
AB
GRAD
CON23

1
00:00:04,230 --> 00:00:11,230
[Music]

2
00:00:15,829 --> 00:00:13,490
hi everyone so I'll be talking about

3
00:00:18,349 --> 00:00:15,839
Martian metabolism and biotic chlorate

4
00:00:19,189 --> 00:00:18,359
reduction in Mars analog environments on

5
00:00:22,370 --> 00:00:19,199
Earth

6
00:00:23,630 --> 00:00:22,380
so uh since the discovery of let's see

7
00:00:25,429 --> 00:00:23,640
if I can get this video since the

8
00:00:27,769 --> 00:00:25,439
discovery of perchlorate

9
00:00:29,750 --> 00:00:27,779
on Mars by the Phoenix Lander in 2008

10
00:00:31,669 --> 00:00:29,760
it's been a compound of interest on the

11
00:00:34,150 --> 00:00:31,679
red planet this is due to its high

12
00:00:36,950 --> 00:00:34,160
oxidative potential on par with oxygen

13
00:00:40,250 --> 00:00:36,960

which means that it's a potential energy

14
00:00:42,229 --> 00:00:40,260
source for life on the red planet uh on

15
00:00:44,030 --> 00:00:42,239
Mars it's ubiquitous in Martian regolith

16
00:00:45,650 --> 00:00:44,040
reaching concentrations of 0.5 weight

17
00:00:47,389 --> 00:00:45,660
percentage

18
00:00:49,670 --> 00:00:47,399
um on Earth there are microbes that

19
00:00:51,170 --> 00:00:49,680
reduce perchlorate in place of oxygen

20
00:00:52,850 --> 00:00:51,180
and Metabolism using it to drive the

21
00:00:55,670 --> 00:00:52,860
electron transport chain

22
00:00:57,650 --> 00:00:55,680
and perchlorate accumulates in Mars

23
00:00:59,029 --> 00:00:57,660
analog systems on Earth such as the

24
00:01:01,670 --> 00:00:59,039
Atacama Desert where it reaches

25
00:01:03,470 --> 00:01:01,680
concentrations up to 0.18 percent

26
00:01:04,750 --> 00:01:03,480
as well as the Antarctic dry valleys

27
00:01:07,789 --> 00:01:04,760
where it reaches concentrations up to

28
00:01:09,710 --> 00:01:07,799
.0038 these are Mars analog systems that

29
00:01:13,429 --> 00:01:09,720
are incredibly dry and accumulate

30
00:01:16,789 --> 00:01:13,439
perchlorate via atmospheric deposition

31
00:01:19,670 --> 00:01:16,799
um over long time scales and uh

32
00:01:21,710 --> 00:01:19,680
they're likely uh looking at these

33
00:01:23,929 --> 00:01:21,720
systems it seems reasonable that per

34
00:01:25,370 --> 00:01:23,939
reducing microbes might evolve and

35
00:01:28,249 --> 00:01:25,380
persist in these types of environments

36
00:01:30,469 --> 00:01:28,259
however the model organisms that we use

37
00:01:32,510 --> 00:01:30,479
to study biotic perchlorate reduction

38
00:01:36,109 --> 00:01:32,520

don't come from Mars analog environments

39
00:01:39,230 --> 00:01:36,119
they come from the Potomac River in

40
00:01:41,450 --> 00:01:39,240
Washington DC where there's very little

41
00:01:43,490 --> 00:01:41,460
to no natural perchlorate that

42
00:01:47,929 --> 00:01:43,500
accumulates all the pcori that we do

43
00:01:49,490 --> 00:01:47,939
find here is um is waste from Munitions

44
00:01:51,530 --> 00:01:49,500
factories that gets dumped into the

45
00:01:53,870 --> 00:01:51,540
river so how did perchlorate reducing

46
00:01:54,969 --> 00:01:53,880
microbes arrive in this type of

47
00:01:57,649 --> 00:01:54,979
environment

48
00:02:00,530 --> 00:01:57,659
if they likely didn't evolve here due to

49
00:02:02,210 --> 00:02:00,540
the lack of perchloride well we know

50
00:02:03,950 --> 00:02:02,220
that the perchlorate reduction genomic

51
00:02:06,350 --> 00:02:03,960
island is widely spread via horizontal

52
00:02:08,990 --> 00:02:06,360
Gene transfer we know this because when

53
00:02:11,750 --> 00:02:09,000
we look at reducing organisms can you

54
00:02:14,449 --> 00:02:11,760
see my mouse yeah there we go

55
00:02:15,710 --> 00:02:14,459
um the elements required for biotic

56
00:02:17,869 --> 00:02:15,720
report reduction the genes that are

57
00:02:19,790 --> 00:02:17,879
required for court reduction

58
00:02:21,410 --> 00:02:19,800
um share a lot of homology between the

59
00:02:25,070 --> 00:02:21,420
genes but where the genes are situated

60
