1
00:00:05,349 --> 00:00:03,189
a lot of experiments recently arriving

2
00:00:06,630 --> 00:00:05,359
on the cygnus cargo vehicle which docked

3
00:00:08,629 --> 00:00:06,640
with the international space station

4
00:00:10,470 --> 00:00:08,639
back on sunday

5
00:00:12,310 --> 00:00:10,480
yesterday i got a chance to catch up

6
00:00:14,150 --> 00:00:12,320
with one of the principal investigators

7
00:00:16,470 --> 00:00:14,160
of one of the more unique experience

8
00:00:17,750 --> 00:00:16,480
experiments that was brought on board

9
00:00:21,670 --> 00:00:17,760
so why don't we go ahead and take a

10
00:00:24,230 --> 00:00:21,680
listen to that now here on nasa tv

11
00:00:26,630 --> 00:00:24,240
so the cygnus resupply craft responsible

12
00:00:29,349 --> 00:00:26,640
for bringing over 2 700 pounds of

13
00:00:31,189 --> 00:00:29,359

supplies up to the crew of expedition 38

14
00:00:33,350 --> 00:00:31,199
among those supplies dozens of new

15
00:00:35,350 --> 00:00:33,360
experiments being brought on board the

16
00:00:36,790 --> 00:00:35,360
international space station probably one

17
00:00:39,190 --> 00:00:36,800
of the most unique and one of the most

18
00:00:41,350 --> 00:00:39,200
interesting on board is known as the

19
00:00:43,030 --> 00:00:41,360
ants in space joining me now the

20
00:00:44,470 --> 00:00:43,040
principal investigator for the project

21
00:00:46,709 --> 00:00:44,480
from the department of biology at

22
00:00:48,709 --> 00:00:46,719
stanford university professor debra m

23
00:00:50,709 --> 00:00:48,719
gordon professor thanks so much for

24
00:00:52,150 --> 00:00:50,719
joining me today i really appreciate it

25
00:00:54,150 --> 00:00:52,160
thanks for having me

26
00:00:56,310 --> 00:00:54,160
now as a professor of biology at

27
00:00:57,910 --> 00:00:56,320
stanford i've come to understand you

28
00:01:00,709 --> 00:00:57,920
study what's known as the evolutionary

29
00:01:03,670 --> 00:01:00,719
ecology of collective behavior now why

30
00:01:05,429 --> 00:01:03,680
is that you know an important research

31
00:01:08,390 --> 00:01:05,439
field and why are we studying ants in

32
00:01:10,550 --> 00:01:08,400
space to learn about it

33
00:01:13,030 --> 00:01:10,560
i study how systems work without any

34
00:01:14,789 --> 00:01:13,040
central control so in an ant colony

35
00:01:16,149 --> 00:01:14,799
nobody's in charge nobody tells anybody

36
00:01:18,710 --> 00:01:16,159
what to do

37
00:01:20,310 --> 00:01:18,720
and a lot of human engineered systems

38
00:01:21,590 --> 00:01:20,320

are like that too for example the

39
00:01:22,550 --> 00:01:21,600
internet

40
00:01:25,429 --> 00:01:22,560
or

41
00:01:27,510 --> 00:01:25,439
the problem that the ants are solving in

42
00:01:29,910 --> 00:01:27,520
space is a problem that we have to solve

43
00:01:32,630 --> 00:01:29,920
ourselves and it's the problem of how to

44
00:01:34,630 --> 00:01:32,640
search collectively how a group of

45
00:01:37,510 --> 00:01:34,640
individuals they could be ants they

46
00:01:39,990 --> 00:01:37,520
could be robots can search a space

47
00:01:41,510 --> 00:01:40,000
as effectively as possible without any

48
00:01:42,630 --> 00:01:41,520
central control

49
00:01:45,030 --> 00:01:42,640
so

50
00:01:48,469 --> 00:01:45,040
this experiment is about expandable

51
00:01:50,710 --> 00:01:48,479
search networks it's about how ant can

52
00:01:53,109 --> 00:01:50,720
adjust the shape of their paths

53
00:01:56,709 --> 00:01:53,119
to search a space in the best possible

54
00:01:59,350 --> 00:01:56,719
way adjusting their searching to the

55
00:02:00,870 --> 00:01:59,360
number of ants and the size of the space

56
00:02:02,709 --> 00:02:00,880
it's the same problem that a group of

57
00:02:05,109 --> 00:02:02,719
robots have to solve if they enter a

58
00:02:07,350 --> 00:02:05,119
