
AB
GRAD
CON23

1
00:00:04,230 --> 00:00:11,049
[Music]

2
00:00:15,709 --> 00:00:13,490
okay so we're gonna shift gears a little

3
00:00:17,390 --> 00:00:15,719
bit here and so my project largely

4
00:00:20,090 --> 00:00:17,400
focuses on the evolution of

5
00:00:22,550 --> 00:00:20,100
multicellularity uh in bacteria

6
00:00:24,529 --> 00:00:22,560
specifically so titled here cellular

7
00:00:26,750 --> 00:00:24,539
differentiation within an obligate

8
00:00:28,189 --> 00:00:26,760
multicellular bacteria

9
00:00:29,570 --> 00:00:28,199
so where I like to start is just

10
00:00:32,210 --> 00:00:29,580
generally when we think about the

11
00:00:33,889 --> 00:00:32,220
evolution of life on Earth we can kind

12
00:00:38,030 --> 00:00:33,899
of think of it as an increase in

13
00:00:40,069 --> 00:00:38,040

complexity as as life continue to evolve

14
00:00:42,530 --> 00:00:40,079
and this is yes and over Simplicity but

15
00:00:44,150 --> 00:00:42,540
thinking of it as molecules coming

16
00:00:46,450 --> 00:00:44,160
together to form a first cell and

17
00:00:49,729 --> 00:00:46,460
eventually getting a multi-cellular

18
00:00:50,990 --> 00:00:49,739
organism and then some something that

19
00:00:53,150 --> 00:00:51,000
looks like the life that we have on

20
00:00:56,689 --> 00:00:53,160
Earth today

21
00:00:58,490 --> 00:00:56,699
if we look at our classic uh Tree of

22
00:01:00,049 --> 00:00:58,500
Life where we have different domains of

23
00:01:03,590 --> 00:01:00,059
the bacteria the archaea and the

24
00:01:05,270 --> 00:01:03,600
eukaryotes generally we tend to think of

25
00:01:07,969 --> 00:01:05,280
all the multicellular life forms

26
00:01:10,149 --> 00:01:07,979
belonging to the Eukarya and we think of

27
00:01:14,210 --> 00:01:10,159
the bacteria and archaea as these simple

28
00:01:18,830 --> 00:01:16,490
um if we look at uh the Tree of Life as

29
00:01:20,749 --> 00:01:18,840
we know it today uh multicellularity

30
00:01:23,870 --> 00:01:20,759
actually it can be plotted across the

31
00:01:27,410 --> 00:01:23,880
entire uh tree of life and so what I'm

32
00:01:29,270 --> 00:01:27,420
showing here is the aggregative uh

33
00:01:31,609 --> 00:01:29,280
evolution of multicellularity or a

34
00:01:33,830 --> 00:01:31,619
clonal uh evolution of multicellularity

35
00:01:35,870 --> 00:01:33,840
and we see it present in the bacteria

36
00:01:39,230 --> 00:01:35,880
the archaea and the Eukarya of course

37
00:01:41,630 --> 00:01:39,240
and so just focusing in on some bacteria

38
00:01:43,810 --> 00:01:41,640

that are capable of this these are just

39
00:01:46,190 --> 00:01:43,820
some micrographs showing different uh

40
00:01:49,249 --> 00:01:46,200
cyanobacteria that are in those chains

41
00:01:52,670 --> 00:01:49,259
up there in the upper left and then mixo

42
00:01:55,190 --> 00:01:52,680
Cox mixobacteria that sporolate an

43
00:01:58,010 --> 00:01:55,200
archaea called methanosarcina another

44
00:01:59,929 --> 00:01:58,020
example is this uh bacteria called cable

45
00:02:01,730 --> 00:01:59,939
bacteria that form these long centimeter

46
00:02:03,469 --> 00:02:01,740
long filaments and can actually move

47
00:02:05,870 --> 00:02:03,479
electrons along that

48
00:02:08,330 --> 00:02:05,880
so the organism that I study is called

49
00:02:09,830 --> 00:02:08,340
multicellular magnetotactic bacteria or

50
00:02:11,630 --> 00:02:09,840
MMB for short because I just don't want

51
00:02:13,670 --> 00:02:11,640
to say that the whole talk and so this

52
00:02:16,430 --> 00:02:13,680
is what they look like where we have a

53
00:02:18,589 --> 00:02:16,440
tem image sewing uh where these cells

54
00:02:22,070 --> 00:02:18,599
are grouped together in this kind of

55
00:02:23,449 --> 00:02:22,080
soccer ball shape or football shape

56
00:02:25,070 --> 00:02:23,459
um and then here in the lower half just

57
00:02:27,410 --> 00:02:25,080
an sem showing you what that structure

58
00:02:28,490 --> 00:02:27,420
looks like so I built a cartoon kind of

59
00:02:30,110 --> 00:02:28,500
showing

60
00:02:31,850 --> 00:02:30,120
um what this Ultra structure looks like

61
00:02:33,850 --> 00:02:31,860
and one of the things I want to point

62
00:02:36,650 --> 00:02:33,860
out that pertains the name is this

63
00:02:38,150 --> 00:02:36,660

magnetotaxis and so they make these uh

