



AbSciCon
2019

The logo is a circular emblem with a green border. Inside, a blue satellite with a long antenna orbits a stylized landscape. The landscape includes a row of green coniferous trees at the bottom, blue mountains in the middle, and a white lighthouse-like tower in the background. The text 'AbSciCon' is written in a black, sans-serif font across the top half of the circle, and '2019' is written in a larger, bold black font across the bottom half. Small white stars are scattered around the circle's perimeter.

1
00:00:00,790 --> 00:00:07,320

[Music]

2
00:00:11,960 --> 00:00:09,160

[Applause]

3
00:00:14,450 --> 00:00:11,970

I'm excited to be here and today I want

4
00:00:16,280 --> 00:00:14,460

to talk to you about Rubisco in marine

5
00:00:19,190 --> 00:00:16,290

environments and so you've had a little

6
00:00:21,350 --> 00:00:19,200

bit of introduction to risk oh and

7
00:00:25,550 --> 00:00:21,360

Rubisco is the enzyme that fixes carbon

8
00:00:27,529 --> 00:00:25,560

dioxide in photosynthesis so just to put

9
00:00:28,570 --> 00:00:27,539

it into context I have I'm gonna go

10
00:00:31,310 --> 00:00:28,580

straight to this slide this is a

11
00:00:33,799 --> 00:00:31,320

schematic of how photosynthesis works

12
00:00:36,320 --> 00:00:33,809

and you can see Rubisco up here this is

13
00:00:39,770 --> 00:00:36,330

the enzyme that takes co2 and fixes it

14

00:00:41,899 --> 00:00:39,780

into organic carbon and then it is used

15

00:00:45,170 --> 00:00:41,909

oxygen excited synthesis so all plants

16

00:00:47,390 --> 00:00:45,180

algae cyanobacteria all use this process

17

00:00:49,399 --> 00:00:47,400

here and you can see Rubisco is part of

18

00:00:51,320 --> 00:00:49,409

the light independent reaction and it

19

00:00:54,710 --> 00:00:51,330

gets the reductant and energy to power

20

00:00:56,780 --> 00:00:54,720

this light independent reaction by using

21

00:00:58,340 --> 00:00:56,790

this light dependent reaction which

22

00:01:01,280 --> 00:00:58,350

harnesses the sun's energy and uses

23

00:01:03,920 --> 00:01:01,290

chlorophyll and all that to generate to

24

00:01:07,280 --> 00:01:03,930

generate oxygen and so as I said all

25

00:01:09,109 --> 00:01:07,290

plants algae cyanobacteria use oxygen

26

00:01:11,000 --> 00:01:09,119

'ok further synthesis to autotrophic we

27

00:01:13,310 --> 00:01:11,010

fix carbon and this is by far and away

28

00:01:17,090 --> 00:01:13,320

the most dominant way of fixing carbon

29

00:01:19,969 --> 00:01:17,100

on our planet right now but there are

30

00:01:22,819 --> 00:01:19,979

parts of the earth which are there is no

31

00:01:25,219 --> 00:01:22,829

light parts of the early Earth where and

32

00:01:26,779 --> 00:01:25,229

different environments where oxygen 'ok

33

00:01:28,999 --> 00:01:26,789

photosynthesis wasn't around and there's

34

00:01:31,450 --> 00:01:29,009

actually plenty of bacteria and archaea

35

00:01:33,830 --> 00:01:31,460

at the moment that's also used Rubisco

36

00:01:36,469 --> 00:01:33,840

but they don't have this light dependent

37

00:01:38,510 --> 00:01:36,479

pathway they can use oxidized other

38

00:01:40,700 --> 00:01:38,520

chemicals and do other reactions to

39

00:01:42,560 --> 00:01:40,710

generate reductive and energy so I

40

00:01:44,270 --> 00:01:42,570

really want to focus on Rubisco because

41

00:01:46,069 --> 00:01:44,280

it is such an important part when you

42

00:01:49,160 --> 00:01:46,079

think about how carbon is fixed on our

43

00:01:51,380 --> 00:01:49,170

