
NASA
Dr. Marcello Coradini
European Space Agency Programs Coordinator

1
00:00:08,950 --> 00:00:06,309
welcome to our audience and our audience

2
00:00:10,549 --> 00:00:08,960
online i'm john grant the chair of the

3
00:00:12,070 --> 00:00:10,559
center for earth and planetary studies

4
00:00:13,589 --> 00:00:12,080
here at the smithsonian's national air

5
00:00:15,030 --> 00:00:13,599
and space museum

6
00:00:18,150 --> 00:00:15,040
the center for earth and planetary

7
00:00:20,470 --> 00:00:18,160
studies is active in planetary research

8
00:00:23,029 --> 00:00:20,480
in terrestrial planets in general but in

9
00:00:25,269 --> 00:00:23,039
mars in particular we have involvement

10
00:00:27,509 --> 00:00:25,279
in a variety of missions as well as

11
00:00:29,189 --> 00:00:27,519
scientific research programs

12
00:00:31,189 --> 00:00:29,199
i'm delighted to be standing here in the

13
00:00:33,910 --> 00:00:31,199

moving beyond earth gallery today to

14
00:00:35,750 --> 00:00:33,920
welcome you all to a mars program update

15
00:00:37,910 --> 00:00:35,760
there's been some very exciting results

16
00:00:39,990 --> 00:00:37,920
related to mars research in the past 10

17
00:00:41,910 --> 00:00:40,000
years or so and we've got a three-part

18
00:00:43,750 --> 00:00:41,920
program that's geared towards bringing

19
00:00:44,950 --> 00:00:43,760
those results to you and telling you

20
00:00:46,069 --> 00:00:44,960
where we're going to be going in the

21
00:00:48,150 --> 00:00:46,079
future

22
00:00:49,990 --> 00:00:48,160
i'd also like to welcome the stuart

23
00:00:52,229 --> 00:00:50,000
hobson middle school who's in attendance

24
00:00:54,630 --> 00:00:52,239
today and also the whittier education

25
00:00:56,389 --> 00:00:54,640
campus stem school who's also in

26
00:00:57,670 --> 00:00:56,399
attendance

27
00:00:59,830 --> 00:00:57,680
i'd like to point out that this is going

28
00:01:00,869 --> 00:00:59,840
to be broadcast live on nasa tv for

29
00:01:02,150 --> 00:01:00,879
those of you that are here in the

30
00:01:04,229 --> 00:01:02,160
audience

31
00:01:06,550 --> 00:01:04,239
and what i'd also like to do is take a

32
00:01:08,710 --> 00:01:06,560
second and mention to you that we've got

33
00:01:10,710 --> 00:01:08,720
some of the leaders in mars research in

34
00:01:12,950 --> 00:01:10,720
the research mars program here today to

35
00:01:15,190 --> 00:01:12,960
talk to you basically what we're going

36
00:01:16,789 --> 00:01:15,200
to do is have a three-part program

37
00:01:19,109 --> 00:01:16,799
that's going to tell you something about

38
00:01:20,390 --> 00:01:19,119

what we've done and where we're headed

39
00:01:22,310 --> 00:01:20,400
the first part of this will be a

40
00:01:23,990 --> 00:01:22,320
discussion of recent discoveries

41
00:01:25,670 --> 00:01:24,000
basically we've been out following the

42
00:01:26,870 --> 00:01:25,680
water and now we're going to tell you

43
00:01:28,230 --> 00:01:26,880
what we found

44
00:01:30,550 --> 00:01:28,240
then we'll take a quick break and we'll

45
00:01:32,710 --> 00:01:30,560
talk about an update of the mission

46
00:01:34,469 --> 00:01:32,720
plans that are ongoing but also that are

47
00:01:36,710 --> 00:01:34,479
scheduled for the future

48
00:01:38,310 --> 00:01:36,720
and then third we'll take a little visit

49
00:01:40,390 --> 00:01:38,320
to what and where we hope to go in the

50
00:01:42,550 --> 00:01:40,400
future and the kinds of discoveries that

51
00:01:44,710 --> 00:01:42,560
we think that we can make to start us

52
00:01:46,870 --> 00:01:44,720
off and head us on down this road i'd

53
00:01:48,870 --> 00:01:46,880
like to introduce doug mcquitchen he is

54
00:01:57,749 --> 00:01:48,880
the mars program director over at nasa

55
00:02:01,350 --> 00:01:59,590
well good morning everybody it's uh it's

56
00:02:03,510 --> 00:02:01,360
great to be here it's a it's very

57
00:02:05,670 --> 00:02:03,520
exciting opportunity here

58
00:02:07,429 --> 00:02:05,680
john was talking about just a three-part

59
00:02:09,430 --> 00:02:07,439
program but actually there's an enormous

60
00:02:11,670 --> 00:02:09,440
amount of information and some very

61
00:02:12,869 --> 00:02:11,680
exciting things coming uh in these three

62
00:02:15,190 --> 00:02:12,879
sessions

63
00:02:18,630 --> 00:02:15,200

we're here for two main reasons uh one

64
00:02:21,350 --> 00:02:18,640
of those is we've had about 10 years now

65
00:02:23,030 --> 00:02:21,360
of human presence on another planet

66
00:02:26,150 --> 00:02:23,040
so we've been on mars with the mars

67
00:02:27,670 --> 00:02:26,160
exploration program since 2001

68
00:02:29,350 --> 00:02:27,680
consistently it's pretty much a

69
00:02:31,910 --> 00:02:29,360
permanent presence both with space born

70
00:02:34,390 --> 00:02:31,920
assets as well as surface assets we have

71
00:02:36,710 --> 00:02:34,400
never done this on any other planet

72
00:02:38,390 --> 00:02:36,720
anywhere obviously other than earth so

73
00:02:40,150 --> 00:02:38,400
so that's a pretty big milestone it

74
00:02:42,229 --> 00:02:40,160
really is the second thing that we're

75
00:02:44,070 --> 00:02:42,239
here for is transition this is a major

76
00:02:45,910 --> 00:02:44,080
transition point in the program we've

77
00:02:47,190 --> 00:02:45,920
been as john said following the water

78
00:02:49,270 --> 00:02:47,200
we've been trying to understand the

79
00:02:51,110 --> 00:02:49,280
history of water on this planet

80
00:02:53,509 --> 00:02:51,120
and why our sister planet looks so

81
00:02:55,270 --> 00:02:53,519
different today than the earth looks

82
00:02:57,589 --> 00:02:55,280
we've learned a lot about that but now

83
00:02:59,990 --> 00:02:57,599
we're ready to move to a new phase about

84
00:03:01,190 --> 00:03:00,000
whether life ever existed on that planet

85
00:03:02,790 --> 00:03:01,200
or does it exist today you're going to

86
00:03:04,630 --> 00:03:02,800
hear a lot about that too so that's a

87
00:03:07,430 --> 00:03:04,640
major transition point

88
00:03:09,509 --> 00:03:07,440

um we also have a new activity here with

89
00:03:11,190 --> 00:03:09,519
the europeans we have a partnership

90
00:03:13,110 --> 00:03:11,200
beginning beginning in the middle of

91
00:03:14,790 --> 00:03:13,120
this decade we actually are going to do

92
00:03:16,470 --> 00:03:14,800
our missions in a joint fashion the

93
00:03:19,430 --> 00:03:16,480
europeans and the americans are going to

94
00:03:21,509 --> 00:03:19,440
go to mars jointly as often as we can so

95
00:03:24,789 --> 00:03:21,519
you'll hear from my isa colleague about

96
00:03:29,350 --> 00:03:26,550
we've also been on the planet twice as

97
00:03:31,270 --> 00:03:29,360
long as lewis and clark spent exploring

98
00:03:32,630 --> 00:03:31,280
the northwest

99
00:03:34,550 --> 00:03:32,640
that's interesting it's important

100
00:03:37,270 --> 00:03:34,560
because just like lewis and clark who

101
00:03:38,949 --> 00:03:37,280
spent about six years exploring

102
00:03:41,110 --> 00:03:38,959
we've been there for ten they didn't see

103
00:03:42,309 --> 00:03:41,120
everything they didn't find everything

104
00:03:44,869 --> 00:03:42,319
so they they were looking for the

105
00:03:46,149 --> 00:03:44,879
northwest passage they found the pacific

106
00:03:48,309 --> 00:03:46,159
but what they didn't do they never saw

107
00:03:50,390 --> 00:03:48,319
the grand canyon you know they never

108
00:03:52,229 --> 00:03:50,400
found the deserts of the southwest they

109
00:03:53,670 --> 00:03:52,239
never got to mexico there was a lot they

110
00:03:55,429 --> 00:03:53,680
never saw

111
00:03:57,030 --> 00:03:55,439
while we've seen incredible things we've

112
00:03:59,670 --> 00:03:57,040
done incredible things we've gone places

113
00:04:01,190 --> 00:03:59,680

we never expected to go

114
00:04:03,270 --> 00:04:01,200
and you'll hear from steve squires about

115
00:04:05,190 --> 00:04:03,280
how far we've gone with the mer rovers

116
00:04:06,710 --> 00:04:05,200
which we never expected there's plenty

117
00:04:11,509 --> 00:04:06,720
left to see there's a lot we haven't

118
00:04:14,710 --> 00:04:12,949
we've just like lewis and clark we've

119
00:04:16,789 --> 00:04:14,720
taken a lot of this information taken

120
00:04:18,789 --> 00:04:16,799
the data we've interwoven the data we've

121
00:04:21,670 --> 00:04:18,799
interpreted the data and we've created a

122
00:04:23,830 --> 00:04:21,680
story of what's happened to mars

123
00:04:25,990 --> 00:04:23,840
you're going to hear that story

124
00:04:27,430 --> 00:04:26,000
initially from jack mustard and from

125
00:04:30,070 --> 00:04:27,440
steve squires then you're going to hear

126
00:04:32,790 --> 00:04:30,080
about how we figured this out

127
00:04:33,909 --> 00:04:32,800
from myself and marcelo corradini

128
00:04:35,590 --> 00:04:33,919
