1
00:00:03,590 --> 00:00:01,990
nasa's jet propulsion laboratory

2
00:00:06,309 --> 00:00:03,600
presents

3
00:00:08,310 --> 00:00:06,319
the von carmen lecture a series of talks

4
00:00:11,589 --> 00:00:08,320
by scientists and engineers who are

5
00:00:18,950 --> 00:00:11,599
exploring our planet our solar system

6
00:00:24,630 --> 00:00:21,349
hello and welcome to another edition of

7
00:00:26,230 --> 00:00:24,640
the 2022 von carmen talks i am nikki

8
00:00:28,550 --> 00:00:26,240
weirich from jpl's office of

9
00:00:30,710 --> 00:00:28,560
communications and education and i will

10
00:00:34,389 --> 00:00:30,720
be your host for our topic this evening

11
00:00:36,870 --> 00:00:34,399
curiosity a decade on mars

12
00:00:40,709 --> 00:00:36,880
curiosity successfully landed on the

13
00:00:43,350 --> 00:00:40,719

surface of mars august 5th of 2012.

14
00:00:46,709 --> 00:00:43,360
in the past decade curiosity also known

15
00:00:49,750 --> 00:00:46,719
as the mars science laboratory or msl

16
00:00:52,709 --> 00:00:49,760
has exceeded expectations completed some

17
00:00:54,069 --> 00:00:52,719
amazing science and has so much more to

18
00:00:56,310 --> 00:00:54,079
give

19
00:00:58,869 --> 00:00:56,320
joining us as co-hosts this evening is

20
00:01:01,750 --> 00:00:58,879
sarah marcotte sarah brings over two

21
00:01:03,750 --> 00:01:01,760
decades of experience inspiring learning

22
00:01:06,070 --> 00:01:03,760
in out-of-school environments

23
00:01:08,550 --> 00:01:06,080
currently a public engagement specialist

24
00:01:11,109 --> 00:01:08,560
for jpl she works to connect learners of

25
00:01:14,710 --> 00:01:11,119
all ages to current scientific research

26
00:01:17,670 --> 00:01:14,720
in person and online through events

27
00:01:18,789 --> 00:01:17,680
exhibits and virtual experiences hiya

28
00:01:20,230 --> 00:01:18,799
sarah

29
00:01:21,990 --> 00:01:20,240
hey there

30
00:01:23,670 --> 00:01:22,000
great to be here tonight nikki

31
00:01:25,270 --> 00:01:23,680
oh we are so happy you are here now

32
00:01:26,789 --> 00:01:25,280
you've got some resources to share with

33
00:01:28,310 --> 00:01:26,799
us as well tonight so i'm going to throw

34
00:01:30,149 --> 00:01:28,320
it over to you to share some of those

35
00:01:32,550 --> 00:01:30,159
resources

36
00:01:34,789 --> 00:01:32,560
that sounds great so i am so happy to be

37
00:01:36,149 --> 00:01:34,799
here tonight this mission was the first

38
00:01:37,749 --> 00:01:36,159

one that i

39
00:01:40,550 --> 00:01:37,759
worked on as a public engagement

40
00:01:42,789 --> 00:01:40,560
specialist here at jpl so

41
00:01:45,590 --> 00:01:42,799
it was my first introduction to

42
00:01:48,469 --> 00:01:45,600
um what happens on mars and the biggest

43
00:01:51,749 --> 00:01:48,479
most capable rover that we send to mars

44
00:01:54,870 --> 00:01:51,759
so it has a place near and dear in my

45
00:01:56,550 --> 00:01:54,880
heart now i want to let people know how

46
00:01:58,069 --> 00:01:56,560
they can follow along with the mission

47
00:01:59,749 --> 00:01:58,079
of course you've tuned in tonight to

48
00:02:02,069 --> 00:01:59,759
hear from two very important mission

49
00:02:04,550 --> 00:02:02,079
team members however there are times

50
00:02:07,109 --> 00:02:04,560
when you're at home and you want to um

51
00:02:10,309 --> 00:02:07,119
see what is happening with the rover so

52
00:02:11,750 --> 00:02:10,319
i would like to see the rover website um

53
00:02:12,869 --> 00:02:11,760
if we can

54
00:02:15,110 --> 00:02:12,879
pull up a

55
00:02:16,630 --> 00:02:15,120
i want to tell you about the url first

56
00:02:18,630 --> 00:02:16,640
so the

57
00:02:22,150 --> 00:02:18,640
mars.nasa.gov

58
00:02:23,589 --> 00:02:22,160
slash msl for mars science laboratory

59
00:02:25,110 --> 00:02:23,599
that is your home page that's where

60
00:02:27,190 --> 00:02:25,120
you're going to get all the good stuff

61
00:02:29,430 --> 00:02:27,200
now when i'm on that site i learn about

62
00:02:31,509 --> 00:02:29,440
the rover i see what's happening there's

63
00:02:33,190 --> 00:02:31,519

a blog so you can keep up to date with

64
00:02:35,990 --> 00:02:33,200
the science but one of my favorite

65
00:02:39,670 --> 00:02:36,000
things on this website is the location

66
00:02:42,550 --> 00:02:39,680
map so this shows where curiosity is in

67
00:02:45,509 --> 00:02:42,560
gale crater and has been for the over 3

68
00:02:48,470 --> 00:02:45,519
000 sauls or martian days that curiosity

69
00:02:50,150 --> 00:02:48,480
has been exploring gale crater so every

70
00:02:52,390 --> 00:02:50,160
time the rover drives this map is

71
00:02:54,309 --> 00:02:52,400
updated with the location

72
00:02:57,110 --> 00:02:54,319
now there's another thing neat thing

73
00:02:59,270 --> 00:02:57,120
that ties into this location map so on

74
00:03:01,270 --> 00:02:59,280
the next graphic you're going to see

75
00:03:04,470 --> 00:03:01,280
actually it's cute little video

76
00:03:08,309 --> 00:03:04,480
this is called explore with curiosity

77
00:03:10,790 --> 00:03:08,319
now this is real data so both of these

78
00:03:12,630 --> 00:03:10,800
experiences are using real data from the

79
00:03:14,550 --> 00:03:12,640
rover so when people

80
00:03:16,949 --> 00:03:14,560
drive the rover and it gets updated on

81
00:03:20,070 --> 00:03:16,959
that map and the cameras take pictures

82
00:03:22,949 --> 00:03:20,080
it comes into both of these experiences

83
00:03:23,910 --> 00:03:22,959
so you can see a cgi version of the

84
00:03:26,470 --> 00:03:23,920
rover

85
00:03:28,070 --> 00:03:26,480
in gale crater that's all real data and

86
00:03:30,470 --> 00:03:28,080
then on the left hand side look there

87
00:03:32,470 --> 00:03:30,480
all these pictures that the cameras took

88
00:03:34,550 --> 00:03:32,480

on any particular day

89
00:03:36,789 --> 00:03:34,560
so i love those two things because i can

90
00:03:39,350 --> 00:03:36,799
always see where the rover is in gale

91
00:03:41,430 --> 00:03:39,360
crater as it's ascending up the side of

92
00:03:42,949 --> 00:03:41,440
a mountain and then i like to see all

93
00:03:45,509 --> 00:03:42,959
the different cameras in the pictures

94
00:03:48,470 --> 00:03:45,519
that they took so those are two great

95
00:03:50,550 --> 00:03:48,480
resources to follow along and it's all

96
00:03:53,110 --> 00:03:50,560
using real data and it hits the website

97
00:03:55,190 --> 00:03:53,120
the minute that the rover does anything

98
00:03:56,869 --> 00:03:55,200
so that's what i wanted to share and

99
00:03:57,910 --> 00:03:56,879
then of course i will be taking

100
00:04:00,550 --> 00:03:57,920
questions

101
00:04:02,550 --> 00:04:00,560
both of both of our speakers and after

102
00:04:06,390 --> 00:04:02,560
our speakers finish tonight so have your

103
00:04:08,229 --> 00:04:06,400
questions ready and the social channels

104
00:04:09,830 --> 00:04:08,239
thank you sarah uh those are some great

105
00:04:11,350 --> 00:04:09,840
resources and i'm glad we have you with

106
00:04:13,589 --> 00:04:11,360
us especially because of your personal

107
00:04:14,869 --> 00:04:13,599
connection to curiosity uh sarah and i

108
00:04:16,789 --> 00:04:14,879
want to remind you that this is your

109
00:04:19,189 --> 00:04:16,799
space program so please do get involved

110
00:04:21,270 --> 00:04:19,199
in the chat on the social media sites

111
00:04:23,830 --> 00:04:21,280
and as always if we do run into any

112
00:04:25,590 --> 00:04:23,840
technical difficulties or small failures

113
00:04:27,189 --> 00:04:25,600

we ask for your patience tonight and

114
00:04:30,390 --> 00:04:27,199
please stick with us we will get them

115
00:04:32,550 --> 00:04:30,400
sorted out as soon as we possibly can

116
00:04:35,030 --> 00:04:32,560
now on to our first speaker of the

117
00:04:37,749 --> 00:04:35,040
evening dr ashwin vasavada is a

118
00:04:40,230 --> 00:04:37,759
planetary scientist at jpl and the

119
00:04:43,270 --> 00:04:40,240
project scientist for nasa's curiosity

120
00:04:45,710 --> 00:04:43,280
rover that began development in 2003 and

121
00:04:47,270 --> 00:04:45,720
successfully reached mars in august of

122
00:04:49,590 --> 00:04:47,280
2012.