planet Rubisco is the main one that does

44

00:01:53,330 --> 00:01:51,390

that and I want to talk about it in the

45

00:01:55,370 --> 00:01:53,340

marine environment because half of all

46

00:01:57,169 --> 00:01:55,380

the photosynthesis on the planet happens

47

00:01:59,569 --> 00:01:57,179

in the oceans alright so that means that

48

00:02:01,910 --> 00:01:59,579

every second breath you take that oxygen

49

00:02:04,130 --> 00:02:01,920

was produced by algae in the oceans

50

00:02:06,200 --> 00:02:04,140

which is circle and in the oceans the

51
00:02:07,999 --> 00:02:06,210
oxygen 'ok photosynthesis is largely

52
00:02:10,010 --> 00:02:08,009
produced by is this group called

53
00:02:12,800 --> 00:02:10,020
phytoplankton which is a very loose term

54
00:02:15,020 --> 00:02:12,810
that covers all sorts of single-celled

55
00:02:17,449 --> 00:02:15,030
microbes that do oxygenic photosynthesis

56
00:02:18,860 --> 00:02:17,459
and they come from a remarkably diverse

57
00:02:22,190 --> 00:02:18,870
background all the way from

58
00:02:22,640 --> 00:02:22,200
cyanobacteria to sort of hetrick on

59
00:02:24,679 --> 00:02:22,650
switch

60
00:02:28,759 --> 00:02:24,689
diatoms oquawka livers that make these

61
00:02:31,100 --> 00:02:28,769
beautiful shells to the screen algae

62
00:02:32,119 --> 00:02:31,110
anyway it's just incredibly diverse they

63
00:02:34,670 --> 00:02:32,129

have all these different types of

64

00:02:36,679 --> 00:02:34,680

Rubisco compared to plants which all

65

00:02:38,630 --> 00:02:36,689

arise from one ancestor with you know

66

00:02:40,610 --> 00:02:38,640

one type of Rubisco so the diversity in

67

00:02:42,199 --> 00:02:40,620

the oceans is huge and then you go into

68

00:02:44,240 --> 00:02:42,209

the deep oceans and hydrothermal vents

69

00:02:45,860 --> 00:02:44,250

and anoxic zones and you have all the

70

00:02:48,259 --> 00:02:45,870

bacteria and archaea that are also using

71

00:02:50,479 --> 00:02:48,269

a Rubisco to fix CO_2 so if we want to

72

00:02:52,339 --> 00:02:50,489

understand how a Bisco has evolved and

73

00:02:54,470 --> 00:02:52,349

autotrophic carbon fixation has evolved

74

00:02:57,979 --> 00:02:54,480

on our planet the oceans is a great

75

00:02:59,629 --> 00:02:57,989

place to look and so Rubisco stands for

76

00:03:02,479 --> 00:02:59,639

regulation one five five phosphate

77

00:03:05,449 --> 00:03:02,489

carboxylase oxygenase and which is i'm

78

00:03:07,729 --> 00:03:05,459

getting very good at saying that it's an

79

00:03:10,580 --> 00:03:07,739

amazing enzyme right so I said 99% of

80

00:03:13,220 --> 00:03:10,590

all biologically fixed carbon is thought

81

00:03:15,619 --> 00:03:13,230

to go through this one enzyme they think

82

00:03:17,179 --> 00:03:15,629

it's ancient over three billion years

83

00:03:19,280 --> 00:03:17,189

old and you would think with over three

84

00:03:21,229 --> 00:03:19,290

billion years of evolution it would be

85

00:03:22,789 --> 00:03:21,239

very well adapted and good at what it

86

00:03:24,860 --> 00:03:22,799

does right now right but it's not

87

00:03:28,699 --> 00:03:24,870

it is terrible it is a terrible terrible

88

00:03:31,369 --> 00:03:28,709

enzyme it is really big it is really

89

00:03:34,729 --> 00:03:31,379

slow you need a high concentration of

90

00:03:36,740 --> 00:03:34,739

co₂ around Rubisco for it to work and it

91

00:03:38,000 --> 00:03:36,750

is competitively inhibited by oxygen

92

00:03:41,360 --> 00:03:38,010

which is a challenge right in an

93