after that you're going to hear about

129
00:04:37,670 --> 00:04:35,600
where we're going to go

130
00:04:39,830 --> 00:04:37,680
you'll hear that from mary wojtek and

131
00:04:42,550 --> 00:04:39,840
jen igenbrot and michael meyer john

132
00:04:46,710 --> 00:04:42,560
grant will be back up here

133
00:04:50,310 --> 00:04:48,310
so the important thing

134
00:04:52,310 --> 00:04:50,320
is this transition we're going to make

135
00:04:53,990 --> 00:04:52,320
the transition from following the water

136
00:04:55,270 --> 00:04:54,000
to seeking the signs of life and in the

137
00:04:56,550 --> 00:04:55,280
discussion today there's going to be a

138
00:04:58,469 --> 00:04:56,560

little bit of something for everybody

139
00:05:00,310 --> 00:04:58,479
those of you who like science hopefully

140
00:05:02,150 --> 00:05:00,320
some of you guys like science

141
00:05:03,670 --> 00:05:02,160
uh there'll be plenty of science in this

142
00:05:04,870 --> 00:05:03,680
for those who like hardware and

143
00:05:06,710 --> 00:05:04,880
engineering kind of things there'll be

144
00:05:08,790 --> 00:05:06,720
some of that for those of you guys who

145
00:05:10,150 --> 00:05:08,800
like history

146
00:05:12,070 --> 00:05:10,160
the reason history is important is we're

147
00:05:13,510 --> 00:05:12,080
making history we've changed textbooks

148
00:05:15,029 --> 00:05:13,520
and we're going to keep making textbooks

149
00:05:17,110 --> 00:05:15,039
so you're going to hear about how

150
00:05:18,150 --> 00:05:17,120
history in y'all's lifetime even has

151
00:05:19,110 --> 00:05:18,160
been made and you're going to hear it

152
00:05:21,110 --> 00:05:19,120
right here and you're going to hear it

153
00:05:23,029 --> 00:05:21,120
from a lot of folks that have done this

154
00:05:24,310 --> 00:05:23,039
so i hope you like what we have to say i

155
00:05:26,390 --> 00:05:24,320
hope you like how it goes i hope you

156
00:05:28,790 --> 00:05:26,400
walk away thrilled excited and want to

157
00:05:30,070 --> 00:05:28,800
dig in more about planetary science and

158
00:05:32,469 --> 00:05:30,080
so let's get started with the first

159
00:05:34,710 --> 00:05:32,479
panel so i'm going to reintroduce

160
00:05:35,990 --> 00:05:34,720
wherever he is john grant senior

161
00:05:37,909 --> 00:05:36,000
scientist here at the smithsonian

162
00:05:43,029 --> 00:05:37,919
institution as a moderator for the first

163
00:05:46,710 --> 00:05:44,550

thank you very much

164
00:05:48,790 --> 00:05:46,720
as doug has said there's been a decade

165
00:05:50,790 --> 00:05:48,800
of exploration of mars it's been a

166
00:05:53,110 --> 00:05:50,800
measured approach to understanding mars

167
00:05:55,270 --> 00:05:53,120
and what we've discovered through this

168
00:05:57,189 --> 00:05:55,280
approach is that mars is even more

169
00:05:59,430 --> 00:05:57,199
interesting than we could have imagined

170
00:06:01,189 --> 00:05:59,440
and so to give you an update and provide

171
00:06:02,550 --> 00:06:01,199
some details on some of the exciting

172
00:06:04,309 --> 00:06:02,560
discoveries that have been made over the

173
00:06:06,390 --> 00:06:04,319
past 10 years or so i'd like to

174
00:06:08,230 --> 00:06:06,400
introduce our first panel

175
00:06:15,990 --> 00:06:08,240
first i'd like to introduce dr john

176
00:06:19,830 --> 00:06:18,230
i've known john since we were graduate

177
00:06:21,990 --> 00:06:19,840
students back at brown university where

178
00:06:24,870 --> 00:06:22,000
he is now a professor

179
00:06:26,309 --> 00:06:24,880
john is a preeminent mars scientist he's

180
00:06:27,670 --> 00:06:26,319
involved in a variety of orbital

181
00:06:29,029 --> 00:06:27,680
missions related to mars and

182
00:06:30,629 --> 00:06:29,039
understanding

183
00:06:33,110 --> 00:06:30,639
about its evolution its mineral

184
00:06:35,749 --> 00:06:33,120
composition its geologic history

185
00:06:41,909 --> 00:06:35,759
next i'd like to introduce dr stephen

186
00:06:46,070 --> 00:06:43,749
i haven't known steve quite as long as

187
00:06:48,390 --> 00:06:46,080
i've known jack but our 90-day mission

188
00:06:51,830 --> 00:06:48,400

now is in his seventh year this is the

189
00:06:53,670 --> 00:06:51,840
anniversary of the murr landings on mars

190
00:06:55,589 --> 00:06:53,680
steve is a professor at cornell

191
00:06:56,870 --> 00:06:55,599
university he's the chair of the decadal

192
00:06:59,029 --> 00:06:56,880
survey which will be coming out in the

193
00:07:00,710 --> 00:06:59,039
near future sponsored by the national

194
00:07:03,189 --> 00:07:00,720
academies to have a look forward at the

195
00:07:04,790 --> 00:07:03,199
missions that could be planned and he's

196
00:07:06,790 --> 00:07:04,800
also the pi of the athena science

197
00:07:07,909 --> 00:07:06,800
payload on the mars exploration rovers

198
00:07:09,430 --> 00:07:07,919
gentlemen

199
00:07:11,350 --> 00:07:09,440
thank you

200
00:07:12,950 --> 00:07:11,360
we'll start with jack providing an

201
00:07:14,070 --> 00:07:12,960
update on some of the recent discoveries

202
00:07:16,309 --> 00:07:14,080
on mars

203
00:07:18,070 --> 00:07:16,319
thanks john looking forward to talking

204
00:07:20,390 --> 00:07:18,080
to you all here today as well it's a

205
00:07:22,710 --> 00:07:20,400
pleasure to be here and to see you all

206
00:07:24,710 --> 00:07:22,720
so if i could have the first slide

207
00:07:25,510 --> 00:07:24,720
as we've talked about it's been a decade

208
00:07:30,710 --> 00:07:25,520
of

209
00:07:33,909 --> 00:07:30,720
but it's really been going on for a long

210
00:07:36,390 --> 00:07:33,919
time and mars has been in our

211
00:07:37,990 --> 00:07:36,400
mind and imagination for a long time

212
00:07:39,830 --> 00:07:38,000
this is uh

213
00:07:42,550 --> 00:07:39,840

this is a book from the turn of the last

214
00:07:43,350 --> 00:07:42,560
century about the exploration of mars in

215
00:07:45,270 --> 00:07:43,360
which

216
00:07:47,670 --> 00:07:45,280
entire civilizations were encountered

217
00:07:49,909 --> 00:07:47,680
different types of beings etc and it

218
00:07:52,950 --> 00:07:49,919
really fueled our imagination about

219
00:07:55,589 --> 00:07:52,960
why we would want to go to this planet

220
00:07:57,510 --> 00:07:55,599
and but the reality was could i have the

221
00:07:59,670 --> 00:07:57,520
next slide please

222
00:08:02,230 --> 00:07:59,680
one that was very different

223
00:08:03,670 --> 00:08:02,240
despite the expectation of entire

224
00:08:06,390 --> 00:08:03,680
civilizations

225
00:08:09,110 --> 00:08:06,400
the finding was that there were in fact

226
00:08:11,430 --> 00:08:09,120
a very dynamic and interesting planet

227
00:08:14,070 --> 00:08:11,440
one that as we look at this graphic here

228
00:08:16,710 --> 00:08:14,080
on the left hand side we can see it has

229
00:08:18,710 --> 00:08:16,720
polar caps so actually is very similar

230
00:08:20,869 --> 00:08:18,720
to the earth in that sense it has poles

231
00:08:22,309 --> 00:08:20,879
that was very cold and in that polar cap

232
00:08:24,790 --> 00:08:22,319
there are layers

233
00:08:27,029 --> 00:08:24,800
that can be identified and those layers

234
00:08:29,110 --> 00:08:27,039
indicate change with time from a

235
00:08:30,790 --> 00:08:29,120
geologist's point of view that is gold

236
00:08:33,110 --> 00:08:30,800
because that allows us to see what is

237
00:08:34,870 --> 00:08:33,120
the record of change on the planet but

238
00:08:37,269 --> 00:08:34,880

as we look deeper we can see that there

239
00:08:39,190 --> 00:08:37,279
was evidence for giant canyons

240
00:08:40,870 --> 00:08:39,200
uh potentially

241
00:08:43,350 --> 00:08:40,880
ice flow

242
00:08:44,790 --> 00:08:43,360
that was flowing there and maybe even

243
00:08:46,070 --> 00:08:44,800
indications that there might have been

244
00:08:48,230 --> 00:08:46,080
oceans

245
00:08:49,990 --> 00:08:48,240
but the reality was that this was all

246
00:08:52,790 --> 00:08:50,000
very much in the past

247
00:08:54,949 --> 00:08:52,800
so the question we have is gosh this has

248
00:08:57,590 --> 00:08:54,959
a lot of earth-like characteristics and

249
00:09:00,710 --> 00:08:57,600
qualities and that's very exciting but

250
00:09:02,949 --> 00:09:00,720
is it earth-like and and the key

251
00:09:05,110 --> 00:09:02,959
question is if it was earth-like did

252
00:09:06,710 --> 00:09:05,120
life ever get a chance to get going and

253
00:09:09,030 --> 00:09:06,720
was there life here today could i have

254
00:09:09,910 --> 00:09:09,040
the next slide please

255
00:09:12,310 --> 00:09:09,920
well

256
00:09:14,870 --> 00:09:12,320
a rock that was found actually in

257
00:09:16,310 --> 00:09:14,880
antarctica on the ice sheet was studied

258
00:09:18,710 --> 00:09:16,320
intensively by scientists it was

259
00:09:20,790 --> 00:09:18,720
determined that it was from mars it had