123
00:04:51,990 --> 00:04:49,600
he now leads the international team of

124
00:04:53,670 --> 00:04:52,000
scientists as they explore gale crater

125
00:04:55,350 --> 00:04:53,680
on the martian surface

126
00:04:57,909 --> 00:04:55,360
he also has participated in the

127
00:05:00,790 --> 00:04:57,919
operation and analysis of data from

128
00:05:03,189 --> 00:05:00,800
several other nasa spacecraft missions

129
00:05:05,270 --> 00:05:03,199
including the galileo mission to jupiter

130
00:05:07,670 --> 00:05:05,280
the cassini mission to saturn and the

131
00:05:09,670 --> 00:05:07,680
lunar reconnaissance orbiter he holds a

132
00:05:12,629 --> 00:05:09,680
bachelor of science in geophysics and

133
00:05:14,469 --> 00:05:12,639
space physics from ucla and a phd in

134
00:05:16,390 --> 00:05:14,479
planetary science from caltech we are

135
00:05:19,029 --> 00:05:16,400
honored to have you with us this evening

136
00:05:21,110 --> 00:05:19,039
hello ashwin

137
00:05:22,629 --> 00:05:21,120
hello no great to be here i can't wait

138
00:05:25,430 --> 00:05:22,639

to talk about everything we've done in

139
00:05:27,590 --> 00:05:25,440
10 years oh yeah i mean 10 years have

140
00:05:29,590 --> 00:05:27,600
flown by i'm sure but i want to start

141
00:05:31,430 --> 00:05:29,600
off with how you actually got to where

142
00:05:33,430 --> 00:05:31,440
you are so how did you get to where you

143
00:05:34,870 --> 00:05:33,440
are today

144
00:05:37,029 --> 00:05:34,880
you know as you heard a little bit in

145
00:05:39,029 --> 00:05:37,039
the introduction you just gave

146
00:05:41,029 --> 00:05:39,039
i went all over the solar system to get

147
00:05:43,430 --> 00:05:41,039
to where i am today on mars

148
00:05:46,550 --> 00:05:43,440
uh it all i think for me really started

149
00:05:48,469 --> 00:05:46,560
when i was um a kid and i had a book

150
00:05:50,629 --> 00:05:48,479
that was that had a bunch of pictures

151
00:05:53,029 --> 00:05:50,639
about um spacecraft missions that had

152
00:05:55,270 --> 00:05:53,039
gone to mars and jupiter before and the

153
00:05:57,350 --> 00:05:55,280
picture that really caught me when i was

154
00:05:59,670 --> 00:05:57,360
little was one from the viking lander on

155
00:06:01,909 --> 00:05:59,680
mars where a camera was just looking out

156
00:06:03,430 --> 00:06:01,919
over this vast landscape and it just

157
00:06:04,710 --> 00:06:03,440
blew my mind as a kid that there's an

158
00:06:06,790 --> 00:06:04,720
entire other

159
00:06:09,590 --> 00:06:06,800
world out there a whole planet that you

160
00:06:11,590 --> 00:06:09,600
could explore you know with robots

161
00:06:13,110 --> 00:06:11,600
and that's what i wanted to do from that

162
00:06:15,110 --> 00:06:13,120
point onward and i didn't really know

163
00:06:17,350 --> 00:06:15,120

how to get there i majored in aerospace

164
00:06:19,430 --> 00:06:17,360
engineering when i got to ucla and

165
00:06:21,909 --> 00:06:19,440
figured out that actually i'm more

166
00:06:23,590 --> 00:06:21,919
interested in science than engineering

167
00:06:25,990 --> 00:06:23,600
like understanding

168
00:06:27,430 --> 00:06:26,000
how things work and not necessarily

169
00:06:29,909 --> 00:06:27,440
building the things

170
00:06:31,909 --> 00:06:29,919
to put it kind of in a simple way but

171
00:06:33,110 --> 00:06:31,919
so then i switched to physics and i

172
00:06:35,270 --> 00:06:33,120
still didn't really know how to get

173
00:06:36,950 --> 00:06:35,280
there but i found a faculty member

174
00:06:38,950 --> 00:06:36,960
professor who was working on jpl

175
00:06:41,110 --> 00:06:38,960
missions and that's how i learned how

176
00:06:43,029 --> 00:06:41,120
how to actually get there so i went to

177
00:06:45,270 --> 00:06:43,039
grad school to work on a spacecraft

178
00:06:46,790 --> 00:06:45,280
called mars observer and that's when i

179
00:06:48,629 --> 00:06:46,800
learned my first lesson that you know

180
00:06:51,029 --> 00:06:48,639
planetary science is doesn't have

181
00:06:52,469 --> 00:06:51,039
guarantees it's difficult and what we do

182
00:06:53,990 --> 00:06:52,479
is very challenging and there's a lot of

183
00:06:57,189 --> 00:06:54,000
risks and things don't always go your

184
00:06:59,350 --> 00:06:57,199
way and uh as i was actually driving my

185
00:07:01,029 --> 00:06:59,360
car to go to caltech for my first day of

186
00:07:04,070 --> 00:07:01,039
grad school i heard that the mission was

187
00:07:06,309 --> 00:07:04,080
lost and i then worked on galileo on

188
00:07:09,110 --> 00:07:06,319

jupiter for a few years came back to

189
00:07:11,990 --> 00:07:09,120
mars on another spacecraft that also

190
00:07:14,070 --> 00:07:12,000
failed to reach mars tough game

191
00:07:16,629 --> 00:07:14,080
and worked on cassini for a few years on

192
00:07:18,070 --> 00:07:16,639
saturn and then finally i got this

193
00:07:20,629 --> 00:07:18,080
wonderful opportunity to work on

194
00:07:21,909 --> 00:07:20,639
curiosity which has made up more than

195
00:07:26,230 --> 00:07:21,919
enough for

196
00:07:28,070 --> 00:07:26,240
uh the the disappointments i had earlier

197
00:07:29,909 --> 00:07:28,080
well i'm certainly glad that it has made

198
00:07:31,510 --> 00:07:29,919
up for the disappointments of earlier

199
00:07:33,110 --> 00:07:31,520
you've been on this mission for a while

200
00:07:35,350 --> 00:07:33,120
i mean you really know the story of this

201
00:07:37,830 --> 00:07:35,360
so tell us what were we intending to

202
00:07:39,990 --> 00:07:37,840
find with curiosity

203
00:07:42,550 --> 00:07:40,000
sure you know and because this is the

204
00:07:44,469 --> 00:07:42,560
anniversary uh celebration i'm just

205
00:07:47,110 --> 00:07:44,479
gonna kind of go all the way back

206
00:07:49,350 --> 00:07:47,120
and talk about why nasa

207
00:07:51,510 --> 00:07:49,360
wanted to fly the curiosity mission in

208
00:07:53,110 --> 00:07:51,520
the first place and we were charged with

209
00:07:55,589 --> 00:07:53,120
answering this question you know was

210
00:07:57,029 --> 00:07:55,599
mars ever habitable you see this picture

211
00:07:59,029 --> 00:07:57,039
of mars

212
00:08:02,070 --> 00:07:59,039
today this is what it looks like it has

213
00:08:04,710 --> 00:08:02,080

a little wispy water ice clouds it has

214
00:08:06,309 --> 00:08:04,720
polar caps that are made of water ice

215
00:08:07,990 --> 00:08:06,319
but the one thing you see when you kind

216
00:08:10,469 --> 00:08:08,000
of compare in your mind how earth looks

217
00:08:12,790 --> 00:08:10,479
versus mars is there's no liquid water

218
00:08:14,469 --> 00:08:12,800
there's no oceans there's no lakes but

219
00:08:17,029 --> 00:08:14,479
we have evidence that in the past there

220
00:08:19,670 --> 00:08:17,039
was so we think in the distant past on

221
00:08:22,550 --> 00:08:19,680
mars it may have been a much more

222
00:08:24,869 --> 00:08:22,560
friendly place to possible life

223
00:08:26,629 --> 00:08:24,879
so in the next graphic let's talk about

224
00:08:28,869 --> 00:08:26,639
what it actually means to study

225
00:08:31,589 --> 00:08:28,879
habitability um so we're looking for

226
00:08:33,670 --> 00:08:31,599
three things and we needed to figure out

227
00:08:36,469 --> 00:08:33,680
how to answer uh how to how to explore

228
00:08:38,070 --> 00:08:36,479
for these three things um on mars we

229
00:08:40,550 --> 00:08:38,080
wanted to look for persistent liquid

230
00:08:42,550 --> 00:08:40,560
water wanted to see if mars ever had

231
00:08:45,430 --> 00:08:42,560
water that lasted not just for a day or

232
00:08:47,430 --> 00:08:45,440
a year but millions or tens of millions

233
00:08:49,670 --> 00:08:47,440
of years long enough that life could

234
00:08:51,110 --> 00:08:49,680
actually make use of it and and the slow

235
00:08:53,110 --> 00:08:51,120
processes like

236
00:08:55,110 --> 00:08:53,120
life originating and evolving could make

237
00:08:58,070 --> 00:08:55,120
use of that water we also wanted to look

238
00:09:00,070 --> 00:08:58,080

for the key chemical ingredients of life

239
00:09:03,030 --> 00:09:00,080
life doesn't only need water of course

240
00:09:04,710 --> 00:09:03,040
it needs organic carbon it needs other

241
00:09:07,350 --> 00:09:04,720
things like nitrogen and sulfur and

242
00:09:09,750 --> 00:09:07,360
oxygen and phosphorus all the all the

243
00:09:11,670 --> 00:09:09,760
various elements that make up the

244
00:09:13,269 --> 00:09:11,680
biological machinery within us we want

245
00:09:15,269 --> 00:09:13,279
to look if those raw materials were

246
00:09:17,190 --> 00:09:15,279
there on mars and finally we want to

247
00:09:19,590 --> 00:09:17,200
look for sources of energy that could

248
00:09:21,110 --> 00:09:19,600
power metabolism that could power life

249
00:09:23,430 --> 00:09:21,120
uh there's some light of course like

250
00:09:24,790 --> 00:09:23,440
there is on earth but you can dig down

251
00:09:27,670 --> 00:09:24,800
on earth and find

252
00:09:29,990 --> 00:09:27,680
places where life has managed to use the

253
00:09:31,590 --> 00:09:30,000
chemical energy within the the rocks and

254
00:09:33,829 --> 00:09:31,600
soils themselves

255
00:09:36,470 --> 00:09:33,839
to power itself and so we could look for

256
00:09:37,990 --> 00:09:36,480
those sorts of things on mars as well

257
00:09:41,110 --> 00:09:38,000
on the next one

258
00:09:42,710 --> 00:09:41,120
we needed to find a place to go to ask

259
00:09:44,710 --> 00:09:42,720
to ask these questions and search for

260
00:09:47,590 --> 00:09:44,720
those things so we spent about five

261
00:09:49,590 --> 00:09:47,600
years looking for a kind of the perfect

262
00:09:51,829 --> 00:09:49,600
site where we could study habitability

263
00:09:53,030 --> 00:09:51,839

and have a chance of looking for those

264
00:09:55,590 --> 00:09:53,040
key

265
00:09:57,190 --> 00:09:55,600
requirements for habitable conditions

266
00:09:59,350 --> 00:09:57,200
and we found this very special place

267
00:10:02,389 --> 00:09:59,360
called gale crater it's a crater that's

268
00:10:04,069 --> 00:10:02,399
100 miles across but the very unique

269
00:10:06,550 --> 00:10:04,079
thing about this crater it has a big

270
00:10:08,630 --> 00:10:06,560
mountain of rock in the middle of it and

271
00:10:10,470 --> 00:10:08,640
that mountain isn't

272
00:10:12,550 --> 00:10:10,480
a mountain that was pushed up by plate

273
00:10:14,389 --> 00:10:12,560
tectonics it's not a volcano it's a

274
00:10:17,670 --> 00:10:14,399
mountain of sedimentary rock meaning

275
00:10:19,990 --> 00:10:17,680
that over time wind and water brought in

276
00:10:22,150 --> 00:10:20,000
sediments and slowly built up the floor

277
00:10:23,750 --> 00:10:22,160
of the crater which was then eroded into

278
00:10:25,910 --> 00:10:23,760
the shape of a mountain what's

279
00:10:27,750 --> 00:10:25,920
significant about that is that that slow

280
00:10:29,670 --> 00:10:27,760
action of sediment going in the crater

281
00:10:32,150 --> 00:10:29,680
by either wind or water

282
00:10:33,750 --> 00:10:32,160
created a mountain that is composed of

283
00:10:35,269 --> 00:10:33,760
many different layers that built up

284
00:10:37,990 --> 00:10:35,279
slowly over time

285
00:10:40,069 --> 00:10:38,000
and therefore are now a record of what

286
00:10:42,550 --> 00:10:40,079
the environmental conditions were like

287
00:10:44,389 --> 00:10:42,560
as each layer was laid down

288
00:10:45,829 --> 00:10:44,399

and even more exciting even before we

289
00:10:48,550 --> 00:10:45,839
landed we could see from orbit that

290
00:10:50,230 --> 00:10:48,560
those layers were not all the same

291
00:10:52,870 --> 00:10:50,240
some had evidence of minerals that

292
00:10:54,310 --> 00:10:52,880
formed when water was present some had

293
00:10:56,310 --> 00:10:54,320
textures that were quite different from

294
00:10:58,389 --> 00:10:56,320
the others so we knew that there was a

295
00:11:00,310 --> 00:10:58,399
geological record there to explore that

296
00:11:01,910 --> 00:11:00,320
would tell us how the environment was

297
00:11:04,150 --> 00:11:01,920
changing over time

298
00:11:06,230 --> 00:11:04,160
and so by going through those layers

299
00:11:08,870 --> 00:11:06,240
layer by layer we could kind of read the

300
00:11:10,870 --> 00:11:08,880
history of mars and figure out if any of

301
00:11:13,829 --> 00:11:10,880
those time periods had all those

302
00:11:16,870 --> 00:11:13,839
elements needed for habitability

303
00:11:19,190 --> 00:11:16,880
so then of course we needed um

304
00:11:20,710 --> 00:11:19,200
to figure out uh well actually there's

305
00:11:24,069 --> 00:11:20,720
one more very special thing about guild

306
00:11:28,550 --> 00:11:27,350
mars was once we think much more

307
00:11:30,870 --> 00:11:28,560
of a

308
00:11:33,590 --> 00:11:30,880
earth-like planet you could say it was

309
00:11:35,670 --> 00:11:33,600
uh had a lot more water and maybe was

310
00:11:39,030 --> 00:11:35,680
even warmer and then of course change to

311
00:11:39,829 --> 00:11:39,040
the dry cold desert planet is today

312
00:11:41,750 --> 00:11:39,839
and

313
00:11:43,590 --> 00:11:41,760

maybe the first billion years or so of

314
00:11:45,750 --> 00:11:43,600