00:03:42,920 --> 00:03:41,370

oxygenated atmosphere and so the big

94

00:03:46,129 --> 00:03:42,930

question is why is this the enzyme of

95

00:03:50,930 --> 00:03:46,139

choice why is this how this planet fixes

96

00:03:52,699 --> 00:03:50,940

its carbon for life and so I want to

97

00:03:54,229 --> 00:03:52,709

introduce to you a couple of projects

98

00:03:55,849 --> 00:03:54,239

that my lab group is going through

99

00:03:57,830 --> 00:03:55,859

studying Rubisco in the diversity of

100

00:03:59,659 --> 00:03:57,840

Rubisco kinetics in modern species and

101
00:04:02,349 --> 00:03:59,669
well how that can help us inform this

102
00:04:04,369 --> 00:04:02,359
question and so I want to say that the

103
00:04:07,250 --> 00:04:04,379
one of the fundamental sort of the

104
00:04:10,580 --> 00:04:07,260
current consensus of why Rubisco isn't

105
00:04:13,309 --> 00:04:10,590
so much better than what each it is is

106
00:04:15,740 --> 00:04:13,319
because Rubisco is adapting it is

107
00:04:18,560 --> 00:04:15,750
evolving but it is biochemical

108
00:04:20,899 --> 00:04:18,570
biochemically constrained between how

109
00:04:22,700 --> 00:04:20,909
fast it can fix carbon and how specific

110
00:04:24,379 --> 00:04:22,710
it is for co2 and so what I'm showing

111
00:04:26,689 --> 00:04:24,389
you on the left-hand panel here is

112
00:04:28,370 --> 00:04:26,699
basically the speed of carboxylation

113
00:04:31,399 --> 00:04:28,380

which is the k-kat against its

114

00:04:33,019 --> 00:04:31,409

specificity for co2 / oxygen and you can

115

00:04:35,209 --> 00:04:33,029

see they generally fall across this line

116

00:04:36,170 --> 00:04:35,219

that the faster you can fix carbon the

117

00:04:38,270 --> 00:04:36,180

less specific you

118

00:04:40,550 --> 00:04:38,280

the co2 now the problem is as most of

119

00:04:41,720 --> 00:04:40,560

this data is based on plants because

120

00:04:43,430 --> 00:04:41,730

that's what people study it's really

121

00:04:44,150 --> 00:04:43,440

easy to go out and grab a plant these

122

00:04:47,120 --> 00:04:44,160

two outliers

123

00:04:48,080 --> 00:04:47,130

these are cyanobacteria all right and

124

00:04:50,390 --> 00:04:48,090

actually if we go into the marine

125

00:04:52,100 --> 00:04:50,400

environment and extract Rubisco is from

126

00:04:53,480 --> 00:04:52,110

a variety of different organisms and

127

00:04:55,430 --> 00:04:53,490

measure their abisco kinetics we see a

128

00:04:58,130 --> 00:04:55,440

remarkable diversity so that's the

129

00:05:00,440 --> 00:04:58,140

middle panel here and what I'm showing

130

00:05:02,810 --> 00:05:00,450

you on the y-axis is the KC this is the

131

00:05:04,820 --> 00:05:02,820

Hoff situation constant for co₂ so the

132

00:05:06,710 --> 00:05:04,830

concentration of co₂ you need to give

133

00:05:09,050 --> 00:05:06,720

half the maximum rate so a high scan

134

00:05:11,150 --> 00:05:09,060

means that you need a lot of co₂ to

135

00:05:13,700 --> 00:05:11,160

saturate the enzyme a low km means it's

136

00:05:15,830 --> 00:05:13,710

very has a good affinity for co₂ and

137

00:05:17,720 --> 00:05:15,840

then these are the values from bacteria

138

00:05:19,340 --> 00:05:17,730

diatoms which are really dominant

139

00:05:21,320 --> 00:05:19,350

phytoplankton group in the oceans and

140

00:05:23,390 --> 00:05:21,330

some red algae the plants and the

141

00:05:25,100 --> 00:05:23,400

cyanobacteria and you can see this

142

00:05:27,140 --> 00:05:25,110

variable response and I want to point