burning building and have to figure out

59
00:02:09,830 --> 00:02:07,360
where to go and whether there's anything

60
00:02:12,229 --> 00:02:09,840
going on anything that needs to be fixed

61
00:02:14,869 --> 00:02:12,239
anybody that needs to be rescued

62
00:02:17,190 --> 00:02:14,879
and we'd like to be able to design a

63
00:02:18,309 --> 00:02:17,200

system and algorithm for robots to do

64
00:02:19,430 --> 00:02:18,319
that

65
00:02:21,270 --> 00:02:19,440
without

66
00:02:23,510 --> 00:02:21,280
with as little information as possible

67
00:02:25,830 --> 00:02:23,520
because that's the cheapest way to do it

68
00:02:28,630 --> 00:02:25,840
and that's a problem that ants have had

69
00:02:30,790 --> 00:02:28,640
150 million years of evolution to come

70
00:02:33,430 --> 00:02:30,800
up with great solutions

71
00:02:35,190 --> 00:02:33,440
okay and so we obviously know a lot

72
00:02:36,949 --> 00:02:35,200
about the evolution of ants up until

73
00:02:38,630 --> 00:02:36,959
this point so specifically for this

74
00:02:40,309 --> 00:02:38,640
experiment what was what were your

75
00:02:43,990 --> 00:02:40,319
guys's thoughts going into this what

76
00:02:46,229 --> 00:02:44,000
hypothesis were you working from

77
00:02:48,070 --> 00:02:46,239
well we know something about how ants on

78
00:02:50,710 --> 00:02:48,080
earth organize their searching

79
00:02:53,030 --> 00:02:50,720
collectively they adjust the shape of

80
00:02:56,229 --> 00:02:53,040
their paths so that

81
00:02:58,630 --> 00:02:56,239
when there are a few ants in a large

82
00:03:00,710 --> 00:02:58,640
space they use very straight paths to

83
00:03:03,270 --> 00:03:00,720
cover a lot of ground but when there are

84
00:03:04,390 --> 00:03:03,280
many ants in a small space

85
00:03:06,630 --> 00:03:04,400
they can

86
00:03:09,509 --> 00:03:06,640
be more thorough and each ant can take a

87
00:03:11,910 --> 00:03:09,519
much more convoluted path turning round

88
00:03:13,910 --> 00:03:11,920

and round in order to cover more ground

89
00:03:16,309 --> 00:03:13,920
because an ant searching thoroughly in

90
00:03:19,110 --> 00:03:16,319
one place can afford to do that because

91
00:03:20,229 --> 00:03:19,120
there'll be another ant nearby searching

92
00:03:21,750 --> 00:03:20,239
next door

93
00:03:23,350 --> 00:03:21,760
and they can afford to do that when

94
00:03:25,430 --> 00:03:23,360
they're very crowded

95
00:03:27,190 --> 00:03:25,440
so how do they know

96
00:03:29,670 --> 00:03:27,200
how crowded they are how do they assess

97
00:03:30,789 --> 00:03:29,680
density they use the rate at which they

98
00:03:32,630 --> 00:03:30,799
meet

99
00:03:34,710 --> 00:03:32,640
but in microgravity

100
00:03:37,430 --> 00:03:34,720
information about

101
00:03:39,350 --> 00:03:37,440
density isn't perfect in microgravity

102
00:03:41,270 --> 00:03:39,360
because the way that they walk around is

103
00:03:44,710 --> 00:03:41,280
influenced by

104
00:03:46,710 --> 00:03:44,720
the lack of gravity by that very basic

105
00:03:47,910 --> 00:03:46,720
orientation that they get from gravity

106
00:03:49,750 --> 00:03:47,920
being missing

107
00:03:51,990 --> 00:03:49,760
then the rate at which they meet won't

108
00:03:54,710 --> 00:03:52,000
correspond to density exactly

109
00:03:56,710 --> 00:03:54,720
so the hypothesis that we're testing is

110
00:03:59,910 --> 00:03:56,720
how in microgravity with imperfect

111
00:04:01,830 --> 00:03:59,920
information do ants adjust their paths

112
00:04:04,630 --> 00:04:01,840
to density

113
00:04:06,229 --> 00:04:04,640

okay and that was this was literally one

114
00:04:08,630 --> 00:04:06,239
of the first things to come out of the

115
00:04:10,710 --> 00:04:08,640
cygnus craft once it was docked and uh

116
00:04:12,470 --> 00:04:10,720
nas astronaut rick mastracchio was able