64
00:02:40,910 --> 00:02:38,160
organelles inside the cells called

65
00:02:43,309 --> 00:02:40,920
magnetosomes where they synthesize a

66
00:02:45,170 --> 00:02:43,319
Paramount or ferromagnetic mineral that

67
00:02:47,570 --> 00:02:45,180
allows them to sense Earth's geomagnetic

68
00:02:50,330 --> 00:02:47,580
poles and then they can taxi in the

69
00:02:52,729 --> 00:02:50,340
water column or the sediment column

70
00:02:55,130 --> 00:02:52,739
um they also have these carbon or energy

71
00:02:57,110 --> 00:02:55,140
storage granules inside them this

72
00:02:59,330 --> 00:02:57,120
acellular Center so it's just one layer

73
00:03:00,170 --> 00:02:59,340
of cells surrounding this acellular

74
00:03:02,150 --> 00:03:00,180
Center

75
00:03:04,070 --> 00:03:02,160
and then these actin like filaments that

76
00:03:07,610 --> 00:03:04,080
seem to have some something to do with

77
00:03:11,869 --> 00:03:09,470
um I've referred to them as obligate

78
00:03:13,670 --> 00:03:11,879
multicellular organisms and this is rare

79
00:03:16,130 --> 00:03:13,680
in bacteria in fact the only example

80
00:03:18,110 --> 00:03:16,140
where the hypothesized life cycle is

81
00:03:20,750 --> 00:03:18,120
that they grow in size and then the

82
00:03:23,869 --> 00:03:20,760
entire consortia divides and so we don't

83
00:03:26,630 --> 00:03:23,879
typically see this in uh bacteria where

84
00:03:29,750 --> 00:03:26,640
typically we see this this facultative

85
00:03:31,970 --> 00:03:29,760
multicellularity so they can be uh

86
00:03:33,710 --> 00:03:31,980
multicellular but they can also exist as

87
00:03:35,030 --> 00:03:33,720
a single cell and that's true for all

88
00:03:36,229 --> 00:03:35,040

the examples I showed you with the tree

89
00:03:38,570 --> 00:03:36,239
life

90
00:03:40,910 --> 00:03:38,580
so here's just an image of uh one of the

91
00:03:43,970 --> 00:03:40,920
MMB from my sample site and kind of what

92
00:03:46,369 --> 00:03:43,980
we think it looks like uh MMB dividing

93
00:03:49,070 --> 00:03:46,379
into possibly three

94
00:03:50,869 --> 00:03:49,080
I also mentioned moment of truth if the

95
00:03:55,970 --> 00:03:50,879
video works

96
00:03:58,490 --> 00:03:55,980
um that they're magnetactic oh let me

97
00:04:04,729 --> 00:03:58,500
see if I can get this to work

98
00:04:10,550 --> 00:04:07,869
Okay cool so what we have here is a uh

99
00:04:13,789 --> 00:04:10,560
tube with the MMB in the bottom of it

100
00:04:15,649 --> 00:04:13,799
and then a magnetic stir bar next to it

101
00:04:17,750 --> 00:04:15,659
and if you just watch it you can see

102
00:04:20,569 --> 00:04:17,760
them swim up out of the bottom of that

103
00:04:22,670 --> 00:04:20,579
tube and they taxi towards the the stir

104
00:04:23,990 --> 00:04:22,680
bar these ones are going towards the

105
00:04:27,290 --> 00:04:24,000
magnetic north

106
00:04:30,170 --> 00:04:27,300
here in on the right is a hanging water

107
00:04:33,590 --> 00:04:30,180
droplet just on a cover slip and there's

108
00:04:36,050 --> 00:04:33,600
a magnet uh to the right and then what

109
00:04:37,790 --> 00:04:36,060
I've done is just move that magnet turns

110
00:04:39,230 --> 00:04:37,800
around they start taxiing the in the

111
00:04:40,730 --> 00:04:39,240
opposite direction

112
00:04:43,129 --> 00:04:40,740
so that's uh just showing their

113
00:04:44,390 --> 00:04:43,139

magnetotaxis

114
00:04:46,249 --> 00:04:44,400
um it helps when we think of

115
00:04:47,570 --> 00:04:46,259
multicellularity to have some criteria

116
00:04:49,610 --> 00:04:47,580
for what that is

117
00:04:51,590 --> 00:04:49,620
and so just a list of these would be

118
00:04:53,749 --> 00:04:51,600
built from several cells of the same

119
00:04:55,850 --> 00:04:53,759
species a specific shape and

120
00:04:57,950 --> 00:04:55,860
organization and synchronized growth so

121
00:05:01,129 --> 00:04:57,960
that exclude things like cancer

122
00:05:03,290 --> 00:05:01,139
no competition between the cells

123
00:05:06,170 --> 00:05:03,300
coordinated behavior in response to

124
00:05:08,570 --> 00:05:06,180
external or internal stimuli existence

125
00:05:10,550 --> 00:05:08,580
of cell to cell signaling and then this

126
00:05:13,310 --> 00:05:10,560
last one that's kind of like the

127
00:05:15,850 --> 00:05:13,320