143

00:05:28,670 --> 00:05:27,150

out that this is a log scale on the

144

00:05:31,130 --> 00:05:28,680

y-axis alright so there's a truly

145

00:05:33,110 --> 00:05:31,140

dramatic range of Rubisco kinetics in

146

00:05:34,940 --> 00:05:33,120

these different organisms and if we take

147

00:05:36,670 --> 00:05:34,950

these diatoms which are dominant in the

148

00:05:39,860 --> 00:05:36,680

marine environment and plot their cans

149

00:05:41,690 --> 00:05:39,870

and carboxylation speeds on where we

150

00:05:43,810 --> 00:05:41,700

would expect them to fall so the grey is

151

00:05:46,400 --> 00:05:43,820

the expected relationship between

152

00:05:48,410 --> 00:05:46,410

carboxylation speed and affinity for co2

153

00:05:50,690 --> 00:05:48,420

and the diatoms are in black here and

154

00:05:52,010 --> 00:05:50,700

you can see they fall completely not on

155

00:05:53,570 --> 00:05:52,020

the line alright so we have a

156

00:05:56,240 --> 00:05:53,580

fundamental misunderstanding of how our

157

00:05:57,560 --> 00:05:56,250

Bisco works on our planet and the other

158

00:05:59,750 --> 00:05:57,570

thing is that these measurements are

159

00:06:01,430 --> 00:05:59,760

made at 25 degrees Celsius which is very

160

00:06:06,400 --> 00:06:01,440

relevant for plants they're not so

161

00:06:11,390 --> 00:06:08,620

so in the marine environment we get

162

00:06:16,780 --> 00:06:11,400

sorry don't need this out in the marine

163

00:06:20,510 --> 00:06:18,620

right you're gonna have to listen to it

164

00:06:23,300 --> 00:06:20,520

this is this is the GoPro going through

165

00:06:24,110 --> 00:06:23,310

the sea ice up in northern Alaska and I

166

00:06:27,140 --> 00:06:24,120

don't know if you can see it very well

167

00:06:28,400 --> 00:06:27,150

but this brown coloration on the bottom

168

00:06:30,260 --> 00:06:28,410

this is a metre and a half thick sea ice

169

00:06:31,790 --> 00:06:30,270

these are all diatoms growing within the

170

00:06:33,980 --> 00:06:31,800

bottom five centimetres of sea ice right

171

00:06:36,170 --> 00:06:33,990

it's an incredibly productive ecosystem

172

00:06:38,090 --> 00:06:36,180

it feeds everything out there these are

173

00:06:39,800 --> 00:06:38,100

microscopic organisms that just grow in

174

00:06:41,810 --> 00:06:39,810

these dense mats and this is at minus

175

00:06:43,580 --> 00:06:41,820

two degrees Celsius so we know that

176

00:06:46,910 --> 00:06:43,590

temperature has a big effect on how

177

00:06:48,950 --> 00:06:46,920

enzymes work and Rubisco is no exception

178

00:06:49,850 --> 00:06:48,960

and from what we can see extracting

179

00:06:52,040 --> 00:06:49,860

Rubisco from

180

00:06:53,749 --> 00:06:52,050

Paulo diet owns from warm species all

181

00:06:55,490 --> 00:06:53,759

these different things it doesn't look

182

00:06:57,379 --> 00:06:55,500

like Rubisco is cold-adapted which means

183

00:06:58,309 --> 00:06:57,389

Arco temperatures it slows down

184

00:07:00,379 --> 00:06:58,319

dramatically

185

00:07:03,529 --> 00:07:00,389

so in pink here I'm showing you the cup

186

00:07:06,110 --> 00:07:03,539

oxidation rate of which is on this axis

187

00:07:07,610 --> 00:07:06,120

here at 20 degrees and at 0 degrees

188

00:07:10,369 --> 00:07:07,620

Celsius and you get an Eightfold

189

00:07:12,260 --> 00:07:10,379

reduction of carbon fixation speed going

190

00:07:15,050 --> 00:07:12,270

from 20 to 0 degrees Celsius

191

00:07:17,480 --> 00:07:15,060

alright so it slows down a lot in