mars history was when it had all this

315
00:11:47,430 --> 00:11:45,760
liquid water we think and then the last

316
00:11:49,190 --> 00:11:47,440
few billion years have been this cold

317
00:11:51,670 --> 00:11:49,200
dry desert that probably wasn't too

318
00:11:53,750 --> 00:11:51,680
friendly for life but a dramatic change

319
00:11:56,230 --> 00:11:53,760
happened sometime around three billion

320
00:11:58,710 --> 00:11:56,240
years ago and that's exactly when those

321
00:12:00,629 --> 00:11:58,720
rocks were laid down in gale crater so

322
00:12:02,069 --> 00:12:00,639
not only does it have this uh great

323
00:12:04,550 --> 00:12:02,079
history for us to explore but that

324
00:12:06,790 --> 00:12:04,560
history is from a very dramatically

325
00:12:07,750 --> 00:12:06,800
changing time in mars

326
00:12:10,389 --> 00:12:07,760
history

327
00:12:12,150 --> 00:12:10,399
and so then we needed to figure out how

328
00:12:14,230 --> 00:12:12,160
to actually study that and to equip a

329
00:12:15,990 --> 00:12:14,240
rover to make these um

330
00:12:17,430 --> 00:12:16,000
investigations about habitability so on

331
00:12:19,990 --> 00:12:17,440
the next graphic

332
00:12:22,069 --> 00:12:20,000
uh you can see that we have um a car

333
00:12:24,230 --> 00:12:22,079
sized rover so one thing we figured out

334
00:12:26,310 --> 00:12:24,240
is that in order to climb this mountain

335
00:12:27,829 --> 00:12:26,320
explore layer by layer we needed to move

336
00:12:29,269 --> 00:12:27,839
we couldn't just land in one place we

337
00:12:31,750 --> 00:12:29,279
wanted to be able to look at all those

338
00:12:33,990 --> 00:12:31,760

different layers and ask it every moment

339
00:12:35,350 --> 00:12:34,000
in mars history was this a time that was

340
00:12:36,870 --> 00:12:35,360
friendly for life

341
00:12:38,629 --> 00:12:36,880
you know potential life

342
00:12:39,750 --> 00:12:38,639
so we have a rover that could drive and

343
00:12:42,069 --> 00:12:39,760
we have 10

344
00:12:44,230 --> 00:12:42,079
scientific instruments to help answer

345
00:12:45,910 --> 00:12:44,240
the questions that we're asking but very

346
00:12:47,829 --> 00:12:45,920
importantly we have a drill so we can

347
00:12:48,629 --> 00:12:47,839
drill into rocks that make up mount

348
00:12:50,870 --> 00:12:48,639
sharp

349
00:12:52,550 --> 00:12:50,880
deliver that powder to laboratories on

350
00:12:54,949 --> 00:12:52,560
board the rover that could tell us in

351
00:12:57,030 --> 00:12:54,959
detail what minerals are there and what

352
00:12:59,190 --> 00:12:57,040
chemicals are there so we can understand

353
00:13:00,470 --> 00:12:59,200
whether there's organic carbon and what

354
00:13:03,350 --> 00:13:00,480
the minerals tell us about the

355
00:13:04,389 --> 00:13:03,360
environment that was once there

356
00:13:06,870 --> 00:13:04,399
so

357
00:13:09,670 --> 00:13:06,880
we are now all set to go and this has

358
00:13:11,910 --> 00:13:09,680
kind of set the stage uh for um for what

359
00:13:13,509 --> 00:13:11,920
we've done over the past 10 years

360
00:13:15,190 --> 00:13:13,519
yeah so tell us about that i mean it

361
00:13:17,269 --> 00:13:15,200
sounds like you had some very lofty

362
00:13:19,269 --> 00:13:17,279
goals and ambitions and that's wonderful

363
00:13:21,030 --> 00:13:19,279

but what did we actually find in the

364
00:13:22,550 --> 00:13:21,040
last 10 years

365
00:13:24,710 --> 00:13:22,560
yeah you know so

366
00:13:26,710 --> 00:13:24,720
it's it's been i think exceeded our

367
00:13:28,949 --> 00:13:26,720
expectations in every way and and that's

368
00:13:31,030 --> 00:13:28,959
just been wonderful so let's get into

369
00:13:32,629 --> 00:13:31,040
that on the next slide you know we've

370
00:13:34,230 --> 00:13:32,639
now landed

371
00:13:36,310 --> 00:13:34,240
and this is the view we had from our

372
00:13:38,790 --> 00:13:36,320
landing site we had this gorgeous

373
00:13:41,030 --> 00:13:38,800
uh panorama that we took shortly after

374
00:13:43,030 --> 00:13:41,040
landing of mount sharp in the distance

375
00:13:45,269 --> 00:13:43,040
but what was amazing about this is how

376
00:13:47,189 --> 00:13:45,279
far away mount sharp was it looked so

377
00:13:49,269 --> 00:13:47,199
daunting at the time to think that we've

378
00:13:51,430 --> 00:13:49,279
landed you know one person used to say

379
00:13:53,110 --> 00:13:51,440
that we were in the parking lot next to

380
00:13:54,870 --> 00:13:53,120
disneyland looking at disneyland you

381
00:13:56,550 --> 00:13:54,880
know from the parking lot and we still

382
00:13:58,790 --> 00:13:56,560
had to get there and we knew it would

383
00:14:00,710 --> 00:13:58,800
probably take over a year to drive there

384
00:14:02,629 --> 00:14:00,720
so it was pretty daunting but where that

385
00:14:04,310 --> 00:14:02,639
arrow is pointing is exactly where those

386
00:14:05,990 --> 00:14:04,320
very interesting layers were exposed on

387
00:14:07,910 --> 00:14:06,000
the side of mount sharp and we wanted to

388
00:14:09,269 --> 00:14:07,920

get there over time

389
00:14:11,910 --> 00:14:09,279
and if you go to the next graphic we're

390
00:14:14,150 --> 00:14:11,920
kind of zooming in on that area and even

391
00:14:15,430 --> 00:14:14,160
with our telephoto lens it's still so

392
00:14:16,710 --> 00:14:15,440
small

393
00:14:18,710 --> 00:14:16,720
but

394
00:14:21,110 --> 00:14:18,720
on the next graphic you can see that in

395
00:14:22,790 --> 00:14:21,120
10 years we've made a lot of progress

396
00:14:24,470 --> 00:14:22,800
we took about two years to drive to the

397
00:14:26,069 --> 00:14:24,480
mountain partly because what we saw on

398
00:14:28,470 --> 00:14:26,079
the plains was more interesting than we

399
00:14:30,230 --> 00:14:28,480
expected and then we spent about eight

400
00:14:33,829 --> 00:14:30,240
years climbing through the layers of

401
00:14:35,670 --> 00:14:33,839
lower mount sharp uh very systematically

402
00:14:37,430 --> 00:14:35,680
investigating layer by layer and looking

403
00:14:38,870 --> 00:14:37,440
for those ancient habitable environments

404
00:14:41,269 --> 00:14:38,880
at every step and currently we're about

405
00:14:42,629 --> 00:14:41,279
where that star is and we're at a very

406
00:14:44,550 --> 00:14:42,639
interesting site which we'll talk about

407
00:14:47,030 --> 00:14:44,560
later right where

408
00:14:49,030 --> 00:14:47,040
the mineralogy and the textures on mount

409
00:14:50,230 --> 00:14:49,040
sharp change very

410
00:14:51,750 --> 00:14:50,240
dramatically

411
00:14:53,110 --> 00:14:51,760
and we think we're right at the point

412
00:14:54,949 --> 00:14:53,120
where there's a

413
00:14:56,790 --> 00:14:54,959

big change in mars ancient climate that

414
00:14:59,590 --> 00:14:56,800
occurred

415
00:15:01,189 --> 00:14:59,600
so um let's talk about a little bit more

416
00:15:02,790 --> 00:15:01,199
specifically about what we found and you

417
00:15:05,110 --> 00:15:02,800
know when we landed we first drove

418
00:15:07,189 --> 00:15:05,120
across the plains and on the next slide

419
00:15:09,910 --> 00:15:07,199
you can see that um

420
00:15:13,110 --> 00:15:09,920
we uh one of our early discoveries which

421
00:15:14,310 --> 00:15:13,120
was super exciting and very kind of um

422
00:15:16,389 --> 00:15:14,320
something you could just appreciate

423
00:15:18,150 --> 00:15:16,399
almost just by seeing it you know we we

424
00:15:20,069 --> 00:15:18,160
came across a whole bunch of rounded

425
00:15:21,990 --> 00:15:20,079
pebbles littering the landscape and

426
00:15:23,750 --> 00:15:22,000
nature doesn't make round pebbles too

427
00:15:25,829 --> 00:15:23,760
easily

428
00:15:28,150 --> 00:15:25,839
round you know rocks are jagged they're

429
00:15:30,230 --> 00:15:28,160
angular and one way that you can make

430
00:15:33,110 --> 00:15:30,240
rounded pebbles is that uh they're

431
00:15:34,629 --> 00:15:33,120
carried along in a flowing stream and

432
00:15:37,829 --> 00:15:34,639
the rocks kind of grind against each

433
00:15:40,389 --> 00:15:37,839
other and over many many miles of travel

434
00:15:42,949 --> 00:15:40,399
you end up with these rounded rocks in

435
00:15:44,389 --> 00:15:42,959
fact you know i uh i once went to a home

436
00:15:45,670 --> 00:15:44,399
improvement store and wanted to get some

437
00:15:47,670 --> 00:15:45,680
rounded pebbles for my garden and

438
00:15:49,189 --> 00:15:47,680

they're labeled you know river rocks and

439
00:15:50,230 --> 00:15:49,199
so we all kind of understand what this

440
00:15:52,389 --> 00:15:50,240
means and

441
00:15:53,990 --> 00:15:52,399
uh and to see those with our own eyes

442
00:15:56,389 --> 00:15:54,000
you know with the rover's eyes just made

443
00:15:58,710 --> 00:15:56,399
a big impression because you can look at

444
00:16:00,629 --> 00:15:58,720
pictures of mars surface from space and

445
00:16:02,470 --> 00:16:00,639
see that there might be river channels

446
00:16:04,150 --> 00:16:02,480
but to come across a bunch of rounded

447
00:16:06,310 --> 00:16:04,160
pebbles that that

448
00:16:07,670 --> 00:16:06,320
were rounded in flowing water

449
00:16:09,269 --> 00:16:07,680
was amazing

450
00:16:11,990 --> 00:16:09,279
on the next graphic

451
00:16:13,110 --> 00:16:12,000
uh we then continued further towards the

452
00:16:15,509 --> 00:16:13,120
center of the crater and where the

453
00:16:18,230 --> 00:16:15,519
mountain is today and we found evidence

454
00:16:20,710 --> 00:16:18,240
of where those streams once flowed into

455
00:16:22,629 --> 00:16:20,720
standing bodies of water so if you kind

456
00:16:24,069 --> 00:16:22,639
of roll back history three billion years

457
00:16:25,749 --> 00:16:24,079
the crater would have been empty there

458
00:16:27,749 --> 00:16:25,759
wouldn't have been a mountain yet but

459
00:16:29,829 --> 00:16:27,759
water was flowing in carrying sediment

460
00:16:31,350 --> 00:16:29,839
that built up the mountain and these

461
00:16:34,310 --> 00:16:31,360
layers that you see in this picture are

462
00:16:37,189 --> 00:16:34,320
where the streams entered standing

463
00:16:38,949 --> 00:16:37,199

bodies of water and made little deltas

464
00:16:40,310 --> 00:16:38,959
so in the next one

465
00:16:42,310 --> 00:16:40,320
is when we got all the way to where the

466
00:16:44,069 --> 00:16:42,320
mountain is and you know we've seen now

467
00:16:46,230 --> 00:16:44,079
the stream we've seen the delta where

468
00:16:48,550 --> 00:16:46,240
the stream meets the lake and now we're

469
00:16:50,230 --> 00:16:48,560
in the lake where the lake was itself

470
00:16:52,389 --> 00:16:50,240
and we saw that the bottom of mount

471
00:16:55,030 --> 00:16:52,399
sharp was composed of very flat

472
00:16:56,870 --> 00:16:55,040
millimeter scale layers of basically

473
00:16:59,749 --> 00:16:56,880
what used to be mud at the bottom of

474
00:17:01,189 --> 00:16:59,759
ancient lakes that's now turned into mud

475
00:17:02,550 --> 00:17:01,199
stone

476
00:17:04,789 --> 00:17:02,560
and we didn't just find this at the

477
00:17:06,549 --> 00:17:04,799
bottom of mount sharp we found it

478
00:17:08,309 --> 00:17:06,559
for meters and meters and meters and

479
00:17:09,990 --> 00:17:08,319
hundreds of meters above the bottom of

480
00:17:11,750 --> 00:17:10,000
mount sharp meaning that the lakes

481
00:17:13,350 --> 00:17:11,760
persisted for quite

482
00:17:14,470 --> 00:17:13,360
a long time

483
00:17:16,630 --> 00:17:14,480
and of course

484
00:17:19,189 --> 00:17:16,640
as we drove up mount sharp we took out

485
00:17:21,270 --> 00:17:19,199
our drill at every opportunity we could

486
00:17:23,750 --> 00:17:21,280
and sampled the rocks and and did those

487
00:17:25,429 --> 00:17:23,760
detailed investigations of habitability

488
00:17:28,069 --> 00:17:25,439

so in the next slide you can see that

489
00:17:29,270 --> 00:17:28,079
we've now drilled 35 holes with the

490
00:17:31,350 --> 00:17:29,280
mission

491
00:17:33,430 --> 00:17:31,360
and they're not all the same even from

492
00:17:36,230 --> 00:17:33,440
this picture you can see that the uh the

493
00:17:38,630 --> 00:17:36,240
colors are just amazing and some rocks

494
00:17:40,390 --> 00:17:38,640
uh for example you can see

495
00:17:42,310 --> 00:17:40,400
are redder than others and the material

496
00:17:44,230 --> 00:17:42,320
inside the rocks is brighter meaning

497
00:17:45,510 --> 00:17:44,240
that things are more oxidized the iron

498
00:17:47,590 --> 00:17:45,520
in the rock has turned into kind of a

499
00:17:49,110 --> 00:17:47,600
reddish color and other rocks are very

500
00:17:51,110 --> 00:17:49,120
gray inside

501
00:17:53,029 --> 00:17:51,120
meaning that the oxidation that turned

502
00:17:55,669 --> 00:17:53,039
mars into the red planet didn't

503
00:17:57,350 --> 00:17:55,679
penetrate deeply into the rocks which is

504
00:17:59,110 --> 00:17:57,360
actually a good thing for finding

505
00:18:01,110 --> 00:17:59,120
evidence of ancient life because

506
00:18:04,230 --> 00:18:01,120
oxidation can destroy that evidence over

507
00:18:05,590 --> 00:18:04,240
time in some cases so you know 35 holes

508
00:18:07,590 --> 00:18:05,600
we've learned a lot we've seen a lot of

509
00:18:09,750 --> 00:18:07,600