260
00:09:22,550 --> 00:09:20,800
these indications that it may have had

261
00:09:23,990 --> 00:09:22,560
life in it

262
00:09:25,750 --> 00:09:24,000
and this is one of the pieces of

263
00:09:27,509 --> 00:09:25,760

evidence that was used was these

264
00:09:29,990 --> 00:09:27,519
morphologies or shapes that were

265
00:09:31,430 --> 00:09:30,000
indicative of potentially life forms

266
00:09:33,990 --> 00:09:31,440
turned out that it wasn't quite so

267
00:09:35,990 --> 00:09:34,000
simple and this sparked an entire

268
00:09:38,150 --> 00:09:36,000
exploration of the planet mars in a very

269
00:09:39,829 --> 00:09:38,160
systematic way could i have the next uh

270
00:09:41,110 --> 00:09:39,839
slide please

271
00:09:44,870 --> 00:09:41,120
and

272
00:09:46,230 --> 00:09:44,880
saying where's life forms we said we

273
00:09:48,829 --> 00:09:46,240
have to look at this very carefully and

274
00:09:51,110 --> 00:09:48,839
we have to start from a very

275
00:09:52,550 --> 00:09:51,120
uh i wouldn't say simplistic but start

276
00:09:54,949 --> 00:09:52,560
from the beginning

277
00:09:57,110 --> 00:09:54,959
and the key aspect for sustaining life

278
00:09:58,870 --> 00:09:57,120
is water where is the water

279
00:10:00,710 --> 00:09:58,880
and what form is the water so that's

280
00:10:03,030 --> 00:10:00,720
where we started and this

281
00:10:04,710 --> 00:10:03,040
graphic gives us a short summary of what

282
00:10:07,110 --> 00:10:04,720
is the distribution of modern water

283
00:10:09,110 --> 00:10:07,120
where's water today and what we find on

284
00:10:11,590 --> 00:10:09,120
the left upper left hand side of this

285
00:10:13,910 --> 00:10:11,600
graph is in the colors of blue is where

286
00:10:16,389 --> 00:10:13,920
the high concentrations of water exist

287
00:10:17,350 --> 00:10:16,399
frozen it's frozen just beneath the

288
00:10:19,269 --> 00:10:17,360

surface

289
00:10:21,030 --> 00:10:19,279
in the middle region of mars this map of

290
00:10:24,310 --> 00:10:21,040
mars you can see where it's got the

291
00:10:25,829 --> 00:10:24,320
orange tones that's really really dry

292
00:10:27,430 --> 00:10:25,839
so this is great it shows us where the

293
00:10:29,430 --> 00:10:27,440
water is and we set a spacecraft the

294
00:10:31,590 --> 00:10:29,440
phoenix spacecraft there

295
00:10:34,790 --> 00:10:31,600
just a couple of years ago on the right

296
00:10:36,389 --> 00:10:34,800
hand side of this slide where we landed

297
00:10:38,710 --> 00:10:36,399
on one of the places where we predicted

298
00:10:41,110 --> 00:10:38,720
water ice to be they landed in fact the

299
00:10:43,509 --> 00:10:41,120
rockets of the spacecraft exposed water

300
00:10:44,870 --> 00:10:43,519
ice right at the surface so this is

301
00:10:46,710 --> 00:10:44,880
science at its best where we make a

302
00:10:49,030 --> 00:10:46,720
prediction we're able to go to the

303
00:10:51,350 --> 00:10:49,040
surface and confirm that and learn a lot

304
00:10:52,550 --> 00:10:51,360
about the planet along the way

305
00:10:54,949 --> 00:10:52,560
and in addition we're using

306
00:10:57,829 --> 00:10:54,959
sophisticated tools such as radar which

307
00:10:59,509 --> 00:10:57,839
is uh we use for weather sensing on the

308
00:11:01,590 --> 00:10:59,519
earth if we look at the planet with that

309
00:11:03,030 --> 00:11:01,600
we can see that there is buried water in

310
00:11:04,630 --> 00:11:03,040
a lot of different places could i have

311
00:11:06,630 --> 00:11:04,640
the next

312
00:11:07,590 --> 00:11:06,640
slide in this

313
00:11:09,910 --> 00:11:07,600

but

314
00:11:12,870 --> 00:11:09,920
that's water on mars today what about

315
00:11:14,550 --> 00:11:12,880
its past well we can use models

316
00:11:16,870 --> 00:11:14,560
and our best understanding of how the

317
00:11:19,350 --> 00:11:16,880
planet works to predict where water has

318
00:11:21,990 --> 00:11:19,360
been in the past and this view of mars

319
00:11:23,829 --> 00:11:22,000
maybe 500 000 years ago

320
00:11:26,230 --> 00:11:23,839
shows that water was taken from the

321
00:11:29,030 --> 00:11:26,240
polar regions and distributed in this

322
00:11:31,350 --> 00:11:29,040
mid-latitude region and that's a

323
00:11:33,269 --> 00:11:31,360
prediction and the question is did mars

324
00:11:35,269 --> 00:11:33,279
have these ice ages and did it leave a

325
00:11:37,030 --> 00:11:35,279
record of that and does that tell us how

326
00:11:39,509 --> 00:11:37,040
mars operates

327
00:11:41,750 --> 00:11:39,519
in its climate and water today so if we

328
00:11:43,590 --> 00:11:41,760
go to the next slide

329
00:11:45,590 --> 00:11:43,600
in fact the recent

330
00:11:47,750 --> 00:11:45,600
cameras and instruments on the mars

331
00:11:50,069 --> 00:11:47,760
reconnaissance orbiter found

332
00:11:52,470 --> 00:11:50,079
indications that that passed where water

333
00:11:55,670 --> 00:11:52,480
was distributed throughout these middle

334
00:11:57,430 --> 00:11:55,680
regions of the planet in fact existed so

335
00:11:59,910 --> 00:11:57,440
this graphic in the middle shows the

336
00:12:01,590 --> 00:11:59,920
depth in color to the ice table where is

337
00:12:04,069 --> 00:12:01,600
the ice below the surface where red

338
00:12:05,910 --> 00:12:04,079

indicates very deep 10 meters or so and

339
00:12:08,230 --> 00:12:05,920
blue is very close so that's a

340
00:12:11,750 --> 00:12:08,240
prediction and those black dots show

341
00:12:13,430 --> 00:12:11,760
where impact craters landed in the last

342
00:12:15,590 --> 00:12:13,440
couple of years and they actually

343
00:12:17,670 --> 00:12:15,600
excavated some of this buried ice so

344
00:12:19,030 --> 00:12:17,680
that is a that is a fantastic again

345
00:12:21,430 --> 00:12:19,040
prediction you know what's important

346
00:12:23,829 --> 00:12:21,440
about that is it brings the water ice

347
00:12:25,990 --> 00:12:23,839
from the poles much closer to the

348
00:12:28,470 --> 00:12:26,000
equator this is great because it's now

349
00:12:30,389 --> 00:12:28,480
becoming more accessible to the rovers

350
00:12:31,670 --> 00:12:30,399
that we have and perhaps humans in the

351
00:12:32,870 --> 00:12:31,680
future so we're making it more

352
00:12:35,350 --> 00:12:32,880
accessible

353
00:12:39,269 --> 00:12:35,360
could i have the next graphic please

354
00:12:41,269 --> 00:12:39,279
now as we use some of our orbital assets

355
00:12:43,750 --> 00:12:41,279
you'll see that we're learning more and

356
00:12:46,389 --> 00:12:43,760
more about where water may form this is

357
00:12:47,750 --> 00:12:46,399
again using a radar in the upper right

358
00:12:49,750 --> 00:12:47,760
which can

359
00:12:52,230 --> 00:12:49,760
fire electromagnetic waves at the

360
00:12:55,190 --> 00:12:52,240
surface and by measuring the return we

361
00:12:56,230 --> 00:12:55,200
can predict maybe what's buried and in

362
00:12:58,230 --> 00:12:56,240
the upper

363
00:12:59,190 --> 00:12:58,240

upper left-hand side of this graphic you

364
00:13:00,069 --> 00:12:59,200
can see

365
00:13:03,990 --> 00:13:00,079
that

366
00:13:05,590 --> 00:13:04,000
based on the radar

367
00:13:08,550 --> 00:13:05,600
and the lower

368
00:13:09,910 --> 00:13:08,560
left image in that graphic shows one of

369
00:13:11,829 --> 00:13:09,920
these features on mars where you can see

370
00:13:12,550 --> 00:13:11,839
it looks like something has flowed out

371
00:13:15,350 --> 00:13:12,560
the

372
00:13:17,430 --> 00:13:15,360
off this mountain side and in fact

373
00:13:19,829 --> 00:13:17,440
using this radar it shows that there is

374
00:13:21,910 --> 00:13:19,839
water ice and in the blue in that map

375
00:13:24,710 --> 00:13:21,920
shows this is distributed over large

376
00:13:25,750 --> 00:13:24,720
regions not as much as the other water

377
00:13:28,230 --> 00:13:25,760
ice

378
00:13:30,629 --> 00:13:28,240
but it's again moving it closer to the

379
00:13:33,670 --> 00:13:30,639
equator moving the accessible water ice

380
00:13:35,590 --> 00:13:33,680
closer to the equator where rovers and

381
00:13:37,350 --> 00:13:35,600
astronauts et cetera could have access

382
00:13:39,750 --> 00:13:37,360
to it and it's showing this record of

383
00:13:41,269 --> 00:13:39,760
climate change that is preserved on the

384
00:13:43,750 --> 00:13:41,279
planet

385
00:13:45,110 --> 00:13:43,760
so could i have the next uh slide there

386
00:13:46,550 --> 00:13:45,120
as well

387
00:13:48,550 --> 00:13:46,560
and i'm going to step through this a

388
00:13:50,470 --> 00:13:48,560

little more quickly because we can

389
00:13:53,910 --> 00:13:50,480
actually show

390
00:13:56,949 --> 00:13:53,920
with our orbit where we find the frosts

391
00:13:59,350 --> 00:13:56,959
of carbon dioxide and water ice and in

392
00:14:01,110 --> 00:13:59,360
the graph in there in the it's showing

