okay we have a question from montana

1529

00:59:23,750 --> 00:59:10,150

montana state montana i think your

1530

00:59:23,760 --> 00:59:33,030

so

1531

00:59:38,309 --> 00:59:34,630

well while we're waiting for montana

1532

00:59:41,829 --> 00:59:38,319

state to unmute their microphone uh

1533

00:59:45,230 --> 00:59:41,839

i'd i'd love to hear more discussion of

1534

00:59:48,390 --> 00:59:45,240

uh this potential for using the

1535

00:59:50,309 --> 00:59:48,400

microstructure of ice as a biosignature

1536

00:59:52,150 --> 00:59:50,319

that really was striking i thought this

1537

00:59:54,549 --> 00:59:52,160

discussion that you just had with

1538

00:59:57,510 --> 00:59:54,559

orlando

1539

01:00:00,870 --> 00:59:57,520

was was very much to the point

1540

01:00:03,270 --> 01:00:00,880

uh are there

1541

01:00:06,230 --> 01:00:03,280

well what what do you think is the next

1542

01:00:08,470 --> 01:00:06,240

step you spoke about writing proposals

1543

01:00:09,589 --> 01:00:08,480

and without asking you to reveal what

1544

01:00:16,230 --> 01:00:09,599

you're writing

1545

01:00:20,230 --> 01:00:18,309

excuse me i overspoke you just at the

1546

01:00:21,990 --> 01:00:20,240

end what was your final question well

1547

01:00:25,910 --> 01:00:22,000

what what do you think are the next

1548

01:00:26,829 --> 01:00:25,920

steps in developing the ability to use

1549

01:00:29,109 --> 01:00:26,839

the

1550

01:00:32,710 --> 01:00:29,119

microstructure alterations that you're

1551

01:00:35,109 --> 01:00:32,720

seeing in ice as a result of the eps

1552

01:00:37,030 --> 01:00:35,119

the next steps in developing the ability

1553

01:00:39,910 --> 01:00:37,040

to use that as a biosignature well

1554

01:00:41,349 --> 01:00:39,920

perhaps the next baby step if you will

1555

01:00:43,990 --> 01:00:41,359

would be to

1556

01:00:46,390 --> 01:00:44,000

advance to a different scale from

1557

01:00:47,829 --> 01:00:46,400

we've gone from the millimeter down to

1558

01:00:50,069 --> 01:00:47,839

the micrometer and back up to the

1559

01:00:53,190 --> 01:00:50,079

millimeter scale let's get to the meter

1560

01:00:55,190 --> 01:00:53,200

scale which we could test in our arctic

1561

01:00:58,789 --> 01:00:55,200

develop some instrumentation that would

1562

01:01:00,309 --> 01:00:58,799

look down on arctic sea ice and look and

1563

01:01:02,870 --> 01:01:00,319

i don't know what the sensor would be

1564

01:01:04,870 --> 01:01:02,880

that would have to be worked out

1565

01:01:06,549 --> 01:01:04,880

the proposal i'm thinking of was not my

1566

01:01:08,630 --> 01:01:06,559

own

1567

01:01:09,589 --> 01:01:08,640

so i certainly won't elaborate further

1568

01:01:11,829 --> 01:01:09,599

on it

1569

01:01:14,150 --> 01:01:11,839

but there should be ways to take the

1570

01:01:15,670 --> 01:01:14,160

next step forward on the meter scale see

1571

01:01:16,630 --> 01:01:15,680

what different types of ice we can

1572

01:01:19,910 --> 01:01:16,640

detect

1573

01:01:21,190 --> 01:01:19,920

remotely at a distance of several meters

1574

01:01:23,670 --> 01:01:21,200

and you could even begin in the

1575

01:01:26,630 --> 01:01:23,680

laboratory with that process and and

1576

01:01:28,789 --> 01:01:26,640

eventually take it to the field

1577

01:01:32,710 --> 01:01:28,799

great thank you montana state do you

1578

01:01:35,670 --> 01:01:34,309

on the chat

1579

01:01:39,910 --> 01:01:35,680

ah

1580

01:01:41,990 --> 01:01:39,920

there a potential to isolate ancient

1581

01:01:43,670 --> 01:01:42,000

organisms from these brine channels in

1582

01:01:47,910 --> 01:01:43,680

an analogous fashion to what has been

1583

01:01:52,230 --> 01:01:49,270

um

1584

01:01:54,950 --> 01:01:52,240