different things and the next one is

510
00:18:11,430 --> 00:18:09,760
kind of a summary coming back to our

511
00:18:12,950 --> 00:18:11,440
questions about what makes a habitable

512
00:18:15,909 --> 00:18:12,960
environment

513
00:18:18,070 --> 00:18:15,919

curiosity has found a lot of evidence

514
00:18:19,669 --> 00:18:18,080
that of water in the ancient past that

515
00:18:21,270 --> 00:18:19,679
was suitable for life

516
00:18:23,350 --> 00:18:21,280
and what i mean by that is we found

517
00:18:26,310 --> 00:18:23,360
evidence that the water in these lakes

518
00:18:28,549 --> 00:18:26,320
in ancient mars was not um

519
00:18:31,510 --> 00:18:28,559
too acidic for to support life it was

520
00:18:33,750 --> 00:18:31,520
not too salty to support life it was uh

521
00:18:35,510 --> 00:18:33,760
just the kind of water that life would

522
00:18:37,830 --> 00:18:35,520
need uh to flourish

523
00:18:38,870 --> 00:18:37,840
and we've also seen that in these same

524
00:18:41,029 --> 00:18:38,880
lakes

525
00:18:43,110 --> 00:18:41,039
there was organic molecules organic

526
00:18:44,870 --> 00:18:43,120
carbon and some of the other chemical

527
00:18:47,270 --> 00:18:44,880
elements that life needs in fact all of

528
00:18:48,950 --> 00:18:47,280
the main ones that life would need and

529
00:18:50,950 --> 00:18:48,960
and even evidence for nutrients that

530
00:18:53,270 --> 00:18:50,960
were in those likes as well

531
00:18:55,270 --> 00:18:53,280
and then we found different minerals

532
00:18:57,590 --> 00:18:55,280
that that when paired together could

533
00:18:59,350 --> 00:18:57,600
provide those chemical sources of energy

534
00:19:00,630 --> 00:18:59,360
for certain types of microbes to use

535
00:19:03,110 --> 00:19:00,640
underground

536
00:19:05,590 --> 00:19:03,120
so um you know really we've checked all

537
00:19:07,110 --> 00:19:05,600
the boxes in all these uh in many of

538
00:19:08,230 --> 00:19:07,120

these different drill holes especially

539
00:19:10,870 --> 00:19:08,240
the ones that come from these

540
00:19:12,870 --> 00:19:10,880
environments where lakes once were we

541
00:19:14,870 --> 00:19:12,880
found really abundant evidence for

542
00:19:17,270 --> 00:19:14,880
habitable environments

543
00:19:18,390 --> 00:19:17,280
so in the next one

544
00:19:19,750 --> 00:19:18,400
uh

545
00:19:20,950 --> 00:19:19,760
you know honestly i throw this picture

546
00:19:23,029 --> 00:19:20,960
into my talks just because it's one of

547
00:19:25,510 --> 00:19:23,039
my favorite ones in the mission but

548
00:19:26,710 --> 00:19:25,520
what what it does show though is

549
00:19:29,029 --> 00:19:26,720
um

550
00:19:30,630 --> 00:19:29,039
that lakes didn't last forever and so

551
00:19:33,350 --> 00:19:30,640
what you're looking at here are the lake

552
00:19:34,390 --> 00:19:33,360
sediments in the foreground and some

553
00:19:36,789 --> 00:19:34,400
really

554
00:19:39,430 --> 00:19:36,799
amazing buttes and mesas on the two

555
00:19:41,110 --> 00:19:39,440
sides and what's on the top of these uh

556
00:19:43,430 --> 00:19:41,120
mesas are

557
00:19:47,110 --> 00:19:43,440
sandstones that formed when the lakes

558
00:19:49,590 --> 00:19:47,120
were gone and dry sand dunes uh covered

559
00:19:51,669 --> 00:19:49,600
the entire area and then those those

560
00:19:53,430 --> 00:19:51,679
sand dunes turned into rocks so what do

561
00:19:56,150 --> 00:19:53,440
you what you would have seen then is

562
00:19:57,830 --> 00:19:56,160
those uh those dark mesa tops connecting

563
00:20:00,470 --> 00:19:57,840

with each other and forming a continuous

564
00:20:02,549 --> 00:20:00,480
layer but since then billion you know a

565
00:20:06,070 --> 00:20:02,559
couple more billion years has gone by

566
00:20:08,149 --> 00:20:06,080
and wind has eroded that sand layer away

567
00:20:10,549 --> 00:20:08,159
to where now there's just these buttes

568
00:20:12,230 --> 00:20:10,559
and mesas left over

569
00:20:14,070 --> 00:20:12,240
but on the next one

570
00:20:15,029 --> 00:20:14,080
you'll see one of my other

571
00:20:16,390 --> 00:20:15,039
favorite

572
00:20:17,830 --> 00:20:16,400
discoveries of the mission one of the

573
00:20:18,710 --> 00:20:17,840
other most important discoveries of the

574
00:20:21,430 --> 00:20:18,720
mission

575
00:20:23,350 --> 00:20:21,440
is that habitability wasn't just present

576
00:20:24,470 --> 00:20:23,360
you know at the surface where the lakes

577
00:20:25,830 --> 00:20:24,480
were

578
00:20:28,310 --> 00:20:25,840
but was

579
00:20:30,710 --> 00:20:28,320
present underground as well

580
00:20:32,149 --> 00:20:30,720
and this is really meaningful i mean uh

581
00:20:33,669 --> 00:20:32,159
because

582
00:20:34,630 --> 00:20:33,679
underneath everything we see at the

583
00:20:35,430 --> 00:20:34,640
surface

584
00:20:37,590 --> 00:20:35,440
uh

585
00:20:39,029 --> 00:20:37,600
the rocks were

586
00:20:41,270 --> 00:20:39,039
were forming and then they were

587
00:20:43,270 --> 00:20:41,280
fracturing as they were being buried and

588
00:20:45,590 --> 00:20:43,280

then groundwater flowed through those

589
00:20:47,590 --> 00:20:45,600
fractures and precipitated minerals

590
00:20:49,350 --> 00:20:47,600
along the walls of those fractures and

591
00:20:50,950 --> 00:20:49,360
what you're seeing in this picture

592
00:20:52,710 --> 00:20:50,960
is now that

593
00:20:54,470 --> 00:20:52,720
some of those that rock has been eroded

594
00:20:56,950 --> 00:20:54,480
that softer rock has been eroded away

595
00:20:58,630 --> 00:20:56,960
what's left are the white minerals that

596
00:21:00,789 --> 00:20:58,640
used to coat the inside of those

597
00:21:03,190 --> 00:21:00,799
fractures and these are calcium sulfate

598
00:21:05,110 --> 00:21:03,200
minerals but what this tells us is that

599
00:21:07,830 --> 00:21:05,120
water was circulating within these rocks

600
00:21:10,310 --> 00:21:07,840
long after the lakes disappeared and the

601
00:21:12,310 --> 00:21:10,320
mud they left behind hardened into rock

602
00:21:13,990 --> 00:21:12,320
so whatever was happening at the surface

603
00:21:16,630 --> 00:21:14,000
i think an even a longer story was

604
00:21:19,110 --> 00:21:16,640
happening below the surface so on the

605
00:21:21,190 --> 00:21:19,120
next slide

606
00:21:24,549 --> 00:21:21,200
um here you know let's let's see where

607
00:21:25,990 --> 00:21:24,559
we are was mars ever habitable um and i

608
00:21:29,909 --> 00:21:26,000
think the mission has answered a

609
00:21:31,909 --> 00:21:29,919
resounding yes and not only for a short

610
00:21:34,230 --> 00:21:31,919
period of time but probably for tens of

611
00:21:36,230 --> 00:21:34,240
millions of years and maybe even longer

612
00:21:38,149 --> 00:21:36,240
in the subsurface so this is

613
00:21:40,390 --> 00:21:38,159

a great discovery for the mission and

614
00:21:42,070 --> 00:21:40,400
really why curiosity was sent to mars

615
00:21:45,430 --> 00:21:42,080
and i think it's exceeded all our

616
00:21:48,789 --> 00:21:46,630
i mean it's great to know that we've

617
00:21:50,470 --> 00:21:48,799
answered the big question right but that

618
00:21:53,029 --> 00:21:50,480
kind of leads into this nest point we've

619
00:21:56,390 --> 00:21:53,039
done so many great things but what comes

620
00:21:57,669 --> 00:21:56,400
next what do we where do we go from here

621
00:21:59,750 --> 00:21:57,679
yeah um

622
00:22:02,390 --> 00:21:59,760
we are at a really exciting time in the

623
00:22:05,590 --> 00:22:02,400
mission even 10 years in it has not

624
00:22:08,070 --> 00:22:05,600
gotten uh boring by any means in fact i

625
00:22:10,149 --> 00:22:08,080
think we're on the brink of making some

626
00:22:11,110 --> 00:22:10,159
truly astounding discoveries with the

627
00:22:13,270 --> 00:22:11,120
mission

628
00:22:15,430 --> 00:22:13,280
where we're at now is where this um

629
00:22:17,190 --> 00:22:15,440
arrow is pointing and and look then you

630
00:22:19,270 --> 00:22:17,200
know this is that view from sol 23 that

631
00:22:21,430 --> 00:22:19,280
i showed earlier that we were so far

632
00:22:23,350 --> 00:22:21,440
away from and now we're actually where

633
00:22:25,270 --> 00:22:23,360
that arrow is and we're right at that

634
00:22:27,029 --> 00:22:25,280
boundary from where the flat layers of

635
00:22:29,190 --> 00:22:27,039
lower mount sharp turn into these

636
00:22:30,390 --> 00:22:29,200
rounded hills and these rounded hills we

637
00:22:32,070 --> 00:22:30,400
think are

638
00:22:34,149 --> 00:22:32,080

well we know from

639
00:22:35,750 --> 00:22:34,159
spacecraft measurements from orbit that

640
00:22:37,110 --> 00:22:35,760
they have a different mineralogy they

641
00:22:39,430 --> 00:22:37,120
have these sulfate

642
00:22:40,870 --> 00:22:39,440
magnesium sulfate minerals

643
00:22:41,909 --> 00:22:40,880
enrichment

644
00:22:44,230 --> 00:22:41,919
you know they're enriched with these

645
00:22:46,470 --> 00:22:44,240
magnesium sulfate minerals which we

646
00:22:48,630 --> 00:22:46,480
believe might be telling us that they

647
00:22:51,029 --> 00:22:48,640
formed in environments that were drier

648
00:22:53,350 --> 00:22:51,039
than the ones below so we might be right

649
00:22:55,750 --> 00:22:53,360
at the brink of seeing uh

650
00:22:57,190 --> 00:22:55,760
at the at the minimum of dramatic change

651
00:22:59,830 --> 00:22:57,200
in mars climate

652
00:23:01,510 --> 00:22:59,840
and maybe even an end to the era of

653
00:23:04,070 --> 00:23:01,520
habitability that's the thing we need to

654
00:23:06,310 --> 00:23:04,080
answer now did habitability persist

655
00:23:08,789 --> 00:23:06,320
through a dramatic change in the climate

656
00:23:11,669 --> 00:23:08,799
from the the environments that were much

657
00:23:14,310 --> 00:23:11,679
wetter to environments that were drier

658
00:23:16,870 --> 00:23:14,320
on the next one

659
00:23:19,110 --> 00:23:16,880
um you know look here's where we are you

660
00:23:20,470 --> 00:23:19,120
know this this is uh

661
00:23:22,070 --> 00:23:20,480
something i always dreamed of you know

662
00:23:23,830 --> 00:23:22,080
in those pictures from saul 23 you can

663
00:23:25,510 --> 00:23:23,840

kind of look out in the distance and you

664
00:23:27,669 --> 00:23:25,520
can imagine that one day the rover was

665
00:23:29,350 --> 00:23:27,679
going to be among all these beautiful

666
00:23:31,510 --> 00:23:29,360
hills on mount sharp and that's this is

667
00:23:33,190 --> 00:23:31,520
exactly where we are now and so these

668
00:23:35,750 --> 00:23:33,200
are hills that kind of tower above the

669
00:23:37,430 --> 00:23:35,760
rover on all sides and on the next slide

670
00:23:38,390 --> 00:23:37,440
you can see that

671
00:23:41,029 --> 00:23:38,400
here's a

672
00:23:43,350 --> 00:23:41,039
cliff a face that's just much taller

673
00:23:45,430 --> 00:23:43,360
much bigger than the rover we're driving

674
00:23:47,269 --> 00:23:45,440
next to it couldn't imagine we would be

675
00:23:49,110 --> 00:23:47,279
in such a fantastic landscape ten years

676
00:23:50,630 --> 00:23:49,120
ago and on this cliff face there's all

677
00:23:52,310 --> 00:23:50,640
these beautiful colors where the

678
00:23:54,789 --> 00:23:52,320
groundwater that once flowed through the

679
00:23:57,190 --> 00:23:54,799
rocks has affected the minerals in this

680
00:23:58,950 --> 00:23:57,200
uh cliff face in different ways causing

681
00:24:00,950 --> 00:23:58,960
some of them to turn red and leaving

682
00:24:03,830 --> 00:24:00,960
other ones in the more grayish color

683
00:24:06,789 --> 00:24:03,840
it's just a truly fantastic landscape

684
00:24:10,390 --> 00:24:08,710
here's looking back now so we can kind

685
00:24:12,230 --> 00:24:10,400
of look in the rear view mirror and see

686
00:24:14,070 --> 00:24:12,240
where we came from and you can see we're

687
00:24:17,430 --> 00:24:14,080
pretty high up we've gained over 2000

688
00:24:20,710 --> 00:24:17,440

feet in elevation after driving 18 miles

689
00:24:22,070 --> 00:24:20,720
and we can look back uh and and

690
00:24:23,750 --> 00:24:22,080
and see where we came from there's a

691
00:24:26,230 --> 00:24:23,760
crater floor in the distance and the

692
00:24:27,350 --> 00:24:26,240
wall of the crater in the very far

693
00:24:30,789 --> 00:24:27,360
distance

694
00:24:34,789 --> 00:24:32,710
what's really special about this picture

695
00:24:37,350 --> 00:24:34,799
is this is kind of the reverse one the

696
00:24:39,750 --> 00:24:37,360
reverse you know uh counterpart to that

697
00:24:41,669 --> 00:24:39,760
saul 23 mosaic and where the arrow is

698
00:24:43,909 --> 00:24:41,679
pointing is our landing site it took

699
00:24:45,669 --> 00:24:43,919
until just recently for us to be high

700
00:24:47,269 --> 00:24:45,679
enough on mount sharp where we can

701
00:24:49,110 --> 00:24:47,279
actually look back and see all the way

702
00:24:50,390 --> 00:24:49,120
to where we landed

703
00:24:52,630 --> 00:24:50,400
and

704
00:24:53,830 --> 00:24:52,640
so i i just you know i'm just amazed

705
00:24:55,830 --> 00:24:53,840
that we can

706
00:24:57,269 --> 00:24:55,840
look back at that saw 23 picture

707
00:24:59,190 --> 00:24:57,279
dreaming of where we would be one day

708
00:25:00,950 --> 00:24:59,200