192

00:07:19,550 --> 00:07:17,490

addition the km the house situation

193

00:07:21,290 --> 00:07:19,560

constant goes from about 40 which don't

194

00:07:23,360 --> 00:07:21,300

on the it's in blue and it's shown on

195

00:07:25,490 --> 00:07:23,370

this axes here it goes from about 45

196

00:07:28,969 --> 00:07:25,500

down to 15 so it becomes more specific

197

00:07:33,080 --> 00:07:28,979

for co2 but it's really really slow and

198

00:07:34,969 --> 00:07:33,090

so polar diatoms at cold temperatures to

199

00:07:37,369 --> 00:07:34,979

compensate for the slow carboxylation

200

00:07:39,320 --> 00:07:37,379

rate they dramatically up regulate how

201
00:07:42,920 --> 00:07:39,330
much for Biscay they have and so this is

202
00:07:44,439 --> 00:07:42,930
a polar diatom species here grown in the

203
00:07:46,909 --> 00:07:44,449
lab could fragilaria up Cecil Andrus

204
00:07:49,159 --> 00:07:46,919
this is data from the field and

205
00:07:52,100 --> 00:07:49,169
Antarctica of a big diet on bloom at

206
00:07:53,899 --> 00:07:52,110
minus 2 degrees Celsius and they have

207
00:07:56,420 --> 00:07:53,909
about 16 percent of their total protein

208
00:07:58,909 --> 00:07:56,430
as Rubisco compared to only about 2.5

209
00:08:01,040 --> 00:07:58,919
percent at diatoms that grow at about 20

210
00:08:02,409 --> 00:08:01,050
degrees Celsius and this raises an

211
00:08:06,200 --> 00:08:02,419
interesting question on the theoretical

212
00:08:07,939 --> 00:08:06,210
how fast you can grow and fix carbon at

213
00:08:10,279 --> 00:08:07,949

cold temperatures because it's a

214

00:08:12,019 --> 00:08:10,289

combination of how fast the Rubisco

215

00:08:14,480 --> 00:08:12,029

enzyme works and then how much Rubisco

216

00:08:15,890 --> 00:08:14,490

can you actually make in your cell so it

217

00:08:19,790 --> 00:08:15,900

gives an interesting theoretical limit

218

00:08:21,379 --> 00:08:19,800

of how fast carbon can be fixed and so

219

00:08:23,119 --> 00:08:21,389

this work is being continued on I have

220

00:08:25,459 --> 00:08:23,129

two postdocs Ming Lee who's actually

221

00:08:26,809 --> 00:08:25,469

starting on Monday so we have all these

222

00:08:29,209 --> 00:08:26,819

Rubisco kinetic measurements over a

223

00:08:30,709 --> 00:08:29,219

range of temperatures he will be using

224

00:08:32,719 --> 00:08:30,719

membrane and mass spectrometry to

225

00:08:33,949 --> 00:08:32,729

measure carbon fixation of the whole

226

00:08:36,439 --> 00:08:33,959

cell over these different environments

227

00:08:38,449 --> 00:08:36,449

to try and get a good idea of wholesale

228

00:08:41,079 --> 00:08:38,459

carbon fixation rates and Rubisco

229

00:08:43,370 --> 00:08:41,089

kinetics and then Katrina Schmidt who

230

00:08:45,230 --> 00:08:43,380

she's not here today um but she is

231

00:08:46,759 --> 00:08:45,240

wandering around this week she is

232

00:08:48,860 --> 00:08:46,769

growing sea ice in the lab that we can

233

00:08:50,120 --> 00:08:48,870

grow algae in the sea ice so we get a

234

00:08:53,449 --> 00:08:50,130

lab environment that's much more

235

00:08:56,720 --> 00:08:53,459

representative of what we see out in the

236

00:08:58,730 --> 00:08:56,730

field so another project I want to talk

237

00:09:00,139 --> 00:08:58,740

about is looking at Rubisco

238

00:09:02,360 --> 00:09:00,149

fractionation so we just had a great

239

00:09:03,410 --> 00:09:02,370

talk on Delta C 13 and Rubisco

240

00:09:07,040 --> 00:09:03,420

fractionation

241

00:09:09,740 --> 00:09:07,050