393
00:14:02,389 --> 00:14:01,120
in the blue arrows

394
00:14:04,550 --> 00:14:02,399
where we can see what's called

395
00:14:07,030 --> 00:14:04,560
absorption features in a measurement of

396
00:14:09,990 --> 00:14:07,040
reflected light and on the bottom is the

397
00:14:12,230 --> 00:14:10,000
uh this is in a scale of wavelength and

398
00:14:14,230 --> 00:14:12,240
with those features from our orbital

399
00:14:16,710 --> 00:14:14,240
data we can actually map where frosts

400
00:14:18,790 --> 00:14:16,720
are of different types of ices and in

401
00:14:21,269 --> 00:14:18,800
this case carbon dioxide

402
00:14:23,590 --> 00:14:21,279
so when we map those which is showing us

403
00:14:25,829 --> 00:14:23,600
in that one map on the right

404
00:14:28,829 --> 00:14:25,839
where deposits of frost form this is

405
00:14:32,470 --> 00:14:28,839
just carbon dioxide frost next slide

406
00:14:34,629 --> 00:14:32,480
please we can see in this map of mars in

407
00:14:37,030 --> 00:14:34,639
the black dots is where we see

408
00:14:39,030 --> 00:14:37,040
this frost to form

409
00:14:41,110 --> 00:14:39,040
but in the red line says where it should

410
00:14:43,430 --> 00:14:41,120
be based on our models it should be in

411
00:14:45,670 --> 00:14:43,440
all these different places why don't we

412
00:14:49,670 --> 00:14:45,680
see it everywhere

413
00:14:51,670 --> 00:14:49,680

could have the next slide please

414
00:14:53,430 --> 00:14:51,680
is that there's something buried which

415
00:14:55,269 --> 00:14:53,440
is warmer

416
00:14:58,069 --> 00:14:55,279
than the ice

417
00:15:00,870 --> 00:14:58,079
for uh then warmer than what would

418
00:15:04,069 --> 00:15:00,880
sustain carbon dioxide frost

419
00:15:07,030 --> 00:15:04,079
and this map shows that that we have a

420
00:15:08,710 --> 00:15:07,040
dry layer on the surface which is which

421
00:15:11,110 --> 00:15:08,720
gets quite cold and supports carbon

422
00:15:12,710 --> 00:15:11,120
dioxide frost but below it is something

423
00:15:15,829 --> 00:15:12,720
that keeps it warm

424
00:15:17,590 --> 00:15:15,839
which in this case is buried water ice

425
00:15:19,750 --> 00:15:17,600
so in that map there you can see where

426
00:15:21,509 --> 00:15:19,760
there's purple that means there's no

427
00:15:23,110 --> 00:15:21,519
buried water ice but everywhere else

428
00:15:26,629 --> 00:15:23,120
there's actually water eyes very close

429
00:15:28,629 --> 00:15:26,639
to the surface and this again brings ice

430
00:15:31,590 --> 00:15:28,639
closer to the poles for us

431
00:15:33,030 --> 00:15:31,600
gonna have the next uh slide please

432
00:15:35,590 --> 00:15:33,040
but one of the things that we've learned

433
00:15:36,550 --> 00:15:35,600
okay so that's modern water and it's

434
00:15:39,350 --> 00:15:36,560
frozen

435
00:15:41,590 --> 00:15:39,360
and it's uh not sustaining a large

436
00:15:44,310 --> 00:15:41,600
civilizations but there might be

437
00:15:47,430 --> 00:15:44,320
microbes potentially buried but when we

438
00:15:49,189 --> 00:15:47,440

look at the history of water on mars we

439
00:15:51,590 --> 00:15:49,199
have a more

440
00:15:53,829 --> 00:15:51,600
even a more dynamic story this this

441
00:15:55,350 --> 00:15:53,839
graphic here a little bit complicated

442
00:15:57,749 --> 00:15:55,360
graphic but on the bottom you can see

443
00:16:00,710 --> 00:15:57,759
the numbers going from zero to 4.5

444
00:16:03,350 --> 00:16:00,720
that's time where zero is today 4.5 is

445
00:16:05,749 --> 00:16:03,360
4.5 billion years ago when we look at

446
00:16:09,110 --> 00:16:05,759
mars we can see that mars has gone

447
00:16:11,430 --> 00:16:09,120
through various stages in its evolution

448
00:16:13,910 --> 00:16:11,440
in the earliest period the first billion

449
00:16:16,629 --> 00:16:13,920
years it's called the nawakian it was

450
00:16:18,310 --> 00:16:16,639
wetter we think based on geology in the

451
00:16:19,670 --> 00:16:18,320
middle period it became a different

452
00:16:22,550 --> 00:16:19,680
planet with

453
00:16:24,150 --> 00:16:22,560
more volcanism and then this amazonian

454
00:16:26,470 --> 00:16:24,160
period the last three billion years has

455
00:16:27,990 --> 00:16:26,480
been this cold dry place where there's

456
00:16:30,310 --> 00:16:28,000
glaciers

457
00:16:32,389 --> 00:16:30,320
and along the top of this graphic we see

458
00:16:35,030 --> 00:16:32,399
there's a mineralogy that goes with this

459
00:16:37,509 --> 00:16:35,040
what types of minerals form

460
00:16:39,030 --> 00:16:37,519
and from that as a geologist we can tell

461
00:16:40,629 --> 00:16:39,040
what was the

462
00:16:43,030 --> 00:16:40,639
habitability

463
00:16:44,470 --> 00:16:43,040

in other words was it a good place to be

464
00:16:46,949 --> 00:16:44,480
a microbe

465
00:16:49,110 --> 00:16:46,959
or a human or was it a difficult place

466
00:16:52,389 --> 00:16:49,120
to live and you see in that first period

467
00:16:54,310 --> 00:16:52,399
where clays form it's a neutral ph but

468
00:16:56,230 --> 00:16:54,320
you reach this middle period where it

469
00:16:58,389 --> 00:16:56,240
becomes acidic where it becomes very

470
00:17:00,310 --> 00:16:58,399
difficult and it's one of the great

471
00:17:01,670 --> 00:17:00,320
discoveries of the rovers and others

472
00:17:03,990 --> 00:17:01,680
that i'm sure steve will be talking

473
00:17:06,150 --> 00:17:04,000
about showed us that it was a much more

474
00:17:07,669 --> 00:17:06,160
challenging environment to live

475
00:17:09,510 --> 00:17:07,679
leading us to the present to live at the

476
00:17:11,110 --> 00:17:09,520
surface has become really difficult to

477
00:17:14,390 --> 00:17:11,120
live because there's not a lot of liquid

478
00:17:16,230 --> 00:17:14,400
water around so something absolutely

479
00:17:19,350 --> 00:17:16,240
phenomenal happened

480
00:17:20,789 --> 00:17:19,360
in that time frame as we go from clays

481
00:17:21,590 --> 00:17:20,799
when it was neutral

482
00:17:29,510 --> 00:17:21,600
to

483
00:17:30,630 --> 00:17:29,520
and we're not quite sure what and it's

484
00:17:31,990 --> 00:17:30,640
one of the things we're really

485
00:17:33,990 --> 00:17:32,000
interested to find out because it

486
00:17:35,909 --> 00:17:34,000
changes the suitability of a planet for

487
00:17:38,390 --> 00:17:35,919
its habitability

488
00:17:40,950 --> 00:17:38,400

so if we go to the next slide

489
00:17:44,230 --> 00:17:40,960
this is an example of one of these

490
00:17:46,230 --> 00:17:44,240
environments that may have sustained

491
00:17:49,029 --> 00:17:46,240
the conditions where if life had been

492
00:17:51,270 --> 00:17:49,039
present it could have been sustained so

493
00:17:54,230 --> 00:17:51,280
in the top of this graphic we see a

494
00:17:56,310 --> 00:17:54,240
topography map of a portion of mars and

495
00:17:58,549 --> 00:17:56,320
you can see the large circular region in

496
00:17:59,510 --> 00:17:58,559
the lower right hand side of this

497
00:18:01,750 --> 00:17:59,520
graphic

498
00:18:03,990 --> 00:18:01,760
and in the bottom we actually show that

499
00:18:05,669 --> 00:18:04,000
we can trace river channels that flowed

500
00:18:09,510 --> 00:18:05,679
into that circular region which is an

501
00:18:11,990 --> 00:18:09,520
impact crater in fact it's it has two

502
00:18:14,630 --> 00:18:12,000
inlets in one outlet so that was a lake

503
00:18:16,789 --> 00:18:14,640
that sustained itself for a while

504
00:18:18,549 --> 00:18:16,799
and in that lake are these two colored

505
00:18:20,310 --> 00:18:18,559
regions which we call the northern delta

506
00:18:21,750 --> 00:18:20,320
and the western delta

507
00:18:24,390 --> 00:18:21,760
and i'm going to show you right now a

508
00:18:26,230 --> 00:18:24,400
close-up of that in the next slide

509
00:18:28,070 --> 00:18:26,240
and in that we can see it's actually got

510
00:18:30,549 --> 00:18:28,080
the shape that you would expect of a

511
00:18:32,630 --> 00:18:30,559
delta on the earth it's dried up now so

512
00:18:34,630 --> 00:18:32,640
the water flowed into this lake formed a

513
00:18:35,830 --> 00:18:34,640

delta in the amazing thing with our

514
00:18:39,990 --> 00:18:35,840
orbital

515
00:18:42,390 --> 00:18:40,000
can determine the minerals and in there

516
00:18:45,909 --> 00:18:42,400
we see the minerals of clay

517
00:18:47,909 --> 00:18:45,919
and carbonate which for a geologist

518
00:18:50,230 --> 00:18:47,919
is really important because it says that

519
00:18:53,350 --> 00:18:50,240
those were the types of minerals where

520
00:18:55,750 --> 00:18:53,360
if um that record the conditions and if

521
00:18:58,630 --> 00:18:55,760
there had been life they would have

522
00:18:59,350 --> 00:18:58,640
captured the evidence of that that might

523
00:19:00,870 --> 00:18:59,360
be

524
00:19:02,950 --> 00:19:00,880