and now we're there and we can look back

709
00:25:04,070 --> 00:25:00,960
and see where we landed

710
00:25:07,110 --> 00:25:05,430
here i just want to tell you a little

711
00:25:09,029 --> 00:25:07,120
bit about where what we're currently

712
00:25:10,549 --> 00:25:09,039
doing what we're currently finding

713
00:25:12,950 --> 00:25:10,559

um we

714
00:25:15,830 --> 00:25:12,960
are definitely out of the era of lakes

715
00:25:17,990 --> 00:25:15,840
on mars in gale crater which is exciting

716
00:25:19,430 --> 00:25:18,000
you know they lasted for a long time but

717
00:25:21,510 --> 00:25:19,440
now we're seeing

718
00:25:23,590 --> 00:25:21,520
that the rocks around us no longer those

719
00:25:27,110 --> 00:25:23,600
ones that formed in ancient lakes but

720
00:25:29,350 --> 00:25:27,120
formed actually in dry dune fields

721
00:25:31,029 --> 00:25:29,360
but that's not the whole story so

722
00:25:34,710 --> 00:25:31,039
we're not completely dry yet because

723
00:25:36,710 --> 00:25:34,720
those dark ridges with that left arrow

724
00:25:40,470 --> 00:25:36,720
are where streams once flowed among

725
00:25:42,549 --> 00:25:40,480
those dunes and deposited sand that

726
00:25:45,029 --> 00:25:42,559
was carried by liquid water flowing

727
00:25:46,789 --> 00:25:45,039
water so we're in kind of a dry-ish

728
00:25:48,630 --> 00:25:46,799
environment on the right you can see all

729
00:25:50,710 --> 00:25:48,640
these wavy layers that formed in dry

730
00:25:53,190 --> 00:25:50,720
dune fields and on the left you can see

731
00:25:56,230 --> 00:25:53,200
these dark ridges that formed in streams

732
00:25:57,590 --> 00:25:56,240
on the next one

733
00:25:59,269 --> 00:25:57,600
uh this is

734
00:26:01,110 --> 00:25:59,279
a self portrait that we took recently in

735
00:26:04,149 --> 00:26:01,120
this area and just wanted to show you

736
00:26:05,990 --> 00:26:04,159
what the rover looks like after 10 years

737
00:26:08,149 --> 00:26:06,000
it's it's almost turning the color of

738
00:26:09,029 --> 00:26:08,159

mars a lot of dust has deposited on the

739
00:26:11,029 --> 00:26:09,039
rover

740
00:26:13,110 --> 00:26:11,039
the wheels are kind of banged up as i

741
00:26:15,110 --> 00:26:13,120
think everyone knows we ran into some

742
00:26:17,269 --> 00:26:15,120
issues early on with holes developing in

743
00:26:19,750 --> 00:26:17,279
the wheels but we've been very careful

744
00:26:21,430 --> 00:26:19,760
in how we drive and i think we've

745
00:26:22,310 --> 00:26:21,440
managed to make the wheels last a long

746
00:26:24,310 --> 00:26:22,320
time

747
00:26:25,909 --> 00:26:24,320
but the rover is doing incredibly well

748
00:26:28,310 --> 00:26:25,919
after 10 years we really have all the

749
00:26:30,149 --> 00:26:28,320
capabilities we need to keep going

750
00:26:32,149 --> 00:26:30,159
further and the last thing i'll just

751
00:26:33,190 --> 00:26:32,159
cover is about um you know what lies

752
00:26:35,510 --> 00:26:33,200
ahead

753
00:26:37,590 --> 00:26:35,520
so in the next one

754
00:26:40,390 --> 00:26:37,600
we'll see a little animation of what

755
00:26:42,070 --> 00:26:40,400
what's going to come up uh come up in in

756
00:26:43,590 --> 00:26:42,080
the next few years

757
00:26:45,029 --> 00:26:43,600
um so

758
00:26:46,470 --> 00:26:45,039
in the foreground there's some places

759
00:26:48,950 --> 00:26:46,480
we've already been

760
00:26:50,549 --> 00:26:48,960
and then right about

761
00:26:52,950 --> 00:26:50,559
in the next few seconds is kind of where

762
00:26:54,710 --> 00:26:52,960
we are

763
00:26:56,710 --> 00:26:54,720

which is right near where those rounded

764
00:26:58,630 --> 00:26:56,720
hills begin and that magnesium sulfate

765
00:27:00,070 --> 00:26:58,640
bearing unit that might talk that might

766
00:27:01,269 --> 00:27:00,080
tell us about that dramatic change in

767
00:27:03,590 --> 00:27:01,279
mars climate

768
00:27:05,190 --> 00:27:03,600
right above that there's actually a

769
00:27:07,110 --> 00:27:05,200
channel that's been etched into those

770
00:27:08,470 --> 00:27:07,120
layers so here you can see

771
00:27:10,789 --> 00:27:08,480
what it looks like to be an ancient

772
00:27:11,990 --> 00:27:10,799
riverbed that's etched into those layers

773
00:27:13,830 --> 00:27:12,000
so that's going to be exciting to see

774
00:27:15,909 --> 00:27:13,840
whether liquid water flowed even after

775
00:27:17,750 --> 00:27:15,919
the sulfate unit formed then we're going

776
00:27:19,590 --> 00:27:17,760
to drive and continue to look at that

777
00:27:22,230 --> 00:27:19,600
sulfate bearing unit

778
00:27:24,389 --> 00:27:22,240
until we once again head more directly

779
00:27:26,630 --> 00:27:24,399
uphill on mount sharp maybe this is in

780
00:27:29,110 --> 00:27:26,640
three or four years from now uh and we

781
00:27:30,789 --> 00:27:29,120
get all the way up to where this uh this

782
00:27:32,870 --> 00:27:30,799
very strange looking layer is it almost

783
00:27:35,909 --> 00:27:32,880
looks like a lemon meringue top on mount

784
00:27:38,470 --> 00:27:35,919
sharp and this layer isn't actually part

785
00:27:40,549 --> 00:27:38,480
of the continuous geological record

786
00:27:42,950 --> 00:27:40,559
it was pasted on at a later point in

787
00:27:44,789 --> 00:27:42,960
time so when we reach here maybe in

788
00:27:47,110 --> 00:27:44,799

three four or five years

789
00:27:48,789 --> 00:27:47,120
we'll have read the entire book of mars

790
00:27:50,389 --> 00:27:48,799
history that's preserved in lower mount

791
00:27:52,710 --> 00:27:50,399
sharp and we'll have done everything we

792
00:27:54,870 --> 00:27:52,720
hoped we could ever do so let's hope we

793
00:27:56,950 --> 00:27:54,880
get there

794
00:27:59,029 --> 00:27:56,960
let's certainly hope so and i mean thank

795
00:28:01,269 --> 00:27:59,039
you for encapsulating 10 years of

796
00:28:02,470 --> 00:28:01,279
amazing science in just a short period

797
00:28:04,389 --> 00:28:02,480
of time

798
00:28:05,669 --> 00:28:04,399
i do want to take a couple questions

799
00:28:07,430 --> 00:28:05,679
from the audience i think we only have

800
00:28:08,549 --> 00:28:07,440
time for two quick questions so i'm

801
00:28:10,070 --> 00:28:08,559
going to throw it over to sarah because

802
00:28:13,669 --> 00:28:10,080
i'm sure there's lots of people asking

803
00:28:17,750 --> 00:28:15,669
well definitely a lot of questions

804
00:28:20,630 --> 00:28:17,760
coming in on the chat so the first one

805
00:28:23,269 --> 00:28:20,640
i'm going to ask you ashwin is from my

806
00:28:29,110 --> 00:28:23,279
on facebook my wants to know what was

807
00:28:34,710 --> 00:28:31,830
hmm i'm sure there's been a lot of

808
00:28:36,870 --> 00:28:34,720
surprising ones uh but i think

809
00:28:37,830 --> 00:28:36,880
the the most surprising and profound one

810
00:28:40,789 --> 00:28:37,840
to me

811
00:28:42,630 --> 00:28:40,799
is that uh those lakes persisted much

812
00:28:44,549 --> 00:28:42,640
longer than we could tell from when we

813
00:28:46,630 --> 00:28:44,559

just had satellite images before we

814
00:28:48,230 --> 00:28:46,640
landed we thought there may have been

815
00:28:50,149 --> 00:28:48,240
lakes at one layer of mount sharp where

816
00:28:52,470 --> 00:28:50,159
there was a lot of clay minerals we

817
00:28:53,909 --> 00:28:52,480
found lakes at the crater floor then we

818
00:28:56,230 --> 00:28:53,919
found lakes at the bottom of mount sharp

819
00:28:57,830 --> 00:28:56,240
and then those lakes persisted for

820
00:28:59,510 --> 00:28:57,840
several hundred meters of thickness

821
00:29:01,110 --> 00:28:59,520
which probably means translates to

822
00:29:02,710 --> 00:29:01,120
something like tens or hundreds of

823
00:29:04,549 --> 00:29:02,720
millions of years

824
00:29:06,070 --> 00:29:04,559
so not only was mars habitable and the

825
00:29:07,909 --> 00:29:06,080
lakes were there but they persisted for

826
00:29:10,710 --> 00:29:07,919
much longer than we ever could have

827
00:29:15,669 --> 00:29:12,710
well that is a perfect segue to my next

828
00:29:17,750 --> 00:29:15,679
question it's from gretel on linkedin um

829
00:29:20,389 --> 00:29:17,760
you're mentioning lakes gretel wants to

830
00:29:21,909 --> 00:29:20,399
know where did the water go

831
00:29:24,789 --> 00:29:21,919
yeah

832
00:29:27,269 --> 00:29:24,799
uh probably evaporated and maybe some of

833
00:29:30,789 --> 00:29:27,279
it's now frozen at the uh in the polar

834
00:29:33,190 --> 00:29:30,799
caps uh but a lot of mars water that's

835
00:29:35,830 --> 00:29:33,200
not still you know in the polar caps or

836
00:29:37,510 --> 00:29:35,840
incorporated into minerals in the soil

837
00:29:39,990 --> 00:29:37,520
uh may have actually been even lost to

838
00:29:41,269 --> 00:29:40,000

space mars used to have a much thicker

839
00:29:44,630 --> 00:29:41,279
atmosphere

840
00:29:46,630 --> 00:29:44,640
the water was lost to space and a lot of

841
00:29:52,389 --> 00:29:46,640
the other water is now just in the form

842
00:29:56,789 --> 00:29:54,549
awesome for one more

843
00:29:59,669 --> 00:29:56,799
okay okay sarah one more you can throw

844
00:30:01,750 --> 00:29:59,679
one more in all right i'm sorry one more

845
00:30:03,350 --> 00:30:01,760
because it's a question that i've heard

846
00:30:06,549 --> 00:30:03,360
before and i think it's an interesting

847
00:30:08,870 --> 00:30:06,559
one so manuel on linkedin wants to know

848
00:30:11,269 --> 00:30:08,880
how much radiation the rover is exposed

849
00:30:16,149 --> 00:30:13,750
yeah um i can't give you like a number

850
00:30:19,590 --> 00:30:16,159
or anything but i can say it's

851
00:30:22,310 --> 00:30:19,600
uh more than you'd get on earth because

852
00:30:24,710 --> 00:30:22,320
uh mars has two things going against it

853
00:30:26,789 --> 00:30:24,720
it has a thinner atmosphere so it has

854
00:30:29,590 --> 00:30:26,799
less shielding from the atmosphere and

855
00:30:32,789 --> 00:30:29,600
it also lacks a strong magnetic field

856
00:30:34,630 --> 00:30:32,799
both of which help us on earth

857
00:30:36,870 --> 00:30:34,640
not be exposed to the radiation that

858
00:30:39,909 --> 00:30:36,880
comes from cosmic rays which

859
00:30:41,029 --> 00:30:39,919
come from deep space or from radiation

860
00:30:42,630 --> 00:30:41,039
from the sun

861
00:30:44,470 --> 00:30:42,640
and i'll just take the opportunity now

862
00:30:47,110 --> 00:30:44,480
to mention that we have an instrument on

863
00:30:49,350 --> 00:30:47,120

the rover that nasa specifically flew on

864
00:30:51,750 --> 00:30:49,360
curiosity to measure that radiation at

865
00:30:54,149 --> 00:30:51,760
the surface of mars in order to prepare

866
00:30:55,029 --> 00:30:54,159
uh for eventual human exploration of

867
00:30:56,789 --> 00:30:55,039
mars

868
00:30:58,149 --> 00:30:56,799
so we've been taking radiation

869
00:30:59,990 --> 00:30:58,159
measurements actually since shortly

870
00:31:02,149 --> 00:31:00,000
after launch we measured radiation the

871
00:31:04,710 --> 00:31:02,159
whole way to mars and then through the

872
00:31:06,789 --> 00:31:04,720
atmosphere and on the surface now for

873
00:31:08,789 --> 00:31:06,799
the last 10 years we've even done

874
00:31:10,789 --> 00:31:08,799
experiments where we snuck the rover up

875
00:31:12,710 --> 00:31:10,799
next to one of those big cliff faces i

876
00:31:15,029 --> 00:31:12,720
showed so that we're blocking part of

877
00:31:16,310 --> 00:31:15,039
the sky and we can measure how well that

878
00:31:19,029 --> 00:31:16,320
cliff face

879
00:31:20,870 --> 00:31:19,039
uh protects the rover uh from radiation

880
00:31:23,269 --> 00:31:20,880
coming from space and therefore if

881
00:31:25,509 --> 00:31:23,279
astronauts could use natural features

882
00:31:28,470 --> 00:31:25,519
like cliffs as shelters to protect

883
00:31:30,389 --> 00:31:28,480
themselves from radiation

884
00:31:31,830 --> 00:31:30,399
well i'm certainly glad i let that last

885
00:31:34,230 --> 00:31:31,840
question in because that's a question

886
00:31:35,590 --> 00:31:34,240
i've been asking myself so ashwin we are

887
00:31:37,350 --> 00:31:35,600
going to come back to you in just a few

888
00:31:39,909 --> 00:31:37,360

minutes i want to take a moment now to

889
00:31:41,990 --> 00:31:39,919
actually introduce our second speaker as

890
00:31:44,149 --> 00:31:42,000
ashwin was talking about curiosity has

891
00:31:46,070 --> 00:31:44,159
done some great science but a lot of it

892
00:31:47,669 --> 00:31:46,080
has been because curiosity has been able

893
00:31:49,350 --> 00:31:47,679
to drive so

894
00:31:52,389 --> 00:31:49,360
i want to introduce our second speaker

895
00:31:55,269 --> 00:31:52,399
carrie bean is a systems engineer at jpl

896
00:31:58,549 --> 00:31:55,279
and she is the deputy lead rover planner

897
00:32:01,269 --> 00:31:58,559
aka mars rover driver and robotic arm

898
00:32:03,669 --> 00:32:01,279
operator for the curiosity mars rover

899
00:32:05,909 --> 00:32:03,679
she also worked on curiosity as a

900
00:32:09,029 --> 00:32:05,919
student at the time of landing on the

901
00:32:10,950 --> 00:32:09,039
environmental science and mast cam teams

902
00:32:13,430 --> 00:32:10,960