and yes so a lot of the assumptions are

242

00:09:12,650 --> 00:09:09,750

that Rubisco fraction eights are 25 to

243

00:09:16,790 --> 00:09:12,660

29 per mil and once again this is based

244

00:09:18,650 --> 00:09:16,800

largely on literature on plants at 25

245

00:09:20,600 --> 00:09:18,660

degrees Celsius and so what I'm showing

246

00:09:22,730 --> 00:09:20,610

you here is a phylogenetic tree of all

247

00:09:25,220 --> 00:09:22,740

the different types of Rubisco that are

248

00:09:26,630 --> 00:09:25,230

found in different organisms I stole

249

00:09:30,590 --> 00:09:26,640

this tree from you cannot see probably

250

00:09:32,510 --> 00:09:30,600

but it's cushaw Bettles paper so these

251
00:09:34,040 --> 00:09:32,520
are the different types of Rubisco I've

252
00:09:35,930 --> 00:09:34,050
matched it up with in different

253
00:09:38,150 --> 00:09:35,940
organisms that have these different

254
00:09:40,490 --> 00:09:38,160
types of Rubisco and so plants all have

255
00:09:42,680 --> 00:09:40,500
this form 1b but in the marine

256
00:09:44,720 --> 00:09:42,690
environment we actually have most of

257
00:09:47,390 --> 00:09:44,730
them the eukaryotic phytoplankton have

258
00:09:49,670 --> 00:09:47,400
form C D right so a lot of diatoms cook

259
00:09:51,260 --> 00:09:49,680
ELISA floors have this seedy group and

260
00:09:53,570 --> 00:09:51,270
then there's cyanobacteria some have 1a

261
00:09:55,220 --> 00:09:53,580
so that won't be there's very few

262
00:09:56,990 --> 00:09:55,230
measurements that have been taken are

263
00:09:58,580 --> 00:09:57,000

the ones that have been measured and

264

00:10:00,830 --> 00:09:58,590

published I've shown on the right-hand

265

00:10:02,420 --> 00:10:00,840

panel here I want to reiterate I forgot

266

00:10:03,830 --> 00:10:02,430

to put the references up this is not my

267

00:10:05,780 --> 00:10:03,840

research this is a compilation of

268

00:10:07,700 --> 00:10:05,790

literature by a whole bunch of different

269

00:10:09,530 --> 00:10:07,710

people so if but I have the list so if

270

00:10:10,820 --> 00:10:09,540

anyone wants a specific number I can

271

00:10:13,190 --> 00:10:10,830

tell you who did the research and which

272

00:10:15,080 --> 00:10:13,200

paper it is but what's interesting is we

273

00:10:17,090 --> 00:10:15,090

only have three measurements from marine

274

00:10:19,520 --> 00:10:17,100

eukaryotic phytoplankton and they are

275

00:10:22,340 --> 00:10:19,530

hugely variable ie hooks as the value of

276

00:10:25,310 --> 00:10:22,350

11 per mil a diatom has 18 a red algae

277

00:10:26,900 --> 00:10:25,320

has 30 is this dramatic difference of

278

00:10:29,000 --> 00:10:26,910

Rubisco fractionation from these

279

00:10:31,550 --> 00:10:29,010

different types of old from film CD

280

00:10:33,050 --> 00:10:31,560

Rubisco so we need to look into this a

281

00:10:35,480 --> 00:10:33,060

little bit further so my grad student

282

00:10:36,920 --> 00:10:35,490

Susan who's in the audience is working

283

00:10:39,770 --> 00:10:36,930

on extracting Rubisco measuring the

284

00:10:41,060 --> 00:10:39,780

isotopic fractionation so if you have

285

00:10:45,020 --> 00:10:41,070

any questions definitely go talk to her

286

00:10:47,990 --> 00:10:45,030

and the last thing I want to talk about

287

00:10:50,240 --> 00:10:48,000

today is looking at Rubisco in even more

288

00:10:51,740 --> 00:10:50,250

extreme environments than in sea ice and

289

00:10:54,860 --> 00:10:51,750

so I want to go back to these cry pegs