00:02:26,330 --> 00:02:25,080
in the genome is very diverse depending

61
00:02:30,410 --> 00:02:26,340
on the organism that you're looking at

62
00:02:32,150 --> 00:02:30,420
so it's a very chimeric metabolism so if

63
00:02:33,949 --> 00:02:32,160

we look here the the bright green that's

64
00:02:35,930 --> 00:02:33,959
chloride dismutates and this long dark

65
00:02:36,890 --> 00:02:35,940
green this perchlorate reductase they're

66
00:02:39,010 --> 00:02:36,900
always kind of in different

67
00:02:41,990 --> 00:02:39,020
configurations in relation to each other

68
00:02:43,610 --> 00:02:42,000
in uh in the genomic Island and that's

69
00:02:47,750 --> 00:02:43,620
because these individual elements are

70
00:02:49,670 --> 00:02:47,760
getting passed uh individually and um

71
00:02:52,130 --> 00:02:49,680
independently of one another via

72
00:02:54,770 --> 00:02:52,140
horizontal Gene transfer so you only get

73
00:02:58,190 --> 00:02:54,780
reducing microbes when these elements

74
00:03:00,290 --> 00:02:58,200
come together in the same organism

75
00:03:02,570 --> 00:03:00,300
so my research question was did

76
00:03:03,830 --> 00:03:02,580
canonical biotic reduction arise in

77
00:03:05,930 --> 00:03:03,840
these Mars analog environments like the

78
00:03:07,850 --> 00:03:05,940
atticama desert or Antarctic dry valleys

79
00:03:10,250 --> 00:03:07,860
and then disperse around the world via

80
00:03:12,710 --> 00:03:10,260
acellular and microbial dispersal

81
00:03:14,509 --> 00:03:12,720
so in order to test that I selected

82
00:03:16,790 --> 00:03:14,519
metagenoms from sites around the world

83
00:03:18,589 --> 00:03:16,800
the metagenome for those of you don't

84
00:03:20,270 --> 00:03:18,599
know is basically all the DNA in a

85
00:03:23,630 --> 00:03:20,280
sample it comes in little

86
00:03:25,970 --> 00:03:23,640
20 base pair of chunks and you have to

87
00:03:27,350 --> 00:03:25,980
piece them together like a puzzle and

88
00:03:29,570 --> 00:03:27,360

then pick out the puzzles that you're

89
00:03:31,970 --> 00:03:29,580
interested in uh that maybe make a

90
00:03:33,890 --> 00:03:31,980
picture you're interested in and then uh

91
00:03:35,869 --> 00:03:33,900
and then analyze those independent of

92
00:03:37,850 --> 00:03:35,879
the rest of the metagenome so basically

93
00:03:39,949 --> 00:03:37,860
what I did is I selected metagenoms from

94
00:03:41,930 --> 00:03:39,959
sites around the world I analyzed the

95
00:03:43,910 --> 00:03:41,940
presence of reduction genes so basically

96
00:03:45,949 --> 00:03:43,920
build the little puzzles and then pulled

97
00:03:47,570 --> 00:03:45,959
out the the ones that made reducing

98
00:03:50,390 --> 00:03:47,580
genes and then I calculated the

99
00:03:53,089 --> 00:03:50,400
phylogenetic diversity of those genes at

100
00:03:54,589 --> 00:03:53,099
each site this is a study that has

101
00:03:57,470 --> 00:03:54,599
really up until this point been done

102
00:03:59,990 --> 00:03:57,480
only in humans which is this uh type of

103
00:04:01,850 --> 00:04:00,000
analysis where we look at diversity of a

104
00:04:03,410 --> 00:04:01,860
species or a gene to determine the

105
00:04:05,030 --> 00:04:03,420
likely places where it's persisted the

106
00:04:07,009 --> 00:04:05,040
longest that's how we know that humans

107
00:04:08,270 --> 00:04:07,019
come out of Africa is because most of

108
00:04:10,610 --> 00:04:08,280
our phylogenetic diversity can be

109
00:04:13,850 --> 00:04:10,620
accounted for in Africa

110
00:04:15,170 --> 00:04:13,860
so when I did this uh so this is for

111
00:04:17,390 --> 00:04:15,180
chloride dismutase a gene that's

112
00:04:21,590 --> 00:04:17,400
involved in per quart reduction I found

113
00:04:23,570 --> 00:04:21,600

the highest diversity to be in uh in the

114
00:04:25,909 --> 00:04:23,580
uh Antarctic dry Valley so what we're

115
00:04:27,590 --> 00:04:25,919
seeing here is these bars are are a

116
00:04:29,330 --> 00:04:27,600
scale that's Faith's phylogenetic

117