kept here for

525
00:19:05,029 --> 00:19:02,960
future generations or us here today to

526
00:19:06,470 --> 00:19:05,039
go and measure and understand what was

527
00:19:07,909 --> 00:19:06,480
going on

528
00:19:08,830 --> 00:19:07,919
could i have the next

529
00:19:10,789 --> 00:19:08,840
slide

530
00:19:11,669 --> 00:19:10,799
here

531
00:19:13,590 --> 00:19:11,679
so

532
00:19:15,909 --> 00:19:13,600
this map shows in the middle of the

533
00:19:18,230 --> 00:19:15,919
grand canyons of valles marineris there

534
00:19:19,669 --> 00:19:18,240
are these deposits in these sedimentary

535
00:19:21,990 --> 00:19:19,679
units in the middle these are quite

536
00:19:24,549 --> 00:19:22,000
large in which the sulfate minerals form

537
00:19:26,630 --> 00:19:24,559
so if you all take a bucket of sea water

538
00:19:28,950 --> 00:19:26,640

from the ocean and let it dry out you

539
00:19:30,950 --> 00:19:28,960
will form these sulfate minerals that's

540
00:19:32,950 --> 00:19:30,960
what appears to have happened on mars

541
00:19:35,270 --> 00:19:32,960
that and here in the middle of the

542
00:19:37,350 --> 00:19:35,280
planet we see it drying out so it went

543
00:19:39,430 --> 00:19:37,360
from a nice clement planet so something

544
00:19:41,590 --> 00:19:39,440
happened and changed it and could i have

545
00:19:42,630 --> 00:19:41,600
the next slide please

546
00:19:44,710 --> 00:19:42,640
and

547
00:19:47,350 --> 00:19:44,720
what were these habitable environments

548
00:19:48,710 --> 00:19:47,360
like and what are the most promising

549
00:19:50,630 --> 00:19:48,720
environments where we could seek the

550
00:19:52,630 --> 00:19:50,640
signs of life is one of the

551
00:19:54,310 --> 00:19:52,640
dramatic questions we're interested in

552
00:19:57,190 --> 00:19:54,320
in this slide at the bottom it could be

553
00:19:58,789 --> 00:19:57,200
weathering a rainfall at the surface or

554
00:20:01,350 --> 00:19:58,799
it could be like in a hydrothermal

555
00:20:03,029 --> 00:20:01,360
system with hot water or hot springs and

556
00:20:05,110 --> 00:20:03,039
in the top part those are the rocks that

557
00:20:06,870 --> 00:20:05,120
we're going to go out but we need to go

558
00:20:08,950 --> 00:20:06,880
and examine in greater detail to

559
00:20:11,190 --> 00:20:08,960
understand this better so could i have

560
00:20:14,390 --> 00:20:11,200
the next slide please

561
00:20:16,470 --> 00:20:14,400
and and with the upcoming

562
00:20:18,789 --> 00:20:16,480
activity of the curiosity rover to be

563
00:20:20,630 --> 00:20:18,799

launched to mars very shortly as to

564
00:20:22,630 --> 00:20:20,640
examine these types of places and john

565
00:20:24,149 --> 00:20:22,640
grant and others will talk about the

566
00:20:25,990 --> 00:20:24,159
compelling sites that we're going to go

567
00:20:28,950 --> 00:20:26,000
to one of them is this impact crater

568
00:20:30,470 --> 00:20:28,960
called gale and nk gale has a giant

569
00:20:33,110 --> 00:20:30,480
mound in the middle

570
00:20:34,950 --> 00:20:33,120
and that mound is a sedimentary mound

571
00:20:37,350 --> 00:20:34,960
and what's important

572
00:20:39,350 --> 00:20:37,360
for us uh geologically and for the

573
00:20:42,950 --> 00:20:39,360
planet is you can see the green line

574
00:20:44,789 --> 00:20:42,960
where the rover might traverse in that

575
00:20:47,990 --> 00:20:44,799
to to examine this place could i go to

576
00:20:51,029 --> 00:20:48,000
the last slide here

577
00:20:53,909 --> 00:20:51,039
and what curiosity can do then is go up

578
00:20:56,310 --> 00:20:53,919
this mound of sedimentary rock and the

579
00:20:59,190 --> 00:20:56,320
important thing is the first part of its

580
00:21:00,789 --> 00:20:59,200
investigation will be in this world

581
00:21:02,470 --> 00:21:00,799
which has clays and sulfates and

582
00:21:05,590 --> 00:21:02,480
remember that timeline i showed the

583
00:21:06,470 --> 00:21:05,600
first part was clays which is a more

584
00:21:08,710 --> 00:21:06,480
um

585
00:21:10,630 --> 00:21:08,720
more habitable type environment or a

586
00:21:11,909 --> 00:21:10,640
nicer place to live than the upper part

587
00:21:14,630 --> 00:21:11,919
where sulfates where it could have

588
00:21:16,870 --> 00:21:14,640

changed to an acidic planet and this is

589
00:21:19,750 --> 00:21:16,880
just one example of among the options

590
00:21:22,149 --> 00:21:19,760
that that msl can go where curiosity can

591
00:21:24,390 --> 00:21:22,159
go but it does allow us now we have very

592
00:21:26,149 --> 00:21:24,400
focused questions to try and uh address

593
00:21:28,230 --> 00:21:26,159
here about the history

594
00:21:31,110 --> 00:21:28,240
of mars and how it could have evolved

595
00:21:33,830 --> 00:21:31,120
and provided a habitable or

596
00:21:35,750 --> 00:21:33,840
or in uninhabitable environments for us

597
00:21:37,510 --> 00:21:35,760
to look in so it's been a pleasure to

598
00:21:39,590 --> 00:21:37,520
try and bring you up to update a little

599
00:21:41,510 --> 00:21:39,600
bit of some of the great discoveries

600
00:21:43,510 --> 00:21:41,520
that we've been having here on mars and

601
00:21:50,470 --> 00:21:43,520
like to pass it back to john

602
00:21:54,070 --> 00:21:52,070
what we're going to do now is hear a

603
00:21:55,669 --> 00:21:54,080
little bit about a couple of locations

604
00:21:57,029 --> 00:21:55,679
on mars where we've been getting up

605
00:21:59,750 --> 00:21:57,039
close and personal with some of the

606
00:22:02,070 --> 00:21:59,760
rocks and how that fits into the story

607
00:22:03,669 --> 00:22:02,080
that jack has just laid out before us

608
00:22:06,070 --> 00:22:03,679
about the history of mars and where

609
00:22:08,070 --> 00:22:06,080
water occurs i'll point out that after

610
00:22:09,510 --> 00:22:08,080
steve gets done describing some of these

611
00:22:11,270 --> 00:22:09,520
recent results

612
00:22:13,350 --> 00:22:11,280
from the mars exploration rovers we will

613
00:22:15,029 --> 00:22:13,360

have time for question and answers so

614
00:22:16,950 --> 00:22:15,039
you'll have a chance to ask some of the

615
00:22:19,270 --> 00:22:16,960
questions that you might have of our

616
00:22:21,110 --> 00:22:19,280
speakers steve all right

617
00:22:24,470 --> 00:22:21,120
well just about exactly

618
00:22:27,029 --> 00:22:24,480
seven years ago uh two explorers landed

619
00:22:28,870 --> 00:22:27,039
on the surface of mars they are robots

620
00:22:31,110 --> 00:22:28,880
their names are spirit and opportunity

621
00:22:32,549 --> 00:22:31,120
they're identical twins more or less

622
00:22:34,470 --> 00:22:32,559
uh they're about

623
00:22:37,350 --> 00:22:34,480
this tall about five feet tall they're

624
00:22:39,830 --> 00:22:37,360
about this wide about six feet wide they

625
00:22:42,710 --> 00:22:39,840
weigh about 350 pounds

626
00:22:44,390 --> 00:22:42,720
they drive really slowly

627
00:22:47,110 --> 00:22:44,400
and over the course of seven years the

628
00:22:48,710 --> 00:22:47,120
two of them have covered something like

629
00:22:51,190 --> 00:22:48,720
20 miles

630
00:22:53,590 --> 00:22:51,200
together over the surface of mars

631
00:22:54,789 --> 00:22:53,600
they've returned many tens of thousands

632
00:22:57,590 --> 00:22:54,799
of pictures you can find all the

633
00:22:59,909 --> 00:22:57,600
pictures out there on the world wide web

634
00:23:01,270 --> 00:22:59,919
and they've told us an enormous amount

635
00:23:02,870 --> 00:23:01,280
about what

636
00:23:04,870 --> 00:23:02,880
rocks are like

637
00:23:05,830 --> 00:23:04,880
at these two locations on the martian

638
00:23:06,630 --> 00:23:05,840

surface

639
00:23:10,549 --> 00:23:06,640
now

640
00:23:11,669 --> 00:23:10,559
as jack described mars today is a cold

641
00:23:13,510 --> 00:23:11,679
and dry

642
00:23:14,710 --> 00:23:13,520
and desolate world if you went there you

643
00:23:17,270 --> 00:23:14,720
would hate it

644
00:23:18,549 --> 00:23:17,280
okay it's 60 degrees below zero if you

645
00:23:19,909 --> 00:23:18,559
took all the water vapor in the martian

646
00:23:21,750 --> 00:23:19,919
atmosphere and you condensed it on the

647
00:23:23,830 --> 00:23:21,760
planet's surface you'd make a layer of

648
00:23:25,830 --> 00:23:23,840
frost that's like 100 of a millimeter

649
00:23:26,710 --> 00:23:25,840
thick so it's a pretty miserable place

650
00:23:29,590 --> 00:23:26,720
today

651
00:23:32,070 --> 00:23:29,600
but these data that we've acquired from

652
00:23:34,310 --> 00:23:32,080
orbit the pictures the spectra

653
00:23:36,950 --> 00:23:34,320
they show evidence that in the past mars

654
00:23:39,830 --> 00:23:36,960
was different it was warmer it was

655
00:23:41,750 --> 00:23:39,840
wetter it was more like earth and so the

656
00:23:43,909 --> 00:23:41,760
job of the rovers was to go to two

657