290

00:10:56,630 --> 00:10:54,870

that Jody Deming was talking about and

291

00:10:58,700 --> 00:10:56,640

she already mentioned that we found

292

00:11:02,240 --> 00:10:58,710

Rubisco in there so you've stolen might

293

00:11:04,400 --> 00:11:02,250

my story but yeah it's for these cry

294

00:11:06,530 --> 00:11:04,410

fakes are truly amazing environments

295

00:11:07,730 --> 00:11:06,540

right they are ancient marine sediments

296

00:11:10,490 --> 00:11:07,740

for those that went here for Jody's

297

00:11:12,920 --> 00:11:10,500

chocolate I think most people were they

298

00:11:14,660 --> 00:11:12,930

are ancient marine sediments trapped

299

00:11:17,360 --> 00:11:14,670

within the permafrost today are really

300

00:11:19,939 --> 00:11:17,370

cold about minus 8 degrees Celsius that

301
00:11:22,850 --> 00:11:19,949
they're anoxic there anywhere between 14

302
00:11:25,519 --> 00:11:22,860
to 40,000 years old right and they are

303
00:11:27,620 --> 00:11:25,529
filled with bacteria they are filled

304
00:11:29,920 --> 00:11:27,630
with organic carbons so the vast

305
00:11:32,749 --> 00:11:29,930
majority of the bacteria in there are

306
00:11:34,999 --> 00:11:32,759
heterotrophs but we wanted to see if

307
00:11:36,829 --> 00:11:35,009
there were Rubisco and so once again

308
00:11:39,829 --> 00:11:36,839
this work was done by JC who is JD

309
00:11:41,900 --> 00:11:39,839
Demmings postdoc these are metagenomic

310
00:11:44,540 --> 00:11:41,910
samples from different car i peg samples

311
00:11:48,379 --> 00:11:44,550
that they took and these are Rubisco

312
00:11:49,850 --> 00:11:48,389
genes and their associated bacteria up

313
00:11:51,379 --> 00:11:49,860

here so we see this wide diversity

314

00:11:53,449 --> 00:11:51,389

they're not in high abundance these

315

00:11:55,160 --> 00:11:53,459

genes but they're definitely present in

316

00:11:57,259 --> 00:11:55,170

the Crytek's carbon fixation is

317

00:11:59,090 --> 00:11:57,269

happening and one bug I wanted to pull

318

00:12:01,400 --> 00:11:59,100

out in particular because this one kept

319

00:12:03,139 --> 00:12:01,410

coming up is this gamma proteobacteria

320

00:12:04,850 --> 00:12:03,149

could this microsphere arctic air which

321

00:12:07,699 --> 00:12:04,860

I stole this picture from this paper

322

00:12:10,579 --> 00:12:07,709

it's an obligate chemo litho autotroph

323

00:12:13,069 --> 00:12:10,589

it's sulfur oxidizing it has two Rubisco

324

00:12:15,050 --> 00:12:13,079

so it has a form one and a form two now

325

00:12:16,910 --> 00:12:15,060

lots of prettier bacteria can have two

326

00:12:19,910 --> 00:12:16,920

different types of Rubisco but generally

327

00:12:21,650 --> 00:12:19,920

the form one is expressed under oxic

328

00:12:23,059 --> 00:12:21,660

environments the form two is expressed

329

00:12:25,670 --> 00:12:23,069

under anoxic environments because they

330

00:12:27,769 --> 00:12:25,680

have different kinetics why this guy in

331

00:12:30,530 --> 00:12:27,779

this very stable ancient environment is

332

00:12:32,000 --> 00:12:30,540

keeping these two Rubisco 'he's might be

333

00:12:35,030 --> 00:12:32,010

a really cool thing to look at to

334

00:12:38,480 --> 00:12:35,040

understand how gene evolution works in

335

00:12:41,540 --> 00:12:38,490

these extreme environments so just to

336

00:12:43,400 --> 00:12:41,550

round it up yeah 99% of all biologically

337

00:12:46,069 --> 00:12:43,410

fixed carbon goes through Rubisco is

338

00:12:48,889 --> 00:12:46,079