so sea ice itself the oldest sea ice

1585

01:01:56,870 --> 01:01:54,960

that we used to have was 10 years

1586

01:01:58,789 --> 01:01:56,880

because of climate change today we're

1587

01:02:00,950 --> 01:01:58,799

losing that ice and we're losing the

1588

01:02:02,069 --> 01:02:00,960

multi-year ice so that our chances of

1589

01:02:04,630 --> 01:02:02,079

even getting

1590

01:02:06,470 --> 01:02:04,640

one or two-year-old ices is slim but

1591

01:02:09,109 --> 01:02:06,480

that certainly is not ancient

1592

01:02:11,030 --> 01:02:09,119

our best shot i think for getting

1593

01:02:13,190 --> 01:02:11,040

ancient microbes

1594

01:02:14,150 --> 01:02:13,200

analogous to the salt work that was

1595

01:02:16,870 --> 01:02:14,160

mentioned

1596

01:02:19,270 --> 01:02:16,880

is to work in permafrost and the deeper

1597

01:02:21,990 --> 01:02:19,280

in permafrost the older that material is

1598

01:02:25,349 --> 01:02:22,000

and that's why i showed you that

1599

01:02:27,430 --> 01:02:25,359

quick slide of cryo pegs these lenses of

1600

01:02:30,069 --> 01:02:27,440

liquid salt that are buried deeply in

1601

01:02:31,990 --> 01:02:30,079

permafrost they are beginning to be of a

1602

01:02:34,549 --> 01:02:32,000

geologic age

1603

01:02:36,230 --> 01:02:34,559

the russians have reported ages of up to

1604

01:02:38,470 --> 01:02:36,240

three million years

1605

01:02:41,349 --> 01:02:38,480

uh the ones that the cryo pegs we have

1606

01:02:42,870 --> 01:02:41,359

access to in alaska for example are more

1607

01:02:45,109 --> 01:02:42,880

on the order of one to two hundred

1608

01:02:48,710 --> 01:02:45,119

thousand years but that's getting us

1609

01:02:51,430 --> 01:02:48,720

there but the difference will be that

1610

01:02:54,870 --> 01:02:51,440

microbes in those cryo pegs they're in a

1611

01:02:57,109 --> 01:02:54,880

liquid uh habitat bathed by all sorts of

1612

01:02:58,230 --> 01:02:57,119

interesting things and i don't expect

1613

01:03:00,470 --> 01:02:58,240

them to be

1614

01:03:02,549 --> 01:03:00,480

preserved there but rather actively

1615

01:03:04,069 --> 01:03:02,559

evolving

1616

01:03:14,630 --> 01:03:04,079

so that's a slightly different question

1617

01:03:19,750 --> 01:03:16,390

ames your hand is still raised do you

1618

01:03:25,990 --> 01:03:22,309

oh sorry we must must have left it up

1619

01:03:31,670 --> 01:03:27,829

further questions from anyone you can

1620

01:03:37,430 --> 01:03:33,190

this is gene brenchley again since

1621

01:03:42,630 --> 01:03:39,990

i appreciated both of the talks by jody

1622

01:03:46,069 --> 01:03:42,640

and jim i did have one other thought for

1623

01:03:48,390 --> 01:03:46,079

jim he mentioned that he thought one

1624

01:03:52,549 --> 01:03:48,400

aspect of a psychophile would be that it

1625

01:03:54,789 --> 01:03:52,559

would have low gc content in the dna

1626

01:03:57,349 --> 01:03:54,799

and i can understand your reasoning and

1627

01:03:59,109 --> 01:03:57,359

thinking of terms of replication but

1628

01:04:01,270 --> 01:03:59,119

wouldn't there be so many replication

1629

01:04:04,950 --> 01:04:01,280

proteins and things to help replication

1630

01:04:07,349 --> 01:04:04,960

that maybe the gc content would be not

1631

01:04:10,150 --> 01:04:07,359

that important

1632

01:04:12,309 --> 01:04:10,160

you're quite likely right on that gene i

1633

01:04:13,109 --> 01:04:12,319

mean this is just sort of thrown out as

1634

01:05:21,829 --> 01:04:13,119

a

1635

01:05:23,750 --> 01:05:21,839

four weeks from now when steve benner

1636

01:05:26,549 --> 01:05:23,760

will be talking with us about a theory

1637

01:05:27,750 --> 01:05:26,559

of life so should be interesting okay