she's worked on numerous other missions

903
00:32:15,830 --> 00:32:13,440
such as ingenuity mars helicopter the

904
00:32:18,470 --> 00:32:15,840
mars exploration rover's spirit and

905
00:32:20,870 --> 00:32:18,480
opportunity and many more she got her

906
00:32:23,750 --> 00:32:20,880
bachelor's and master's degrees at texas

907
00:32:26,870 --> 00:32:23,760
a m university in meteorology with her

908
00:32:29,430 --> 00:32:26,880
focus on studying the weather on mars hi

909
00:32:32,389 --> 00:32:29,440
carrie thanks for being here tonight

910
00:32:34,149 --> 00:32:32,399
hi thanks for having me

911
00:32:35,669 --> 00:32:34,159
so i want to start off the same way i

912
00:32:37,430 --> 00:32:35,679
mean you both have great stories of how

913
00:32:39,990 --> 00:32:37,440

you got to this mission so how did you

914
00:32:42,789 --> 00:32:40,000
get where you are today

915
00:32:44,549 --> 00:32:42,799
yeah so i grew up totally obsessed with

916
00:32:46,310 --> 00:32:44,559
weather i was glued to the weather

917
00:32:48,389 --> 00:32:46,320
channel and it was a huge part of my

918
00:32:50,630 --> 00:32:48,399
life when i was three years old a

919
00:32:52,389 --> 00:32:50,640
tornado hit my house when i was in the

920
00:32:54,470 --> 00:32:52,399
fifth grade i had to evacuate from a

921
00:32:56,549 --> 00:32:54,480
hurricane and when i was in high school

922
00:32:58,789 --> 00:32:56,559
i was struck by lightning so it's always

923
00:33:00,230 --> 00:32:58,799
kind of a big part of my life

924
00:33:02,549 --> 00:33:00,240
and so

925
00:33:04,950 --> 00:33:02,559
i didn't really get interested in space

926
00:33:06,710 --> 00:33:04,960
until high school where my family was

927
00:33:08,870 --> 00:33:06,720
doing the whole disney world vacation in

928
00:33:10,789 --> 00:33:08,880
florida we just happened to be the the

929
00:33:13,909 --> 00:33:10,799
week of a space shuttle launch and it

930
00:33:15,029 --> 00:33:13,919
was sts-114 which was our return to

931
00:33:15,909 --> 00:33:15,039
flight

932
00:33:18,950 --> 00:33:15,919
and

933
00:33:19,830 --> 00:33:18,960
away

934
00:33:22,630 --> 00:33:19,840
um

935
00:33:24,710 --> 00:33:22,640
just you could fill and see the space

936
00:33:26,389 --> 00:33:24,720
shuttle and i was like okay maybe this

937
00:33:28,470 --> 00:33:26,399
space thing is kind of cool so i started

938
00:33:30,870 --> 00:33:28,480

reading a lot more and i decided to go

939
00:33:32,870 --> 00:33:30,880
to space camp and while i was at space

940
00:33:34,710 --> 00:33:32,880
camp uh one of the documentaries they

941
00:33:36,389 --> 00:33:34,720
showed was roving mars which was about

942
00:33:38,389 --> 00:33:36,399
spirit and opportunity and i remember

943
00:33:39,350 --> 00:33:38,399
saying hey those mars rovers are kind of

944
00:33:41,590 --> 00:33:39,360
cool

945
00:33:45,669 --> 00:33:41,600
and i decided to go to school for

946
00:33:47,190 --> 00:33:45,679
meteorology and lucked out that i got to

947
00:33:48,549 --> 00:33:47,200
work with a professor who let me study

948
00:33:50,230 --> 00:33:48,559
the weather on mars if you pull up my

949
00:33:51,669 --> 00:33:50,240
first graphic you'll see

950
00:33:54,630 --> 00:33:51,679
my professor and i when we worked

951
00:33:55,830 --> 00:33:54,640
together on curiosity um

952
00:33:57,029 --> 00:33:55,840
he brought me along to working on a

953
00:33:59,430 --> 00:33:57,039
whole bunch of different missions

954
00:34:02,310 --> 00:33:59,440
including the phoenix marslander

955
00:34:03,830 --> 00:34:02,320
both spirit and opportunity and then on

956
00:34:05,509 --> 00:34:03,840
to curiosity so i actually joined

957
00:34:07,830 --> 00:34:05,519
curiosity first about a year before

958
00:34:09,510 --> 00:34:07,840
launch as part of the masscam team and

959
00:34:10,790 --> 00:34:09,520
the environmental science team working

960
00:34:12,869 --> 00:34:10,800
with oshman and all the other great

961
00:34:14,869 --> 00:34:12,879
meteorologists to get ready to study

962
00:34:17,349 --> 00:34:14,879
weather on mars so i was looking for

963
00:34:21,109 --> 00:34:17,359

clouds and dust doubles and other

964
00:34:23,430 --> 00:34:21,119
anything meteorology related and um

965
00:34:25,829 --> 00:34:23,440
when i was ready to graduate i

966
00:34:27,510 --> 00:34:25,839
luckily got a job at jpl and my first

967
00:34:30,069 --> 00:34:27,520
mission was actually working on dawn and

968
00:34:32,389 --> 00:34:30,079
the asteroid belt and so the asteroid

969
00:34:34,230 --> 00:34:32,399
people are great but i miss mars so as

970
00:34:36,790 --> 00:34:34,240
soon as i could i went back to mars and

971
00:34:38,470 --> 00:34:36,800
i went to opportunity and was one of her

972
00:34:40,230 --> 00:34:38,480
final engineers and i was in the middle

973
00:34:42,149 --> 00:34:40,240
of rover driver training for opportunity

974
00:34:44,629 --> 00:34:42,159
when we lost contact so

975
00:34:46,230 --> 00:34:44,639
in 2018 the curiosity team said hey

976
00:34:48,149 --> 00:34:46,240
we're about to start another class of

977
00:34:50,629 --> 00:34:48,159
river drivers do you want to come along

978
00:34:52,790 --> 00:34:50,639
and so i was able to finally get my mars

979
00:34:54,869 --> 00:34:52,800
rover driver license and work my way up

980
00:34:57,430 --> 00:34:54,879
to now being the deputy lead rover

981
00:34:58,950 --> 00:34:57,440
driver for curiosity

982
00:35:00,390 --> 00:34:58,960
well carrie it's very obvious that

983
00:35:02,710 --> 00:35:00,400
you're passionate just like ashwin about

984
00:35:04,950 --> 00:35:02,720
mars in particular as well but you

985
00:35:07,990 --> 00:35:04,960
mentioned your rover license how do you

986
00:35:10,870 --> 00:35:08,000
get a rover license

987
00:35:13,589 --> 00:35:10,880
yeah so um

988
00:35:14,470 --> 00:35:13,599

it it takes a little bit of time um

989
00:35:16,550 --> 00:35:14,480
so

990
00:35:18,790 --> 00:35:16,560
it usually takes like one to two years

991
00:35:20,310 --> 00:35:18,800
and we start out with classes so

992
00:35:21,829 --> 00:35:20,320
unfortunately if you think once you're

993
00:35:23,270 --> 00:35:21,839
done with school you stop taking classes

994
00:35:25,990 --> 00:35:23,280
that is not true you're gonna keep

995
00:35:27,750 --> 00:35:26,000
taking classes so we have a couple weeks

996
00:35:30,069 --> 00:35:27,760
worth of classes and that includes

997
00:35:32,470 --> 00:35:30,079
homeworks and then we have some hands-on

998
00:35:34,710 --> 00:35:32,480
labs and then we run some training

999
00:35:37,030 --> 00:35:34,720
simulations and being a star wars fan i

1000
00:35:39,190 --> 00:35:37,040
had to make a star wars acronym for them

1001
00:35:42,069 --> 00:35:39,200
porgs practical operational readiness

1002
00:35:45,109 --> 00:35:42,079
gambits and so i

1003
00:35:47,030 --> 00:35:45,119
roast my trainees through some porgs and

1004
00:35:49,349 --> 00:35:47,040
uh once they're ready then they actually

1005
00:35:51,349 --> 00:35:49,359
get to sit on shift with the rest of the

1006
00:35:53,190 --> 00:35:51,359
team and they'll actually develop the

1007
00:35:55,030 --> 00:35:53,200
commands and drive the rover and move

1008
00:35:56,950 --> 00:35:55,040
the robotic arm around

1009
00:35:59,670 --> 00:35:56,960
with someone double checking their work

1010
00:36:01,430 --> 00:35:59,680
and after a couple months um

1011
00:36:02,630 --> 00:36:01,440
usually of uh

1012
00:36:05,670 --> 00:36:02,640
doing that then they'll get their

1013
00:36:09,109 --> 00:36:05,680

driver's license um it takes a while

1014
00:36:10,710 --> 00:36:09,119
it's a big investment but uh you know

1015
00:36:13,270 --> 00:36:10,720
it's there's a lot to learn for river

1016
00:36:15,430 --> 00:36:13,280
driving so it takes a while

1017
00:36:18,630 --> 00:36:15,440
i mean it sounds exciting um i know you

1018
00:36:20,550 --> 00:36:18,640
mentioned before that as far as rover

1019
00:36:21,990 --> 00:36:20,560
drivers there's fewer rover drivers than

1020
00:36:23,589 --> 00:36:22,000
there are astronauts in the world which

1021
00:36:25,349 --> 00:36:23,599
is pretty cool to be part of that elite

1022
00:36:28,310 --> 00:36:25,359
class so congratulations on your rover

1023
00:36:31,670 --> 00:36:28,320
license uh but tell us what is a day in

1024
00:36:34,470 --> 00:36:31,680
the life of rover operations

1025
00:36:37,910 --> 00:36:34,480
yeah um so if you pull up my next

1026
00:36:39,670 --> 00:36:37,920
graphic there um so it starts out

1027
00:36:41,430 --> 00:36:39,680
you've got a lot of like scientists and

1028
00:36:42,790 --> 00:36:41,440
a mix of engineers so this was a picture

1029
00:36:45,670 --> 00:36:42,800
of me from landing night with some of

1030
00:36:47,829 --> 00:36:45,680
the amazing women scientists on the team

1031
00:36:49,270 --> 00:36:47,839
and you start out with all those

1032
00:36:51,109 --> 00:36:49,280
scientists in the morning looking at all

1033
00:36:53,349 --> 00:36:51,119
the images coming down from mars saying

1034
00:36:55,270 --> 00:36:53,359
oh you know here's this cool rock let's

1035
00:36:57,030 --> 00:36:55,280
investigate this today and then let's

1036
00:36:58,630 --> 00:36:57,040
drive the rover over to that next rock

1037
00:37:01,270 --> 00:36:58,640
so if you pull up my next graphic it

1038
00:37:02,310 --> 00:37:01,280

shows a little bit about our process

1039
00:37:03,910 --> 00:37:02,320
so

1040
00:37:05,829 --> 00:37:03,920
the scientists are looking at all that

1041
00:37:07,349 --> 00:37:05,839
data coming back and the engineers are

1042
00:37:09,829 --> 00:37:07,359
looking at the health and safety of the

1043
00:37:11,670 --> 00:37:09,839
rover did the roamer stay warm enough

1044
00:37:13,430 --> 00:37:11,680
through the night how's the power

1045
00:37:15,430 --> 00:37:13,440
situation looking all that kind of

1046
00:37:17,030 --> 00:37:15,440
engineering data just to make sure the

1047
00:37:18,550 --> 00:37:17,040
rover's healthy

1048
00:37:19,990 --> 00:37:18,560
then over the course of the day the

1049
00:37:21,190 --> 00:37:20,000
scientists and engineers will work

1050
00:37:22,870 --> 00:37:21,200
together to make sure that we are

1051
00:37:24,710 --> 00:37:22,880
getting as much science as we can out of

1052
00:37:26,630 --> 00:37:24,720
the rover for the day whether that's

1053
00:37:28,390 --> 00:37:26,640
moving the robotic arm around driving to

1054
00:37:29,589 --> 00:37:28,400
the next location taking pictures of

1055
00:37:32,069 --> 00:37:29,599
cool rocks

1056
00:37:34,390 --> 00:37:32,079
any sort of day the scientists need

1057
00:37:35,829 --> 00:37:34,400
and then the latter half of the day

1058
00:37:37,990 --> 00:37:35,839
they'll actually sit there and write the

1059
00:37:40,550 --> 00:37:38,000
code that will go to the spacecraft we

1060
00:37:42,870 --> 00:37:40,560
call them commands and it's basically a

1061
00:37:44,950 --> 00:37:42,880
laundry to-do list for the rover so

1062
00:37:45,750 --> 00:37:44,960
it'll say do this then do this then do

1063
00:37:46,710 --> 00:37:45,760

this

1064
00:37:48,069 --> 00:37:46,720
and

1065
00:37:50,950 --> 00:37:48,079
then once we've written all those

1066
00:37:52,550 --> 00:37:50,960
commands we'll verify it we'll run

1067
00:37:54,950 --> 00:37:52,560
simulations make sure it's all doing

1068
00:37:56,870 --> 00:37:54,960
what we expect it to and then we'll

1069
00:37:58,950 --> 00:37:56,880
bundle all of that instructions up and

1070
00:38:00,470 --> 00:37:58,960
then we'll use nasa's deep space network

1071
00:38:01,349 --> 00:38:00,480
to radiate all those commands to the

1072
00:38:05,030 --> 00:38:01,359
rover

1073
00:38:07,109 --> 00:38:05,040
commands for us we usually send one to

1074
00:38:09,270 --> 00:38:07,119
three days worth of commands at a time

1075
00:38:11,349 --> 00:38:09,280
but no live joystick for rover driving

1076
00:38:13,430 --> 00:38:11,359
unfortunately mars is just a little bit

1077
00:38:15,589 --> 00:38:13,440
too far away to be able to talk to the

1078
00:38:16,630 --> 00:38:15,599
rovers in real time

1079
00:38:18,150 --> 00:38:16,640
so

1080
00:38:20,550 --> 00:38:18,160
we'll hear back from the rovers a couple

1081
00:38:21,910 --> 00:38:20,560
times a day through our uh orbiter

1082
00:38:23,589 --> 00:38:21,920
missions like the mars reconnaissance

1083
00:38:25,829 --> 00:38:23,599
orbiter mars odyssey all those cool

1084
00:38:28,310 --> 00:38:25,839
missions orbiting mars they'll send all

1085
00:38:29,990 --> 00:38:28,320
of the data back for us and then the

1086
00:38:31,910 --> 00:38:30,000
process starts all over again the next

1087
00:38:33,829 --> 00:38:31,920
day we'll again look at all that cool

1088
00:38:36,710 --> 00:38:33,839

data that came back and figure out what

1089
00:38:40,390 --> 00:38:38,230
i mean it's incredible the amount of

1090
00:38:42,069 --> 00:38:40,400
both on the science and on the driving

1091
00:38:43,750 --> 00:38:42,079
side the operational side how much

1092
00:38:46,069 --> 00:38:43,760
connection and communication and

1093
00:38:47,990 --> 00:38:46,079
teamwork this really takes so carrie can

1094
00:38:50,870 --> 00:38:48,000
you tell us how have the past few years

1095
00:38:52,790 --> 00:38:50,880
kind of changed things