00:23:46,149 --> 00:23:43,919
places where we think there might have

658
00:23:47,110 --> 00:23:46,159
been water in the past and to try to

659
00:23:49,350 --> 00:23:47,120
learn

660
00:23:51,830 --> 00:23:49,360
what the conditions were like there by

661
00:23:53,350 --> 00:23:51,840
reading the story and the rocks

662
00:23:55,750 --> 00:23:53,360
i'll start with spirit

663
00:23:57,669 --> 00:23:55,760

uh the spirit rover went to a place

664
00:23:59,750 --> 00:23:57,679
called gusev crater

665
00:24:01,750 --> 00:23:59,760
uh jack showed you a graphic in which

666
00:24:03,590 --> 00:24:01,760
there was a big crater with a dry

667
00:24:05,350 --> 00:24:03,600
riverbed flowing into it ever like that

668
00:24:06,230 --> 00:24:05,360
there was a lake in gustave once upon a

669
00:24:08,149 --> 00:24:06,240
time

670
00:24:09,830 --> 00:24:08,159
so we went there hoping to find

671
00:24:12,789 --> 00:24:09,840
sediments that were laid down long ago

672
00:24:15,029 --> 00:24:12,799
on a martian lake we didn't find that

673
00:24:16,710 --> 00:24:15,039
what happened at this place was after

674
00:24:17,909 --> 00:24:16,720
the sediments were deposited and i'm

675
00:24:19,830 --> 00:24:17,919
convinced those sediments have to be

676
00:24:21,190 --> 00:24:19,840
down there someplace but after they were

677
00:24:22,149 --> 00:24:21,200
deposited

678
00:24:25,590 --> 00:24:22,159
lava

679
00:24:27,190 --> 00:24:25,600
erupted over top of the sediments and

680
00:24:29,029 --> 00:24:27,200
buried them we didn't know that until we

681
00:24:30,630 --> 00:24:29,039
got there

682
00:24:32,390 --> 00:24:30,640
it was kind of a bad surprise actually

683
00:24:34,390 --> 00:24:32,400
it was kind of a disappointment when we

684
00:24:36,070 --> 00:24:34,400
learned that but

685
00:24:37,990 --> 00:24:36,080
what happened was

686
00:24:40,310 --> 00:24:38,000
about a mile and a half from where we

687
00:24:42,390 --> 00:24:40,320
landed there was this beautiful range of

688
00:24:43,750 --> 00:24:42,400

hills that we named the columbia hills

689
00:24:45,510 --> 00:24:43,760
they're named after the columbia space

690
00:24:48,070 --> 00:24:45,520
shuttle

691
00:24:50,630 --> 00:24:48,080
uh because the rover the roar has lasted

692
00:24:52,470 --> 00:24:50,640
so long we were able to drive that mile

693
00:24:54,870 --> 00:24:52,480
and a half to the hills and the hills

694
00:24:56,789 --> 00:24:54,880
sort of sit up like an island sticking

695
00:24:58,230 --> 00:24:56,799
up through that sea of lava

696
00:25:00,310 --> 00:24:58,240
and they're made of totally different

697
00:25:02,230 --> 00:25:00,320
stuff they're very ancient and what the

698
00:25:05,350 --> 00:25:02,240
columbia hills do is they provide us

699
00:25:06,549 --> 00:25:05,360
with a window into the very ancient past

700
00:25:08,310 --> 00:25:06,559
of mars

701
00:25:10,710 --> 00:25:08,320
and with the spirit rover we were able

702
00:25:12,070 --> 00:25:10,720
to climb actually to the very summit of

703
00:25:14,470 --> 00:25:12,080
one of the tallest hills in the range

704
00:25:16,630 --> 00:25:14,480
and we've spent years now exploring the

705
00:25:17,909 --> 00:25:16,640
columbia hills and looking at the story

706
00:25:21,190 --> 00:25:17,919
in the rocks

707
00:25:23,430 --> 00:25:21,200
the story that these rocks tell of very

708
00:25:25,430 --> 00:25:23,440
ancient mars is that it was it was a

709
00:25:27,590 --> 00:25:25,440
violent place

710
00:25:29,110 --> 00:25:27,600
there were impacts

711
00:25:31,269 --> 00:25:29,120
where meteorites would come in from

712
00:25:33,110 --> 00:25:31,279
space and they would blow a big hole in

713
00:25:35,190 --> 00:25:33,120

the ground dump

714
00:25:37,909 --> 00:25:35,200
rocks all over the place there were

715
00:25:39,909 --> 00:25:37,919
volcanic volcanic explosions

716
00:25:42,070 --> 00:25:39,919
where lavas maybe came into contact with

717
00:25:45,029 --> 00:25:42,080
water and it flashed into steam and boom

718
00:25:48,070 --> 00:25:45,039
blew stuff up in the air so we see the

719
00:25:49,590 --> 00:25:48,080
remains of these violent events

720
00:25:51,510 --> 00:25:49,600
it's a quiet place today but it was a

721
00:25:54,230 --> 00:25:51,520
much different place back then the other

722
00:25:57,029 --> 00:25:54,240
thing is we see compelling evidence

723
00:25:58,789 --> 00:25:57,039
that there was water present and there

724
00:26:00,549 --> 00:25:58,799
were hot springs

725
00:26:02,230 --> 00:26:00,559
we see a lot of evidence for what

726
00:26:03,909 --> 00:26:02,240
geologists would call hydrothermal

727
00:26:06,630 --> 00:26:03,919
activities is what happens when water

728
00:26:08,230 --> 00:26:06,640
comes into contact with with hot lava

729
00:26:09,909 --> 00:26:08,240
and you can get steam vents and you can

730
00:26:11,430 --> 00:26:09,919
get hot springs with water flowing out

731
00:26:12,870 --> 00:26:11,440
of the ground one of the things one of

732
00:26:15,750 --> 00:26:12,880
the big discoveries one of the biggest

733
00:26:18,149 --> 00:26:15,760
surprises we found very concentrated

734
00:26:20,230 --> 00:26:18,159
deposits of silica

735
00:26:21,669 --> 00:26:20,240
this is like it's like opal

736
00:26:23,430 --> 00:26:21,679
like the gemstone this is the kind of

737
00:26:25,590 --> 00:26:23,440
stuff that can form in hot spring and

738
00:26:27,110 --> 00:26:25,600

hydrothermal environments we found very

739
00:26:28,789 --> 00:26:27,120
concentrated deposits of this and what

740
00:26:30,630 --> 00:26:28,799
it says is this is a place where hot

741
00:26:32,630 --> 00:26:30,640
water or hot steam

742
00:26:34,789 --> 00:26:32,640
came out of the ground now you can go to

743
00:26:36,310 --> 00:26:34,799
places on earth today

744
00:26:38,070 --> 00:26:36,320
where hot water and hot steam come out

745
00:26:39,590 --> 00:26:38,080
of the ground and they're teeming with

746
00:26:40,870 --> 00:26:39,600
microbial life

747
00:26:42,710 --> 00:26:40,880
doesn't mean there was life on mars

748
00:26:45,510 --> 00:26:42,720
necessarily but they this points to

749
00:26:48,549 --> 00:26:45,520
evidence of a former

750
00:26:50,230 --> 00:26:48,559
habitable environment a place where life

751
00:26:51,510 --> 00:26:50,240
maybe could have taken hold on the

752
00:26:53,269 --> 00:26:51,520
surface of mars

753
00:26:54,549 --> 00:26:53,279
another thing that we found was we found

754
00:26:55,909 --> 00:26:54,559
carbonate rocks this was something that

755
00:26:56,789 --> 00:26:55,919
jack mentioned too that's been seen from

756
00:26:59,269 --> 00:26:56,799
orbit

757
00:27:00,870 --> 00:26:59,279
carbonates is basically limestone uh in

758
00:27:02,390 --> 00:27:00,880
our case it was iron carbonates and

759
00:27:05,510 --> 00:27:02,400
magnesium carbonates but we found

760
00:27:07,990 --> 00:27:05,520
concentrated deposits of carbonates and

761
00:27:10,310 --> 00:27:08,000
what these point to again is water being

762
00:27:12,310 --> 00:27:10,320
present and water being present with a

763
00:27:14,470 --> 00:27:12,320

water chemistry that's the kind of thing

764
00:27:18,389 --> 00:27:14,480
that could be suitable for life so even

765
00:27:21,269 --> 00:27:18,399
though gusev crater is cold dry desolate

766
00:27:23,350 --> 00:27:21,279
today uh it clearly was quite different

767
00:27:25,110 --> 00:27:23,360
and much more suitable for life in the

768
00:27:26,470 --> 00:27:25,120
past

769
00:27:28,070 --> 00:27:26,480
opportunity

770
00:27:29,350 --> 00:27:28,080
landed completely around the other side

771
00:27:30,950 --> 00:27:29,360
of the planet

772
00:27:32,789 --> 00:27:30,960
180 degrees around the other side of the

773
00:27:36,549 --> 00:27:32,799
planet on a place called meridiani

774
00:27:39,590 --> 00:27:36,559
planum now the reason we chose meridiani

775
00:27:42,950 --> 00:27:39,600
as a landing site was that from orbit

776
00:27:44,470 --> 00:27:42,960
we saw the signs of a mineral called

777
00:27:48,470 --> 00:27:44,480
hematite

778
00:27:50,230 --> 00:27:48,480
that's present in rust

779
00:27:51,750 --> 00:27:50,240
okay and it's a mineral that typically

780
00:27:53,430 --> 00:27:51,760
not always but usually forms in the

781
00:27:55,430 --> 00:27:53,440
presence of water so it was like this

782
00:27:57,750 --> 00:27:55,440
this chemical beacon visible from space

783
00:28:02,149 --> 00:27:57,760
saying hey come land here

784
00:28:06,470 --> 00:28:02,159
we landed at meridiani and we were just

785
00:28:07,909 --> 00:28:06,480
baffled it was bizarre um on the soil

786
00:28:09,990 --> 00:28:07,919
in front of the lander we wrote we

787
00:28:11,430 --> 00:28:10,000
actually landed in a little crater

788
00:28:14,549 --> 00:28:11,440

there were these little they looked like

789
00:28:16,149 --> 00:28:14,559
beads little round things four five six