this amazing ancient enzyme and by

339

00:12:50,840 --> 00:12:48,899

studying the kinetics the adaptation the

340

00:12:52,250 --> 00:12:50,850

evolution the diversity of Rubisco in

341

00:12:55,250 --> 00:12:52,260

all these different organisms and

342

00:12:56,449 --> 00:12:55,260

environments in the modern planet we can

343

00:12:58,879 --> 00:12:56,459

get a really good idea of trying to

344

00:13:01,040 --> 00:12:58,889

reconstruct how evolution adaptation

345

00:13:04,189 --> 00:13:01,050

autotrophic carbon fixation has evolved

346

00:13:05,420 --> 00:13:04,199

on the planet and just to say thank you

347

00:13:08,540 --> 00:13:05,430

obviously this work was a big

348

00:13:10,100 --> 00:13:08,550

compilation of lots of people so hannah

349

00:13:12,590 --> 00:13:10,110

dawson actually is my grad student she

350

00:13:15,800 --> 00:13:12,600

gave a talk yesterday on sea ice algal

351
00:13:18,230 --> 00:13:15,810
metabolism using metabolomics we have

352
00:13:20,720 --> 00:13:18,240
Susan and Catrin the Deming lab group

353
00:13:22,040 --> 00:13:20,730
and these are my funding bodies so yeah

354
00:13:26,590 --> 00:13:22,050
thank you very much and I'll take any

355
00:13:33,970 --> 00:13:29,480
Thank You Jody oh maybe one quick

356
00:13:40,460 --> 00:13:37,790
and Tony Murray from Georgia Tech so you

357
00:13:42,520 --> 00:13:40,470
said that there's a bunch that sort of

358
00:13:46,190 --> 00:13:42,530
lie on this nice trade-off line between

359
00:13:47,690 --> 00:13:46,200
speed and the specificity and whatnot

360
00:13:49,210 --> 00:13:47,700
but there's these others that don't and

361
00:13:52,130 --> 00:13:49,220
then you mentioned that temperature

362
00:13:55,000 --> 00:13:52,140
changes the numbers are thing that maybe

363
00:13:58,310 --> 00:13:55,010

ones that don't follow a nice trade-off

364

00:14:00,350 --> 00:13:58,320

might either because might be trading

365

00:14:01,730 --> 00:14:00,360

off with something else like I'm not

366

00:14:03,290 --> 00:14:01,740

necessarily temperature but something

367

00:14:05,810 --> 00:14:03,300

else but another dimension that like

368

00:14:08,060 --> 00:14:05,820

that like maybe the trade offline is

369

00:14:10,040 --> 00:14:08,070

just a slice of a trade off plane or

370

00:14:11,330 --> 00:14:10,050

something like that yeah no it's a good

371

00:14:12,920 --> 00:14:11,340

question I think there's obviously a lot

372

00:14:15,260 --> 00:14:12,930

more complexity there that we don't

373

00:14:17,690 --> 00:14:15,270

fully understand yet the trade offline I

374

00:14:19,460 --> 00:14:17,700

showed you all those that was all

375

00:14:21,710 --> 00:14:19,470

measurements taken at 25 degrees Celsius

376

00:14:23,060 --> 00:14:21,720

so all those ones were like the standard

377

00:14:25,070 --> 00:14:23,070

when you measure a biscuit kinetics it's

378

00:14:27,080 --> 00:14:25,080

25 so you can compare everything yeah

379

00:14:29,600 --> 00:14:27,090

but yeah obviously they don't function

380

00:14:31,490 --> 00:14:29,610

at 25 degrees Celsius all of them and so

381

00:14:32,930 --> 00:14:31,500

they've evolved to different co2

382

00:14:35,960 --> 00:14:32,940

environments to different temperatures

383

00:14:37,430 --> 00:14:35,970

different salinities all sorts of pH you

384

00:14:39,530 --> 00:14:37,440

know there's a whole myriad of different

385

00:14:41,000 --> 00:14:39,540

things we could look at and it hasn't

386

00:14:42,410 --> 00:14:41,010

really been explored yet so that's