1096
00:38:54,310 --> 00:38:52,800
yeah so it's been really interesting

1097
00:38:56,390 --> 00:38:54,320
over the last few years none of us

1098
00:38:59,190 --> 00:38:56,400
expected to be commanding curiosity from

1099
00:39:01,109 --> 00:38:59,200
our couch and yet here we are so if you

1100
00:39:02,630 --> 00:39:01,119
pull up the the next graphic you'll see

1101
00:39:05,190 --> 00:39:02,640
what it used to look like when we were

1102
00:39:07,030 --> 00:39:05,200
all in person um so this is what it

1103
00:39:08,470 --> 00:39:07,040
looks like in our downlink rooms that's

1104
00:39:10,069 --> 00:39:08,480
where all the engineering telemetry

1105
00:39:12,069 --> 00:39:10,079
comes in and the engineers are assessing

1106
00:39:13,910 --> 00:39:12,079
the data and then on the bottom you can

1107
00:39:15,510 --> 00:39:13,920
see what we call our uplink room so this

1108
00:39:17,030 --> 00:39:15,520
is all the engineers and scientists

1109
00:39:19,589 --> 00:39:17,040
working together to figure out the next

1110
00:39:20,630 --> 00:39:19,599
plan and make those commands

1111
00:39:22,550 --> 00:39:20,640
and

1112
00:39:24,310 --> 00:39:22,560
for most of the mission the science team

1113
00:39:26,230 --> 00:39:24,320

has actually been mostly remote because

1114
00:39:27,190 --> 00:39:26,240
they're working at other universities or

1115
00:39:30,950 --> 00:39:27,200
other

1116
00:39:32,390 --> 00:39:30,960
space agencies around the globe and so

1117
00:39:34,630 --> 00:39:32,400
we already were somewhat of a hybrid

1118
00:39:37,430 --> 00:39:34,640
environment before um

1119
00:39:39,190 --> 00:39:37,440
with all the jpl roles being at jpl and

1120
00:39:40,630 --> 00:39:39,200
then if you go to the next graphic

1121
00:39:43,430 --> 00:39:40,640
you'll see

1122
00:39:45,030 --> 00:39:43,440
we all had to go from home and so we

1123
00:39:47,589 --> 00:39:45,040
brought all of our computers and our

1124
00:39:49,030 --> 00:39:47,599
monitors and one of the things for rover

1125
00:39:50,950 --> 00:39:49,040
drivers we actually have really cool

1126
00:39:52,230 --> 00:39:50,960
stereo glasses we can use but we

1127
00:39:54,710 --> 00:39:52,240
couldn't

1128
00:39:56,550 --> 00:39:54,720
let people bring that home so instead

1129
00:39:59,270 --> 00:39:56,560
i have to sit here and i put on my

1130
00:40:01,510 --> 00:39:59,280
clip-on red blue glasses and flip up and

1131
00:40:04,069 --> 00:40:01,520
down and look in stereo don't look at

1132
00:40:05,589 --> 00:40:04,079
stereo stereo you know i look like this

1133
00:40:07,030 --> 00:40:05,599
all day it's pretty cool

1134
00:40:09,829 --> 00:40:07,040
um

1135
00:40:12,069 --> 00:40:09,839
and uh you know we were working from our

1136
00:40:13,430 --> 00:40:12,079
kitchen tables i'm in the top left photo

1137
00:40:15,270 --> 00:40:13,440
there and you can actually see my cat

1138
00:40:17,190 --> 00:40:15,280

underneath my monitors as well our pets

1139
00:40:19,030 --> 00:40:17,200
have been very involved in uh you know

1140
00:40:21,510 --> 00:40:19,040
operating the rovers with us

1141
00:40:23,270 --> 00:40:21,520
um but it's been very interesting to to

1142
00:40:24,630 --> 00:40:23,280
all be remote and so now we're trying to

1143
00:40:26,630 --> 00:40:24,640
figure out what those next steps are

1144
00:40:28,790 --> 00:40:26,640
going to be of you know how do we

1145
00:40:30,870 --> 00:40:28,800
potentially work in a hybrid environment

1146
00:40:33,030 --> 00:40:30,880
and how do we bring people back safely

1147
00:40:35,109 --> 00:40:33,040
and it's really cool to be exploring

1148
00:40:38,309 --> 00:40:35,119
this time and once again changing how

1149
00:40:40,390 --> 00:40:38,319
we're operating the rover

1150
00:40:42,550 --> 00:40:40,400
that is awesome and thank you for

1151
00:40:43,990 --> 00:40:42,560
sharing that carrie so i want to open it

1152
00:40:46,069 --> 00:40:44,000
up for a few questions because i'm sure

1153
00:40:47,510 --> 00:40:46,079
we've had some questions online on the

1154
00:40:49,109 --> 00:40:47,520
operational side in fact the chats are

1155
00:40:50,630 --> 00:40:49,119
all lit up so please keep asking your

1156
00:40:52,390 --> 00:40:50,640
questions but i'm going to toss it over

1157
00:40:54,550 --> 00:40:52,400
to sarah we'll do two or three questions

1158
00:40:57,109 --> 00:40:54,560
for carrie

1159
00:40:59,670 --> 00:40:57,119
sounds great okay um next question is

1160
00:41:02,470 --> 00:40:59,680
from youtube so this is from akshay

1161
00:41:04,950 --> 00:41:02,480
asking on youtube i heard curiosity will

1162
00:41:08,790 --> 00:41:04,960
be doing some autonomous navigation

1163
00:41:10,790 --> 00:41:08,800

is that true and how is that possible

1164
00:41:12,230 --> 00:41:10,800
yeah so when we rover drive we actually

1165
00:41:14,630 --> 00:41:12,240
have a couple different ways that we can

1166
00:41:16,950 --> 00:41:14,640
drive the rover so we can be very very

1167
00:41:19,349 --> 00:41:16,960
specific with our commands of drive

1168
00:41:20,870 --> 00:41:19,359
forward a couple meters turn 30 degrees

1169
00:41:22,630 --> 00:41:20,880
go forward another couple meters you can

1170
00:41:23,750 --> 00:41:22,640
be very very very precise with what we

1171
00:41:25,829 --> 00:41:23,760
want it to do

1172
00:41:27,829 --> 00:41:25,839
we also have all the way to the other

1173
00:41:29,990 --> 00:41:27,839
end of the spectrum we call it auto nav

1174
00:41:32,710 --> 00:41:30,000
or auto navigation where we can actually

1175
00:41:34,470 --> 00:41:32,720
pick a rock or some other target in the

1176
00:41:36,309 --> 00:41:34,480
distance and tell the rover to figure

1177
00:41:38,870 --> 00:41:36,319
out how to get there itself and it will

1178
00:41:41,030 --> 00:41:38,880
actually take images build a map and we

1179
00:41:42,550 --> 00:41:41,040
can tell it how brave or how careful we

1180
00:41:46,710 --> 00:41:42,560
want the rover to be

1181
00:41:48,470 --> 00:41:46,720
and we will be able to drive the rover

1182
00:41:50,309 --> 00:41:48,480
to those destinations that we may not be

1183
00:41:52,950 --> 00:41:50,319
able to see is it safe to all drive

1184
00:41:55,109 --> 00:41:52,960
there let the rover decide um so just

1185
00:41:56,710 --> 00:41:55,119
kind of depending on what the goal is

1186
00:42:00,550 --> 00:41:56,720
and how we feel we can either let the

1187
00:42:04,790 --> 00:42:02,630
excellent okay next question is coming

1188
00:42:07,670 --> 00:42:04,800

from facebook christopher on facebook

1189
00:42:09,349 --> 00:42:07,680
asks how fast does the rover travel

1190
00:42:11,109 --> 00:42:09,359
on the terrain of mars with the

1191
00:42:13,190 --> 00:42:11,119
atmospheric pressure being slightly

1192
00:42:15,510 --> 00:42:13,200
different does that have any effect on

1193
00:42:17,910 --> 00:42:15,520
the rover

1194
00:42:20,630 --> 00:42:17,920
yeah so not so much the atmosphere um

1195
00:42:22,309 --> 00:42:20,640
really our limitation is that usually

1196
00:42:23,349 --> 00:42:22,319
while we're driving we're tracking our

1197
00:42:25,829 --> 00:42:23,359
position

1198
00:42:28,470 --> 00:42:25,839
and that takes a bit of bring brain

1199
00:42:30,950 --> 00:42:28,480
power and time to think and we don't go

1200
00:42:32,390 --> 00:42:30,960
very fast uh we only go about a meter a

1201
00:42:35,990 --> 00:42:32,400
minute that's about three feet per

1202
00:42:37,430 --> 00:42:36,000
minute it's pretty slow so um

1203
00:42:40,710 --> 00:42:37,440
you know we're very cautious but we'll

1204
00:42:42,230 --> 00:42:40,720
drive for a couple hours at a time um so

1205
00:42:44,309 --> 00:42:42,240
you know we'll make some good distance

1206
00:42:46,710 --> 00:42:44,319
usually somewhere between 20 and 100

1207
00:42:49,109 --> 00:42:46,720
meters per day uh depending on the kind

1208
00:42:51,670 --> 00:42:49,119
of terrain we're in um

1209
00:42:53,510 --> 00:42:51,680
and you know how close the next cool

1210
00:42:55,670 --> 00:42:53,520
rock is um

1211
00:42:59,030 --> 00:42:55,680
so yeah

1212
00:43:00,790 --> 00:42:59,040
we're not we're not very fast

1213
00:43:03,190 --> 00:43:00,800

but you have to be slow and careful

1214
00:43:05,270 --> 00:43:03,200
because you've got a very precious rover

1215
00:43:07,109 --> 00:43:05,280
and of course you want to make sure it

1216
00:43:07,910 --> 00:43:07,119
lasts a long time

1217
00:43:10,550 --> 00:43:07,920
so

1218
00:43:13,030 --> 00:43:10,560
ayush on youtube is asking can you tell

1219
00:43:15,270 --> 00:43:13,040
us about curiosity's twin which is in

1220
00:43:16,790 --> 00:43:15,280
the mars yard on earth so sounds like

1221
00:43:18,710 --> 00:43:16,800
this person has been following us a

1222
00:43:19,910 --> 00:43:18,720
while

1223
00:43:21,349 --> 00:43:19,920
yeah so

1224
00:43:22,790 --> 00:43:21,359
um

1225
00:43:25,349 --> 00:43:22,800
one of the things that we do is we

1226
00:43:27,349 --> 00:43:25,359
actually build kind of back well i don't

1227
00:43:29,430 --> 00:43:27,359
know i say backup but extra rovers here

1228
00:43:31,750 --> 00:43:29,440
on earth so we can test all of our stuff

1229
00:43:33,990 --> 00:43:31,760
here on earth before we send it to mars

1230
00:43:35,430 --> 00:43:34,000
so if we're doing a new activity we can

1231
00:43:37,190 --> 00:43:35,440
test it all here on earth because it's

1232
00:43:39,030 --> 00:43:37,200
much easier to fix the rover here on

1233
00:43:42,470 --> 00:43:39,040
earth than it is on mars

1234
00:43:45,349 --> 00:43:42,480
so what we'll do is um we've got one

1235
00:43:46,630 --> 00:43:45,359
rover that is almost a perfect duplicate

1236
00:43:47,750 --> 00:43:46,640
it tries to have as many of the

1237
00:43:49,990 --> 00:43:47,760
instruments

1238
00:43:52,470 --> 00:43:50,000

it has the drill and the robotic arm and

1239
00:43:54,390 --> 00:43:52,480
its full size

1240
00:43:56,150 --> 00:43:54,400
and that's the one that we can really

1241
00:43:58,390 --> 00:43:56,160
use to test out

1242
00:44:01,030 --> 00:43:58,400
um drilling or anything else we would

1243
00:44:03,349 --> 00:44:01,040
need we also have one um

1244
00:44:05,589 --> 00:44:03,359
that is the weight here on earth what it

1245
00:44:07,750 --> 00:44:05,599
is on mars so it doesn't have the

1246
00:44:09,829 --> 00:44:07,760
robotic arm it's pretty much just the

1247
00:44:12,230 --> 00:44:09,839
wheels and the legs and a computer in

1248
00:44:14,710 --> 00:44:12,240
the middle and so we can use that one a

1249
00:44:16,390 --> 00:44:14,720
lot more for our mobility and driving

1250
00:44:17,190 --> 00:44:16,400
testing because that one will act a lot

1251
00:44:19,910 --> 00:44:17,200
more

1252
00:44:20,870 --> 00:44:19,920
uh like it will on mars but here on

1253
00:44:23,750 --> 00:44:20,880
earth

1254
00:44:25,589 --> 00:44:23,760
so that's a great question

1255
00:44:28,309 --> 00:44:25,599
awesome so i think it's time to open up

1256
00:44:29,990 --> 00:44:28,319
q a for both of our speakers so sarah

1257
00:44:31,510 --> 00:44:30,000
what are they asking for both ashwin

1258
00:44:33,829 --> 00:44:31,520
we'll bring him back to the conversation

1259
00:44:37,430 --> 00:44:33,839
and carrie

1260
00:44:39,589 --> 00:44:37,440
excellent okay so sociodead on facebook

1261
00:44:41,589 --> 00:44:39,599
is asking this will be for you ashwin

1262
00:44:44,309 --> 00:44:41,599
has curiosity confirmed the presence of

1263
00:44:47,589 --> 00:44:44,319

water in any state along its path of

1264
00:44:51,750 --> 00:44:49,750
so the main way we've confirmed the

1265
00:44:54,069 --> 00:44:51,760
presence of water is in

1266
00:44:56,710 --> 00:44:54,079
incorporated into minerals

1267
00:44:58,870 --> 00:44:56,720
so in terms of the rocks on mars we

1268
00:45:01,109 --> 00:44:58,880
found a lot of clay minerals in rocks

1269
00:45:02,710 --> 00:45:01,119
and clay minerals have water bound

1270
00:45:04,790 --> 00:45:02,720
inside of them

1271
00:45:07,430 --> 00:45:04,800
but geologically we've also found you

1272
00:45:09,510 --> 00:45:07,440
know evidence that lakes once existed

1273
00:45:11,349 --> 00:45:09,520
but a long time ago so we found indirect

1274
00:45:13,270 --> 00:45:11,359
evidence for liquid water that once

1275
00:45:14,150 --> 00:45:13,280
existed uh you know billions of years

1276
00:45:15,589 --> 00:45:14,160
ago

1277
00:45:18,550 --> 00:45:15,599
the other place we found evidence for

1278
00:45:20,630 --> 00:45:18,560
water today is in the sky so we found

1279
00:45:23,190 --> 00:45:20,640
really beautiful we've taken really

1280
00:45:24,790 --> 00:45:23,200
beautiful pictures of water ice clouds

1281
00:45:25,990 --> 00:45:24,800
in the atmosphere

1282
00:45:28,790 --> 00:45:26,000
so water

1283
00:45:32,470 --> 00:45:28,800
is is around today just not so much in

1284
00:45:35,030 --> 00:45:33,510
okay

1285
00:45:37,270 --> 00:45:35,040
this next one i think is very

1286
00:45:39,190 --> 00:45:37,280
interesting this is from crystal on

1287
00:45:40,550 --> 00:45:39,200
linkedin ashwin i would like you to

1288
00:45:41,430 --> 00:45:40,560

answer

1289
00:45:42,950 --> 00:45:41,440
to your

1290
00:45:45,109 --> 00:45:42,960
the best of your knowledge

1291
00:45:47,190 --> 00:45:45,119