790
00:28:18,149 --> 00:28:16,159
millimeters in diameter and they were

791
00:28:19,190 --> 00:28:18,159
everywhere we called them blueberries

792
00:28:21,110 --> 00:28:19,200
because they sort of look like that

793
00:28:22,470 --> 00:28:21,120
they're actually not blue they're gray

794
00:28:24,230 --> 00:28:22,480
um and it turns out that they were

795
00:28:26,389 --> 00:28:24,240
embedded in the rocks

796
00:28:28,710 --> 00:28:26,399
and the blueberries are made of hematite

797
00:28:30,310 --> 00:28:28,720
this was bizarre nobody expected this we

798
00:28:32,470 --> 00:28:30,320
drove over to the rocks and we found out

799
00:28:35,350 --> 00:28:32,480
that the rocks were sediments

800
00:28:37,750 --> 00:28:35,360
that had been laid down by wind uh and

801
00:28:39,990 --> 00:28:37,760
in some cases by water long ago you can

802
00:28:42,149 --> 00:28:40,000
see little ripples in the rocks that

803
00:28:44,630 --> 00:28:42,159
show that flowing water was actually at

804
00:28:47,430 --> 00:28:44,640
the surface here the rocks are made

805
00:28:48,950 --> 00:28:47,440
mostly of sulfate salts jack said if you

806
00:28:50,710 --> 00:28:48,960
have a bucket of the right kind of sea

807
00:28:52,470 --> 00:28:50,720
water and you let it evaporate away you

808
00:28:53,590 --> 00:28:52,480
can make sulfate salts well that's what

809
00:29:00,389 --> 00:28:53,600
we see

810
00:29:02,470 --> 00:29:00,399
water near the surface

811
00:29:04,950 --> 00:29:02,480
the blueberries it turns out are things

812
00:29:07,510 --> 00:29:04,960
that geologists call concretions

813
00:29:09,269 --> 00:29:07,520

when water saturates the ground in some

814
00:29:10,470 --> 00:29:09,279
place we find these on earth typically

815
00:29:12,230 --> 00:29:10,480
forms in places where you have

816
00:29:14,470 --> 00:29:12,240
sedimentary rocks that are saturated

817
00:29:15,909 --> 00:29:14,480
with liquid water there's some mineral

818
00:29:17,590 --> 00:29:15,919
that's dissolved in the water it wants

819
00:29:19,350 --> 00:29:17,600
to precipitate out

820
00:29:20,950 --> 00:29:19,360
and it finds a little nucleation point

821
00:29:23,190 --> 00:29:20,960
and it starts to precipitate and it

822
00:29:25,510 --> 00:29:23,200
grows and it adds layer upon layer upon

823
00:29:26,870 --> 00:29:25,520
layer making this little hard spherical

824
00:29:28,149 --> 00:29:26,880
nodule

825
00:29:29,750 --> 00:29:28,159
in the rock like the way sort of like

826
00:29:31,029 --> 00:29:29,760
the way an oyster builds a pearl okay

827
00:29:31,909 --> 00:29:31,039
and it makes these little hard nodules

828
00:29:33,190 --> 00:29:31,919
through the rocks and that's what the

829
00:29:35,750 --> 00:29:33,200
blueberries are

830
00:29:38,070 --> 00:29:35,760
so we've got this compelling evidence at

831
00:29:40,389 --> 00:29:38,080
meridiani that there was water beneath

832
00:29:42,389 --> 00:29:40,399
the ground the water occasionally came

833
00:29:44,789 --> 00:29:42,399
to the surface now when we made this

834
00:29:46,789 --> 00:29:44,799
discovery people made a big deal about

835
00:29:49,430 --> 00:29:46,799
it right rovers discover evidence of

836
00:29:51,269 --> 00:29:49,440
water on mars well honestly we've known

837
00:29:52,630 --> 00:29:51,279
that there was once water on mars if you

838
00:29:53,990 --> 00:29:52,640

want to talk about the space mission

839
00:29:55,830 --> 00:29:54,000
that discovered that there was water on

840
00:29:57,909 --> 00:29:55,840
mars you've got to go back to mariner 9

841
00:29:59,990 --> 00:29:57,919
in 1971. that's the mission that

842
00:30:01,430 --> 00:30:00,000
discovered there was water on mars but

843
00:30:04,149 --> 00:30:01,440
what we've been able to do is we have

844
00:30:05,830 --> 00:30:04,159
been able to add layer upon layer upon

845
00:30:08,789 --> 00:30:05,840
layer of detail

846
00:30:10,389 --> 00:30:08,799
to our understanding of what the

847
00:30:12,230 --> 00:30:10,399
chemistry was like

848
00:30:13,669 --> 00:30:12,240
what the environment was like so for

849
00:30:14,710 --> 00:30:13,679
example when we look at the minerals

850
00:30:17,110 --> 00:30:14,720
that are present in the rocks at

851
00:30:19,990 --> 00:30:17,120
meridiani and we look at those sulfates

852
00:30:21,029 --> 00:30:20,000
they actually tell us that the water was

853
00:30:22,870 --> 00:30:21,039
acid

854
00:30:23,990 --> 00:30:22,880
you know people say ah we found evidence

855
00:30:25,269 --> 00:30:24,000
of water on mars well what we really

856
00:30:26,789 --> 00:30:25,279
found at meridiani was evidence for

857
00:30:28,310 --> 00:30:26,799
sulfuric acid on mars you wouldn't want

858
00:30:30,070 --> 00:30:28,320
to drink this stuff

859
00:30:31,430 --> 00:30:30,080
okay now there are organisms that can

860
00:30:33,510 --> 00:30:31,440
live in environments like that but this

861
00:30:35,029 --> 00:30:33,520
would have been a very challenging place

862
00:30:36,950 --> 00:30:35,039
for life

863
00:30:39,269 --> 00:30:36,960

all the discoveries i just listed we we

864
00:30:40,870 --> 00:30:39,279
made in like what the first two months

865
00:30:42,630 --> 00:30:40,880
of a seven year mission

866
00:30:44,070 --> 00:30:42,640
and then we've been adding detail to it

867
00:30:45,110 --> 00:30:44,080
since then

868
00:30:47,110 --> 00:30:45,120
to date

869
00:30:49,350 --> 00:30:47,120
the opportunity rover has driven

870
00:30:51,269 --> 00:30:49,360
something like 26 kilometers so getting

871
00:30:52,630 --> 00:30:51,279
close to 15 miles

872
00:30:54,789 --> 00:30:52,640
across the martian surface if i could

873
00:30:55,669 --> 00:30:54,799
have the the first graphic

874
00:30:58,230 --> 00:30:55,679
up

875
00:30:59,190 --> 00:30:58,240
uh opportunity is currently

876
00:31:02,230 --> 00:30:59,200
parked

877
00:31:03,909 --> 00:31:02,240
right on the rim of a spectacular

878
00:31:05,669 --> 00:31:03,919
impact crater it's about 100 yards in

879
00:31:06,870 --> 00:31:05,679
diameter we've named it santa maria

880
00:31:08,230 --> 00:31:06,880
crater it's named after one of

881
00:31:09,669 --> 00:31:08,240
columbus's ships and if you look

882
00:31:11,029 --> 00:31:09,679
carefully in this graphic you can

883
00:31:13,669 --> 00:31:11,039
there's a picture taken from orbit you

884
00:31:15,430 --> 00:31:13,679
can actually see the rover

885
00:31:17,590 --> 00:31:15,440
right there on the rim

886
00:31:20,070 --> 00:31:17,600
of uh of santa maria crater it's kind of

887
00:31:22,950 --> 00:31:20,080
cool to see our our rover again uh if

888
00:31:24,149 --> 00:31:22,960

you go to the next graphic you'll see a

889
00:31:27,269 --> 00:31:24,159
the view

890
00:31:29,990 --> 00:31:27,279
that opportunity had from that spot this

891
00:31:32,389 --> 00:31:30,000
is a spectacular hole in the ground it

892
00:31:33,590 --> 00:31:32,399
was caused when there was an impact that

893
00:31:35,750 --> 00:31:33,600
formed

894
00:31:37,509 --> 00:31:35,760
uh an imp impact that took place on the

895
00:31:39,350 --> 00:31:37,519
surface rock from space comes and blows

896
00:31:41,110 --> 00:31:39,360
a big hole in the ground the cool thing

897
00:31:43,990 --> 00:31:41,120
about craters

898
00:31:45,909 --> 00:31:44,000
is they provide us with access to rocks

899
00:31:48,630 --> 00:31:45,919
from below the surface that we can't get

900
00:31:50,389 --> 00:31:48,640
at any other way we didn't bring a drill

901
00:31:53,430 --> 00:31:50,399
we didn't bring a backhoe we didn't

902
00:31:55,990 --> 00:31:53,440
bring dynamite but mars has

903
00:31:57,830 --> 00:31:56,000
dug these big holes for us in the form

904
00:31:59,509 --> 00:31:57,840
of impact craters and the rocks get

905
00:32:00,870 --> 00:31:59,519
thrown out of the crater and right now

906
00:32:02,710 --> 00:32:00,880
as we speak

907
00:32:04,789 --> 00:32:02,720
opportunity is perched right on the rim

908
00:32:06,630 --> 00:32:04,799
of this crater on the far side of the

909
00:32:07,509 --> 00:32:06,640
the view that you see in this in this

910
00:32:09,909 --> 00:32:07,519
picture

911
00:32:11,269 --> 00:32:09,919
and we're hunkering down to really start

912
00:32:13,190 --> 00:32:11,279
in detail

913
00:32:15,669 --> 00:32:13,200

measuring the composition of some of the

914
00:32:16,870 --> 00:32:15,679
rocks that have come out of the interior

915
00:32:20,230 --> 00:32:16,880
of the crater

916
00:32:24,789 --> 00:32:22,870
we have a very

917
00:32:26,310 --> 00:32:24,799
distant goal

918
00:32:27,909 --> 00:32:26,320
that we have chosen for opportunity now

919
00:32:30,310 --> 00:32:27,919
let me stress these things were designed

920
00:32:34,310 --> 00:32:30,320
to last for 90 days

921
00:32:36,230 --> 00:32:34,320
they were designed to drive 600 meters

922
00:32:37,909 --> 00:32:36,240
less than half a mile

923