00:04:31,790 --> 00:04:29,340
diversity zero is basically zero

118
00:04:34,010 --> 00:04:31,800
diversity and then up to 50 would would

119
00:04:35,150 --> 00:04:34,020
be the maximum amount of diversity in

120
00:04:38,330 --> 00:04:35,160
these genes that we see and each of

121
00:04:39,530 --> 00:04:38,340
these blue dots is a separate metagenome

122
00:04:42,350 --> 00:04:39,540
um as you can see there's a little bit

123
00:04:44,570 --> 00:04:42,360
of sampling bias because in the anterior

124
00:04:45,590 --> 00:04:44,580
dry valleys or Atacama Desert we have a

125
00:04:46,850 --> 00:04:45,600
lot more sampling there's a lot more

126
00:04:48,350 --> 00:04:46,860
research that happens in these sites

127
00:04:50,390 --> 00:04:48,360
we've got a lot more metagenomes that I

128
00:04:52,189 --> 00:04:50,400
can analyze whereas if I look at other

129
00:04:54,409 --> 00:04:52,199
Mars analog sites like the Namib Desert

130
00:04:57,409 --> 00:04:54,419
there are quite a few less or in South

131
00:04:58,969 --> 00:04:57,419
Australian desert uh much less access to

132
00:05:01,129 --> 00:04:58,979
that kind of data

133
00:05:02,450 --> 00:05:01,139
when I looked at procore reductase

134
00:05:05,030 --> 00:05:02,460
another Gene involved in biotic

135
00:05:06,830 --> 00:05:05,040
proportion reduction we also see that it

136
00:05:09,230 --> 00:05:06,840
is it reaches highest levels in the

137
00:05:10,490 --> 00:05:09,240
Antarctic dry valleys so that basically

138
00:05:13,010 --> 00:05:10,500

indicates that these genes have

139
00:05:14,870 --> 00:05:13,020
persisted the longest in in these in

140
00:05:16,969 --> 00:05:14,880
this in these in these Mars analog

141
00:05:19,070 --> 00:05:16,979
ecosystems supporting the claim that

142
00:05:20,930 --> 00:05:19,080
these may have evolved and persisted in

143
00:05:23,629 --> 00:05:20,940
those Mars analog systems

144
00:05:25,010 --> 00:05:23,639
so some conclusions uh reduction genes

145
00:05:26,870 --> 00:05:25,020
are present and diverse in Mars analog

146
00:05:28,909 --> 00:05:26,880
systems that's really awesome right

147
00:05:30,710 --> 00:05:28,919
before we didn't even know if they could

148
00:05:32,689 --> 00:05:30,720
persist in Wars analog systems but it

149
00:05:34,550 --> 00:05:32,699
looks like they both evolve and persist

150
00:05:36,110 --> 00:05:34,560
there for long time scales

151
00:05:37,850 --> 00:05:36,120
this metabolism may have evolved in

152
00:05:39,110 --> 00:05:37,860
these environments and then uh prior to

153
00:05:41,629 --> 00:05:39,120
dispersing around the world via

154
00:05:43,189 --> 00:05:41,639
acellular and microbial dispersal and

155
00:05:45,350 --> 00:05:43,199
studying for core reducing organisms in

156
00:05:46,490 --> 00:05:45,360
Mars analog environments can give us

157
00:05:48,650 --> 00:05:46,500
further insight into how life may

158
00:05:50,629 --> 00:05:48,660
persist on the red planet uh when we're

159
00:05:52,189 --> 00:05:50,639
studying life forms that do metabolisms

160
00:05:53,330 --> 00:05:52,199
like what we expect to find on Mars we

161
00:05:54,950 --> 00:05:53,340
shouldn't be looking at organisms that

162
00:05:56,930 --> 00:05:54,960
come out of the Potomac River we should

163
00:06:00,529 --> 00:05:56,940

be looking at at organisms in these Mars

164
00:06:02,930 --> 00:06:00,539
analog systems so I'd like to hear some

165
00:06:04,909 --> 00:06:02,940
some people I'd like to thank so my

166
00:06:06,590 --> 00:06:04,919
funding which is the the NSF grant for

167
00:06:08,930 --> 00:06:06,600
long-term ecological research at McMurdo

168
00:06:10,969 --> 00:06:08,940
Station uh my department at Brigham

169
00:06:13,249 --> 00:06:10,979
Young University as well as the help and

170
00:06:15,170 --> 00:06:13,259
advice of Dr John Coates at UC Berkeley

171
00:06:16,790 --> 00:06:15,180
Dr Kendall Kendall Lynch at the lunar

172
00:06:21,750 --> 00:06:16,800
and planetary Institute and Dr Jennifer

173
00:06:35,990 --> 00:06:25,300
[Music]