117
00:04:14,149 --> 00:04:12,480
to set it up on monday

118
00:04:16,629 --> 00:04:14,159
and actually execute the experiment can

119
00:04:17,749 --> 00:04:16,639
you describe uh just what happened or

120
00:04:21,590 --> 00:04:17,759
kind of what some of your early

121
00:04:22,469 --> 00:04:21,600
observations were from the experiment

122
00:04:25,270 --> 00:04:22,479
yes

123
00:04:26,950 --> 00:04:25,280
well the experiment consists of um ants

124
00:04:29,270 --> 00:04:26,960
in a rectangular

125
00:04:32,230 --> 00:04:29,280
arena with two barriers

126
00:04:35,110 --> 00:04:32,240
so they traveled confined in a very

127
00:04:37,670 --> 00:04:35,120
narrow nest area and then

128
00:04:39,830 --> 00:04:37,680
uh put the barrier down so that there

129
00:04:41,670 --> 00:04:39,840
were a lot of ants searching a small

130
00:04:44,150 --> 00:04:41,680
area and

131
00:04:46,550 --> 00:04:44,160
you'd expect them to use very convoluted

132
00:04:49,110 --> 00:04:46,560
paths because they can afford to be

133
00:04:50,950 --> 00:04:49,120
thorough when they're crowded and then

134
00:04:53,430 --> 00:04:50,960
the second barrier went down so then

135
00:04:55,590 --> 00:04:53,440
they were in a larger space so suddenly

136
00:04:57,909 --> 00:04:55,600
density has gone down it's as though

137
00:05:00,070 --> 00:04:57,919
there are a few ants in a big area and

138
00:05:02,710 --> 00:05:00,080

they have to stretch out the network of

139
00:05:04,469 --> 00:05:02,720
paths they have to use straighter paths

140
00:05:06,390 --> 00:05:04,479
and so the experiment consisted of

141
00:05:09,430 --> 00:05:06,400
seeing how the ants would adjust their

142
00:05:11,670 --> 00:05:09,440
paths when their density changed and it

143
00:05:13,830 --> 00:05:11,680
looks as though they

144
00:05:15,510 --> 00:05:13,840
had a little trouble in microgravity the

145
00:05:17,590 --> 00:05:15,520
arena was very

146
00:05:19,990 --> 00:05:17,600
shallow the ceiling was very low so they

147
00:05:22,950 --> 00:05:20,000
weren't floating around but still they

148
00:05:23,749 --> 00:05:22,960
had to work harder to just to move and

149
00:05:25,670 --> 00:05:23,759
so

150
00:05:27,670 --> 00:05:25,680
their interactions with each other were

151
00:05:30,550 --> 00:05:27,680
influenced by that and so we're going to

152
00:05:32,150 --> 00:05:30,560
be now analyzing the data to see how

153
00:05:35,670 --> 00:05:32,160
exactly they used the rate of

154
00:05:37,110 --> 00:05:35,680
interaction to adjust their searching

155
00:05:39,670 --> 00:05:37,120
okay and

156
00:05:41,270 --> 00:05:39,680
another thing that struck me is pretty

157
00:05:42,790 --> 00:05:41,280
pretty cool about this study is you guys

158
00:05:44,790 --> 00:05:42,800
are also going to be kind of reaching

159
00:05:46,870 --> 00:05:44,800
out to classrooms and students to do

160
00:05:49,110 --> 00:05:46,880
their own versions of this experiment

161
00:05:50,950 --> 00:05:49,120
can you talk a little bit about that

162
00:05:54,230 --> 00:05:50,960
this is a really simple experiment that

163
00:05:57,350 --> 00:05:54,240

anyone can do and with very simple cheap

164
00:05:59,270 --> 00:05:57,360
materials anybody can test how their

165
00:06:01,110 --> 00:05:59,280
local favorite ants

166
00:06:03,510 --> 00:06:01,120
are searching collectively how they're

167
00:06:05,110 --> 00:06:03,520
working together to cover ground and be

168
00:06:08,150 --> 00:06:05,120
effective searchers

169
00:06:09,830 --> 00:06:08,160
and i think that probably the invasive

170
00:06:12,150 --> 00:06:09,840
species that we tend to see in our

171
00:06:13,990 --> 00:06:12,160
kitchens all around the world are there

172
00:06:15,749 --> 00:06:14,000
because for one thing they're really

173
00:06:17,830 --> 00:06:15,759