does mars have the potential to become

1292
00:45:48,790 --> 00:45:47,200
habitable again

1293
00:45:50,230 --> 00:45:48,800
oh

1294
00:45:51,589 --> 00:45:50,240
um

1295
00:45:53,990 --> 00:45:51,599
i you know i think the most

1296
00:45:55,910 --> 00:45:54,000
straightforward way to make uh mars

1297
00:45:57,349 --> 00:45:55,920
habitable is to bring a lot of equipment

1298
00:45:59,750 --> 00:45:57,359
with us if we go there and make it

1299
00:46:01,430 --> 00:45:59,760
habitable for ourselves so right now you

1300
00:46:04,550 --> 00:46:01,440
know if humans were to go there and set

1301
00:46:06,950 --> 00:46:04,560
up a you know permanent kind of station

1302
00:46:08,630 --> 00:46:06,960
we would have to um bring our own

1303
00:46:11,190 --> 00:46:08,640
environment with us

1304
00:46:12,230 --> 00:46:11,200
there's more exotic ideas about you know

1305
00:46:13,750 --> 00:46:12,240
kind of

1306
00:46:15,430 --> 00:46:13,760
you've probably heard about terraforming

1307
00:46:18,390 --> 00:46:15,440
mars and making mars back into an

1308
00:46:19,910 --> 00:46:18,400
environment where uh other forms of life

1309
00:46:21,270 --> 00:46:19,920
could exist

1310
00:46:23,109 --> 00:46:21,280
that's a little bit

1311
00:46:24,630 --> 00:46:23,119
more science fiction than fact at this

1312
00:46:26,309 --> 00:46:24,640
point but a lot of people have

1313
00:46:30,710 --> 00:46:26,319

interesting ideas about how maybe that

1314
00:46:34,870 --> 00:46:33,030
all right next one is for you carrie

1315
00:46:36,150 --> 00:46:34,880
this is from facebook

1316
00:46:37,990 --> 00:46:36,160
mania pen

1317
00:46:40,069 --> 00:46:38,000
on facebook is asking

1318
00:46:41,750 --> 00:46:40,079
since mars is super dusty how are the

1319
00:46:44,230 --> 00:46:41,760
camera lenses clean and taking those

1320
00:46:46,550 --> 00:46:44,240
great pictures

1321
00:46:47,670 --> 00:46:46,560
yeah that's a great question so

1322
00:46:50,069 --> 00:46:47,680
um

1323
00:46:51,829 --> 00:46:50,079
our hand lens imager the molle camera

1324
00:46:53,270 --> 00:46:51,839
actually has a cover on it so when we're

1325
00:46:55,349 --> 00:46:53,280
not using the camera we actually have a

1326
00:46:57,750 --> 00:46:55,359
nice little cover we put over it

1327
00:46:59,430 --> 00:46:57,760
and the mars dust actually settles

1328
00:47:01,109 --> 00:46:59,440
pretty straight down so when we're not

1329
00:47:02,230 --> 00:47:01,119
using the cameras we actually point our

1330
00:47:04,309 --> 00:47:02,240
head down

1331
00:47:05,990 --> 00:47:04,319
and so all of the dust kind of settles

1332
00:47:08,630 --> 00:47:06,000
on the back of our head instead of on

1333
00:47:13,829 --> 00:47:08,640
our camera lenses so um that works out

1334
00:47:17,910 --> 00:47:16,470
all right let's see

1335
00:47:19,349 --> 00:47:17,920
this is a

1336
00:47:21,589 --> 00:47:19,359
a person who has a

1337
00:47:24,390 --> 00:47:21,599
good appropriate name estrella

1338
00:47:25,430 --> 00:47:24,400

this is from linkedin and this is for

1339
00:47:27,589 --> 00:47:25,440
you carrie

1340
00:47:31,349 --> 00:47:27,599
would you say curiosity has performed

1341
00:47:34,630 --> 00:47:33,430
yeah absolutely so

1342
00:47:37,109 --> 00:47:34,640
um

1343
00:47:39,190 --> 00:47:37,119
we've operated well beyond our expected

1344
00:47:40,630 --> 00:47:39,200
lifetime and our wheels have held up

1345
00:47:42,470 --> 00:47:40,640
great even though we had a little bit of

1346
00:47:44,230 --> 00:47:42,480
trouble with them at first we've figured

1347
00:47:47,030 --> 00:47:44,240
that out now

1348
00:47:49,109 --> 00:47:47,040
we just figured out how to drill again

1349
00:47:51,270 --> 00:47:49,119
we've had a couple drill anomalies all

1350
00:47:52,950 --> 00:47:51,280
throughout the course of the mission and

1351
00:47:54,790 --> 00:47:52,960
uh that's one of my favorite things

1352
00:47:56,470 --> 00:47:54,800
about working at jpl is we have a lot of

1353
00:47:58,470 --> 00:47:56,480
great people here and a lot of really

1354
00:47:59,990 --> 00:47:58,480
smart people and so every time we're

1355
00:48:01,589 --> 00:48:00,000
faced with a problem we turn around and

1356
00:48:07,349 --> 00:48:01,599
solve it and so

1357
00:48:12,230 --> 00:48:09,349
great next question is from youtube it's

1358
00:48:14,069 --> 00:48:12,240
for you ashwin this is from peter peter

1359
00:48:16,230 --> 00:48:14,079
on youtube is asking is there any

1360
00:48:18,950 --> 00:48:16,240
evidence of plant life to have existed

1361
00:48:21,510 --> 00:48:18,960
on mars when she was covered with lakes

1362
00:48:24,630 --> 00:48:21,520
and rivers

1363
00:48:26,870 --> 00:48:24,640

not that we've discovered you know so

1364
00:48:29,030 --> 00:48:26,880
we have found that mars

1365
00:48:30,790 --> 00:48:29,040
was a very habitable place it offered

1366
00:48:33,589 --> 00:48:30,800
conditions that could have supported

1367
00:48:35,270 --> 00:48:33,599
life if life ever was present and that's

1368
00:48:36,950 --> 00:48:35,280
the result of you know our detailed

1369
00:48:39,349 --> 00:48:36,960
investigations we found that to be the

1370
00:48:41,589 --> 00:48:39,359
case for you know maybe tens or hundreds

1371
00:48:44,069 --> 00:48:41,599
of millions of years in mars past but we

1372
00:48:44,950 --> 00:48:44,079
have not found any obvious evidence for

1373
00:48:47,109 --> 00:48:44,960
life

1374
00:48:48,630 --> 00:48:47,119
and i say that i that it would be

1375
00:48:49,910 --> 00:48:48,640
obvious because

1376
00:48:52,150 --> 00:48:49,920
uh we're not

1377
00:48:54,309 --> 00:48:52,160
equipped to look in a more in a very

1378
00:48:55,990 --> 00:48:54,319
detailed way for like evidence of

1379
00:48:57,270 --> 00:48:56,000
microbial life that may have existed 3

1380
00:48:59,190 --> 00:48:57,280
billion years ago that would be very

1381
00:49:01,030 --> 00:48:59,200
hard to detect at this point in time

1382
00:49:03,990 --> 00:49:01,040
because mostly because microbes don't

1383
00:49:06,630 --> 00:49:04,000
leave really great fossils behind

1384
00:49:08,790 --> 00:49:06,640
so we found evidence for habitability no

1385
00:49:11,030 --> 00:49:08,800
obvious evidence of life but in the

1386
00:49:13,430 --> 00:49:11,040
future you know when we hopefully will

1387
00:49:15,589 --> 00:49:13,440
bring back samples of mars rock back to

1388
00:49:17,910 --> 00:49:15,599

earth we can use the vet the very best

1389
00:49:19,109 --> 00:49:17,920
laboratories on earth to do that uh

1390
00:49:20,870 --> 00:49:19,119
extremely

1391
00:49:22,790 --> 00:49:20,880
careful observation to figure out if

1392
00:49:26,390 --> 00:49:22,800
there's any actual evidence that life

1393
00:49:31,510 --> 00:49:29,109
that is awesome unfortunately that is

1394
00:49:34,390 --> 00:49:31,520
all the time we have for questions today

1395
00:49:36,150 --> 00:49:34,400
uh i do want to give our speakers one

1396
00:49:37,910 --> 00:49:36,160
final chance for their final remarks so

1397
00:49:39,430 --> 00:49:37,920
please do stick with us carrie i'm going

1398
00:49:41,910 --> 00:49:39,440
to toss it over to you for your final

1399
00:49:43,270 --> 00:49:41,920
words for the evening

1400
00:49:45,589 --> 00:49:43,280
yeah so

1401
00:49:48,150 --> 00:49:45,599
one of the fun things about working on

1402
00:49:50,309 --> 00:49:48,160
this mission is that

1403
00:49:55,109 --> 00:49:50,319
you do not have to be the absolute

1404
00:49:57,109 --> 00:49:55,119
perfect 4.0 a plus student uh to be a

1405
00:49:59,190 --> 00:49:57,119
rover driver i actually failed my first

1406
00:50:02,309 --> 00:49:59,200
calculus class in college and i'm now

1407
00:50:04,549 --> 00:50:02,319
the deputy lead rover driver so you know

1408
00:50:06,870 --> 00:50:04,559
take your failures learn from them keep

1409
00:50:08,950 --> 00:50:06,880
going and if you pull up my last graphic

1410
00:50:10,390 --> 00:50:08,960
i think working with some of the amazing

1411
00:50:13,270 --> 00:50:10,400
people on this mission

1412
00:50:16,549 --> 00:50:13,280
is just fantastic uh recently we had for

1413
00:50:18,549 --> 00:50:16,559

international women's day we actually uh

1414
00:50:20,710 --> 00:50:18,559
had a shift where we tried to staff

1415
00:50:22,309 --> 00:50:20,720
every single role with a woman and i

1416
00:50:23,829 --> 00:50:22,319
think that was really exciting to be a

1417
00:50:26,309 --> 00:50:23,839
part of um

1418
00:50:27,829 --> 00:50:26,319
to have such a really great diverse team

1419
00:50:29,829 --> 00:50:27,839
um and

1420
00:50:31,910 --> 00:50:29,839
all sorts of backgrounds as well and fun

1421
00:50:33,990 --> 00:50:31,920
hobbies of we have some people that

1422
00:50:36,230 --> 00:50:34,000
actually have music records that they've

1423
00:50:38,390 --> 00:50:36,240
put out we have pottery makers we have

1424
00:50:40,150 --> 00:50:38,400
board game geeks all over the place

1425
00:50:41,910 --> 00:50:40,160
we're all super diverse and we all come

1426
00:50:43,990 --> 00:50:41,920
together for this love for this mars

1427
00:50:46,630 --> 00:50:44,000
river and to keep going and exploring

1428
00:50:48,710 --> 00:50:46,640
another planet so um

1429
00:50:51,510 --> 00:50:48,720
you know stick around and we'll have a

1430
00:50:53,109 --> 00:50:51,520
lot more fun adventures coming up

1431
00:50:56,230 --> 00:50:53,119
that's awesome thank you carrie and

1432
00:50:57,510 --> 00:50:56,240
ashwin your final remarks

1433
00:50:59,990 --> 00:50:57,520
yeah

1434
00:51:01,750 --> 00:51:00,000
on the graphic that i chose you know for

1435
00:51:04,150 --> 00:51:01,760
these final remarks you can

1436
00:51:05,910 --> 00:51:04,160
you can see a picture of a poster that's

1437
00:51:07,349 --> 00:51:05,920
down the hall from my office

1438
00:51:08,390 --> 00:51:07,359

and the tradition had become that

1439
00:51:10,710 --> 00:51:08,400
everyone who

1440
00:51:12,390 --> 00:51:10,720
works on curiosity operations you know

1441
00:51:14,470 --> 00:51:12,400
signs this poster and you can see that

1442
00:51:15,589 --> 00:51:14,480
there's just hundreds of names on it

1443
00:51:17,750 --> 00:51:15,599
and now you know with our 10th

1444
00:51:19,910 --> 00:51:17,760
anniversary it just makes me uh very

1445
00:51:21,829 --> 00:51:19,920
grateful and thinking back to the

1446
00:51:23,030 --> 00:51:21,839
literally thousands of people who are

1447
00:51:23,910 --> 00:51:23,040
responsible

1448
00:51:26,630 --> 00:51:23,920
for

1449
00:51:27,910 --> 00:51:26,640
designing and building and testing and

1450
00:51:30,150 --> 00:51:27,920
flying

1451
00:51:31,510 --> 00:51:30,160
the spacecraft to mars and then the

1452
00:51:33,829 --> 00:51:31,520
hundreds of people who have helped

1453
00:51:34,630 --> 00:51:33,839
operate it you know an amazing fact is

1454
00:51:36,150 --> 00:51:34,640
that

1455
00:51:37,910 --> 00:51:36,160
almost all of the people operating

1456
00:51:41,109 --> 00:51:37,920
curiosity now were not there when it

1457
00:51:42,950 --> 00:51:41,119
landed we're um on you know our our

1458
00:51:44,390 --> 00:51:42,960
second and third generation of people

1459
00:51:46,309 --> 00:51:44,400
running the rover

1460
00:51:48,069 --> 00:51:46,319
uh and that just goes to show that it

1461
00:51:50,150 --> 00:51:48,079
takes so many people and so many people

1462
00:51:52,230 --> 00:51:50,160
have contributed to the rover's success

1463
00:51:53,829 --> 00:51:52,240

not only at jpl but at other places

1464
00:51:57,190 --> 00:51:53,839
around the country and in other places

1465
00:52:00,549 --> 00:51:58,630
i mean it's incredible to think of the

1466
00:52:02,549 --> 00:52:00,559
team that has done all this amazing work

1467
00:52:05,190 --> 00:52:02,559
and who's here today unfortunately that

1468
00:52:07,670 --> 00:52:05,200
is all the time we have for today for

1469
00:52:10,069 --> 00:52:07,680
our talk it seems like you know 10 years

1470
00:52:11,670 --> 00:52:10,079
to wrap it up in such a short time but i

1471
00:52:14,069 --> 00:52:11,680
do want to thank our speakers for

1472
00:52:16,470 --> 00:52:14,079
joining us this evening dr ashwin

1473
00:52:20,230 --> 00:52:16,480
vasavada and carrie bean for joining us

1474
00:52:21,910 --> 00:52:20,240
to discuss a curiosity a decade on mars

1475
00:52:24,549 --> 00:52:21,920
also i want to thank our wonderful

1476
00:52:25,750 --> 00:52:24,559
questions co-host sarah marcotte and all

1477
00:52:27,990 --> 00:52:25,760
of you that are working behind the

1478
00:52:30,390 --> 00:52:28,000
scenes to make this possible to those of

1479
00:52:32,150 --> 00:52:30,400
you watching online thank you so much

1480
00:52:34,069 --> 00:52:32,160
for taking the time to join us every

1481
00:52:36,630 --> 00:52:34,079
month if you missed one or would like to

1482
00:52:38,630 --> 00:52:36,640
revisit any of our von carmen talks from

1483
00:52:41,750 --> 00:52:38,640
the past five years they are available

1484
00:52:45,030 --> 00:52:41,760
on jpl's youtube page and please do join

1485
00:52:47,430 --> 00:52:45,040
us next month for voyager 45 years in

1486
00:52:49,510 --> 00:52:47,440
space we will see you next time have a

1487
00:52:58,410 --> 00:52:49,520
wonderful evening bye everyone thank you