catch-all metabolic differentiation or a

128
00:05:18,890 --> 00:05:15,860
division of labor so with my organism

129
00:05:21,110 --> 00:05:18,900
they fit these first four and these

130
00:05:23,570 --> 00:05:21,120
second the last two are what we're kind

131
00:05:25,249 --> 00:05:23,580
of looking into

132
00:05:27,830 --> 00:05:25,259
um one of the things we found with our

133
00:05:30,469 --> 00:05:27,840
project was that the these MMB are not

134
00:05:33,290 --> 00:05:30,479
actually clonal and how we did this was

135
00:05:35,450 --> 00:05:33,300
we sorted whole consortia's

136
00:05:37,249 --> 00:05:35,460
did multiple displacement amplifications

137
00:05:39,050 --> 00:05:37,259
so we Amplified their entire genome and

138
00:05:41,210 --> 00:05:39,060

sequenced that and we were able to map

139
00:05:43,189 --> 00:05:41,220
reads to the longest read the best

140
00:05:46,189 --> 00:05:43,199
assembly there and look at these single

141
00:05:48,770 --> 00:05:46,199
nucleotide polymorphism differences

142
00:05:50,510 --> 00:05:48,780
and what we found was that they have

143
00:05:52,430 --> 00:05:50,520
compared to controls which is a

144
00:05:54,770 --> 00:05:52,440
pseudomonas control as well as other

145
00:05:56,150 --> 00:05:54,780
environmental cosorts they have this

146
00:05:58,850 --> 00:05:56,160
much higher

147
00:06:00,350 --> 00:05:58,860
um single nucleotide polymorphism rate

148
00:06:02,990 --> 00:06:00,360
than than what we see with other

149
00:06:04,610 --> 00:06:03,000
organisms which was kind of a surprise

150
00:06:06,050 --> 00:06:04,620
and we're still scratching our heads

151
00:06:08,029 --> 00:06:06,060
about this

152
00:06:10,670 --> 00:06:08,039
um and that equates to 20 to 100

153
00:06:12,230 --> 00:06:10,680
nucleotide polymorphisms in the genome

154
00:06:14,990 --> 00:06:12,240
and their genomes are about eight

155
00:06:16,670 --> 00:06:15,000
megabases which is about double that of

156
00:06:18,770 --> 00:06:16,680
E coli

157
00:06:20,450 --> 00:06:18,780
another thing that we looked into was

158
00:06:22,790 --> 00:06:20,460
this metabolic differentiation or this

159
00:06:24,890 --> 00:06:22,800
division of labor and this was done by

160
00:06:26,450 --> 00:06:24,900
doing stable isotope incubations where

161
00:06:29,770 --> 00:06:26,460
we incubated them in the presence of

162
00:06:33,070 --> 00:06:29,780
these 13c or deuterium oxide

163
00:06:35,809 --> 00:06:33,080

chemicals and then we use uh

164
00:06:39,830 --> 00:06:35,819
nanosecondary ion Mass spectroscopy to

165
00:06:42,050 --> 00:06:39,840
look at those and map that back where we

166
00:06:44,510 --> 00:06:42,060
found in the lower left whereas the 13c

167
00:06:46,610 --> 00:06:44,520
image differences in the use of that

168
00:06:49,490 --> 00:06:46,620
substrate indicating this the vision of

169
00:06:52,430 --> 00:06:49,500
Labor that we suspected

170
00:06:54,350 --> 00:06:52,440
so with that just to kind of give

171
00:06:56,090 --> 00:06:54,360
conclusions and takeaways

172
00:06:58,309 --> 00:06:56,100
um the m and b are the only known

173
00:07:00,409 --> 00:06:58,319
obligate multidocellular bacteria that

174
00:07:02,090 --> 00:07:00,419
we know of yet

175
00:07:05,210 --> 00:07:02,100
um they are not clonal and do not

176
00:07:08,270 --> 00:07:05,220
conform to these canonical ideas of what

177
00:07:09,590 --> 00:07:08,280
multicellular multicellularity is where

178
00:07:10,490 --> 00:07:09,600
we typically have this clonal

179
00:07:13,010 --> 00:07:10,500
development

180
00:07:15,290 --> 00:07:13,020
from where one cell divides into

181
00:07:17,689 --> 00:07:15,300
daughter cells that stick together or

182
00:07:18,650 --> 00:07:17,699
this aggregative multicellularity and

183
00:07:21,170 --> 00:07:18,660
they seem to

184
00:07:23,570 --> 00:07:21,180
fall somewhere in the middle there

185
00:07:25,790 --> 00:07:23,580
they also engage in a division of labor

186
00:07:27,409 --> 00:07:25,800
as we were looking at with the metabolic

187
00:07:29,270 --> 00:07:27,419
differentiation

188
00:07:30,589 --> 00:07:29,280

and then of course just to think the lab

189
00:07:31,900 --> 00:07:30,599
and all the collaborators that help us

190
00:07:32,160 --> 00:07:31,910
with that thank you

191
00:07:37,500 --> 00:07:32,170
[Applause]