good at searching and so i think it'll

174
00:06:19,909 --> 00:06:17,840
be really interesting if kids around the

175
00:06:21,510 --> 00:06:19,919
world try this experiment with different

176
00:06:23,590 --> 00:06:21,520
kinds of ants and then we're going to

177
00:06:26,230 --> 00:06:23,600
have a central database compare the

178
00:06:29,029 --> 00:06:26,240
results and see how ants in different

179
00:06:31,029 --> 00:06:29,039
places operate as searchers

180
00:06:32,950 --> 00:06:31,039
so it's interesting to see not just how

181
00:06:35,110 --> 00:06:32,960
they do it in gravity and microgravity

182
00:06:36,790 --> 00:06:35,120
but how they do it in different kinds of

183
00:06:38,230 --> 00:06:36,800
ecological conditions in different

184
00:06:39,749 --> 00:06:38,240
places

185
00:06:41,590 --> 00:06:39,759
and i mean that definitely sounds good i

186
00:06:43,110 --> 00:06:41,600
mean what kids don't like playing with

187
00:06:45,270 --> 00:06:43,120
bugs so it could definitely be a really

188
00:06:47,350 --> 00:06:45,280

cool way to you know get young kids

189
00:06:48,950 --> 00:06:47,360
interested in math and science so

190
00:06:50,710 --> 00:06:48,960
obvious next steps for your research

191
00:06:52,790 --> 00:06:50,720
you're going to be analyzing the data do

192
00:06:55,189 --> 00:06:52,800
you have any you know further outlooking

193
00:06:56,950 --> 00:06:55,199
plans flying more ants any other type of

194
00:06:59,589 --> 00:06:56,960
insect that might work with that swarm

195
00:07:01,990 --> 00:06:59,599
mentality

196
00:07:03,589 --> 00:07:02,000
i've learned in the course of talking to

197
00:07:04,950 --> 00:07:03,599
people about this experiment that there

198
00:07:07,749 --> 00:07:04,960
are a lot of really interesting

199
00:07:09,749 --> 00:07:07,759
biological changes that go on in

200
00:07:11,830 --> 00:07:09,759
microgravity for example the way that

201
00:07:13,749 --> 00:07:11,840
nutrients circulate around cells the way

202
00:07:15,909 --> 00:07:13,759
that genes are expressed

203
00:07:18,390 --> 00:07:15,919
and so i think that we really have a lot

204
00:07:21,029 --> 00:07:18,400
to learn about how collective behavior

205
00:07:23,909 --> 00:07:21,039
operates by trying it in space

206
00:07:25,029 --> 00:07:23,919
so if i'm invited again to design more

207
00:07:27,510 --> 00:07:25,039
research

208
00:07:29,110 --> 00:07:27,520
i would definitely say yes

209
00:07:31,510 --> 00:07:29,120
would you be using ants again you think

210
00:07:34,629 --> 00:07:31,520
they seem to have quite a bit of

211
00:07:36,870 --> 00:07:34,639
evolutionary history behind them

212
00:07:39,830 --> 00:07:36,880
yes there's uh ants

213
00:07:41,909 --> 00:07:39,840

well ants have evolved collective

214
00:07:44,390 --> 00:07:41,919
behavior what we call in robotics

215
00:07:46,629 --> 00:07:44,400
distributed algorithms for accomplishing

216
00:07:48,150 --> 00:07:46,639
a lot of different tasks and i think

217
00:07:49,830 --> 00:07:48,160
that we really have a lot to learn from

218
00:07:52,790 --> 00:07:49,840
the ants

219
00:07:54,469 --> 00:07:52,800
well in the words of a famous tv newsman

220
00:07:55,749 --> 00:07:54,479
i for one welcome our new insect

221
00:07:57,029 --> 00:07:55,759
overlords

222
00:07:59,830 --> 00:07:57,039
uh well

223
00:08:02,390 --> 00:07:59,840
i mean again fascinating study i really

224
00:08:03,909 --> 00:08:02,400
appreciate you taking some time out to

225
00:08:05,830 --> 00:08:03,919
give us the nuts and bolts of this we

226
00:08:08,070 --> 00:08:05,840
really look forward to uh seeing your

227
00:08:10,070 --> 00:08:08,080
results again uh principal investigator

228
00:08:11,830 --> 00:08:10,080
for ants in space professor deborah m

229
00:08:13,589 --> 00:08:11,840
gordon from stanford university thank