00:32:41,190 --> 00:32:37,919
over their lifetimes we've gone

924
00:32:42,789 --> 00:32:41,200
something like 15 miles with this thing

925
00:32:44,470 --> 00:32:42,799
if you look at this graphic what you can

926
00:32:47,029 --> 00:32:44,480
see there's a there's a crater there

927
00:32:50,149 --> 00:32:47,039
named victoria we spent years exploring

928
00:32:52,389 --> 00:32:50,159
victoria crater uh right now you can see

929
00:32:54,549 --> 00:32:52,399
where opportunity is santa maria crater

930
00:32:57,669 --> 00:32:54,559
it's it's so tiny that you can't even

931
00:33:00,070 --> 00:32:57,679
see it in this view where we are going

932
00:33:03,110 --> 00:33:00,080
is this crater called endeavor

933
00:33:04,549 --> 00:33:03,120
endeavor is enormous this thing is a

934
00:33:06,950 --> 00:33:04,559
monster compared to any of the craters

935
00:33:10,230 --> 00:33:06,960
that we've seen before it's like 15

936
00:33:13,590 --> 00:33:10,240
miles in diameter it is a big hole in

937
00:33:16,230 --> 00:33:13,600
the ground the rim of endeavor crater is

938
00:33:18,149 --> 00:33:16,240

visible from where we are now let me

939
00:33:19,990 --> 00:33:18,159
show the next slide the next picture

940
00:33:21,750 --> 00:33:20,000
this is the current view

941
00:33:23,509 --> 00:33:21,760
this is looking off in the distance and

942
00:33:25,190 --> 00:33:23,519
like islands

943
00:33:27,830 --> 00:33:25,200
on the horizon

944
00:33:29,830 --> 00:33:27,840
as an explorer is traveling across this

945
00:33:31,509 --> 00:33:29,840
this sea of sand dunes and sulfate rocks

946
00:33:33,269 --> 00:33:31,519
we can see the rim

947
00:33:34,870 --> 00:33:33,279
of victoria crater and it's now only

948
00:33:35,909 --> 00:33:34,880
about four miles away

949
00:33:37,029 --> 00:33:35,919
i don't know when we're going to get

950
00:33:38,789 --> 00:33:37,039
there but i'm starting to believe we're

951
00:33:41,909 --> 00:33:38,799
really going to make it the cool thing

952
00:33:44,149 --> 00:33:41,919
about the rim of endeavor crater

953
00:33:45,350 --> 00:33:44,159
you heard jack talk about

954
00:33:51,110 --> 00:33:45,360
clay

955
00:33:52,389 --> 00:33:51,120
minerals

956
00:33:54,549 --> 00:33:52,399
at the rim

957
00:33:55,350 --> 00:33:54,559
of endeavor crater and if we can make it

958
00:33:56,470 --> 00:33:55,360
and i don't know if we're going to make

959
00:33:57,750 --> 00:33:56,480
it i mean

960
00:33:59,509 --> 00:33:57,760
you know these these we voided the

961
00:34:00,950 --> 00:33:59,519
warranty on these vehicles a long time

962
00:34:02,310 --> 00:34:00,960
ago

963
00:34:03,590 --> 00:34:02,320

but we're going to try

964
00:34:05,830 --> 00:34:03,600
we're going to try to get to endeavor

965
00:34:07,190 --> 00:34:05,840
crater and my goal

966
00:34:09,750 --> 00:34:07,200
is to actually get there before the

967
00:34:12,389 --> 00:34:09,760
curiosity rover curiosity is being

968
00:34:13,829 --> 00:34:12,399
targeted to go to clay minerals and i

969
00:34:15,349 --> 00:34:13,839
you know they're going to get there and

970
00:34:16,629 --> 00:34:15,359
they're going to do great stuff but we

971
00:34:19,270 --> 00:34:16,639
want to do it first

972
00:34:21,909 --> 00:34:19,280
so we're going to try anyway we've got a

973
00:34:25,349 --> 00:34:21,919
spectacular mission still ahead of us

974
00:34:27,030 --> 00:34:25,359
uh seven years in and still going strong

975
00:34:27,909 --> 00:34:27,040
and i'm looking forward to seeing what

976
00:34:36,230 --> 00:34:27,919
we see

977
00:34:40,389 --> 00:34:38,069
so we've heard a little bit about recent

978
00:34:42,230 --> 00:34:40,399
discoveries where water occurs on mars

979
00:34:43,829 --> 00:34:42,240
how it occurs on mars we've heard a

980
00:34:45,510 --> 00:34:43,839
little bit about how the rovers have

981
00:34:47,270 --> 00:34:45,520
been exploring mars

982
00:34:49,589 --> 00:34:47,280
and investigating where this water

983
00:34:51,669 --> 00:34:49,599
occurs what i'd like to do now as long

984
00:34:53,589 --> 00:34:51,679
as we've got our esteemed panel up here

985
00:34:55,750 --> 00:34:53,599
is open this up for a couple questions

986
00:34:58,230 --> 00:34:55,760
from our audience and find out if folks

987
00:34:59,589 --> 00:34:58,240
have some things they'd like to ask

988
00:35:00,710 --> 00:34:59,599

yes

989
00:35:03,510 --> 00:35:00,720
could you please come up and use the

990
00:35:05,430 --> 00:35:03,520
microphone so that we can

991
00:35:07,750 --> 00:35:05,440
let everybody that's uh listening and

992
00:35:10,550 --> 00:35:07,760
watching online understand as well has

993
00:35:13,270 --> 00:35:10,560
there been any investigation of the

994
00:35:14,870 --> 00:35:13,280
meteorology

995
00:35:16,550 --> 00:35:14,880
around mars

996
00:35:19,030 --> 00:35:16,560
has there been any investigation of the

997
00:35:21,349 --> 00:35:19,040
meteorology or the weather on mars sure

998
00:35:23,430 --> 00:35:21,359
meteorology is is a

999
00:35:24,710 --> 00:35:23,440
really important uh subject of what we

1000
00:35:27,109 --> 00:35:24,720
learned so we've been using a lot of

1001
00:35:29,750 --> 00:35:27,119
orbital data from which we can determine

1002
00:35:31,670 --> 00:35:29,760
where the dust clouds are where the ices

1003
00:35:34,230 --> 00:35:31,680
are forming and being removed we can

1004
00:35:35,109 --> 00:35:34,240
determine the temperature of the planet

1005
00:35:36,870 --> 00:35:35,119
and

1006
00:35:38,630 --> 00:35:36,880
uh through the

1007
00:35:40,710 --> 00:35:38,640
landers that have been on mars over the

1008
00:35:43,430 --> 00:35:40,720
years we actually get weather stations

1009
00:35:47,030 --> 00:35:43,440
on the surface what we really need in

1010
00:35:49,030 --> 00:35:47,040
order to do meteorology is a half dozen

1011
00:35:50,230 --> 00:35:49,040
of permanent weather stations and so

1012
00:35:52,630 --> 00:35:50,240
that's one of the things that would be

1013
00:35:55,030 --> 00:35:52,640

really exciting uh to to have in our

1014
00:35:57,030 --> 00:35:55,040
future our future rovers and let me say

1015
00:35:59,030 --> 00:35:57,040
that we really care about the weather on

1016
00:36:00,310 --> 00:35:59,040
mars in a practical sense on our rover

1017
00:36:02,630 --> 00:36:00,320
mission because we got solar-powered

1018
00:36:04,630 --> 00:36:02,640
vehicles and we really really worry

1019
00:36:07,030 --> 00:36:04,640
about things like dust storms so i get a

1020
00:36:08,470 --> 00:36:07,040
weekly weather report uh from the

1021
00:36:09,990 --> 00:36:08,480
orbiters that tell us you know what kind

1022
00:36:13,349 --> 00:36:10,000
of weather we can expect in the in the

1023
00:36:16,710 --> 00:36:13,359
week ahead for the uh for the rovers

1024
00:36:19,589 --> 00:36:16,720
other questions for our speakers

1025
00:36:20,630 --> 00:36:19,599
over here please use the microphone

1026
00:36:23,430 --> 00:36:20,640
professor

1027
00:36:25,510 --> 00:36:23,440
squires i was curious if you could

1028
00:36:28,230 --> 00:36:25,520
summarize or actually all of you

1029
00:36:30,470 --> 00:36:28,240
we know there's a lot of water on mars

1030
00:36:32,150 --> 00:36:30,480
do we know enough to make some kind of

1031
00:36:34,310 --> 00:36:32,160
quantitative assay

1032
00:36:36,870 --> 00:36:34,320
about what sort of useful resource this

1033
00:36:38,870 --> 00:36:36,880
water would be when humans explore it i

1034
00:36:41,190 --> 00:36:38,880
mean from the water and some energy and

1035
00:36:43,910 --> 00:36:41,200
the co2 you can make rocket fuel

1036
00:36:45,270 --> 00:36:43,920
transportation fuel of various types how

1037
00:36:47,829 --> 00:36:45,280
much do we know

1038
00:36:50,390 --> 00:36:47,839

that would underlie the use of that

1039
00:36:51,990 --> 00:36:50,400
water as a resource for exploration yeah

1040
00:36:54,470 --> 00:36:52,000
that's a very good question can you can

1041
00:36:56,390 --> 00:36:54,480
you go to mars and live off the land

1042
00:36:57,910 --> 00:36:56,400
the answer looks like it kind of might

1043
00:36:59,750 --> 00:36:57,920
be yes i mean

1044
00:37:02,710 --> 00:36:59,760
jack described these impact craters

1045
00:37:05,510 --> 00:37:02,720
where very fresh craters have excavated

1046
00:37:07,430 --> 00:37:05,520
not very far below the surface and found

1047
00:37:09,990 --> 00:37:07,440
compelling evidence for there being ice

1048
00:37:12,150 --> 00:37:10,000
there and it exists closer to the

1049
00:37:14,790 --> 00:37:12,160
equator than uh than a lot of people

1050
00:37:16,630 --> 00:37:14,800
initially expected so yeah i think you

1051
00:37:18,390 --> 00:37:16,640
can probably go there you can excavate

1052
00:37:21,510 --> 00:37:18,400
ice from beneath the surface you're

1053
00:37:23,589 --> 00:37:21,520
gonna need a major source of energy

1054
00:37:25,349 --> 00:37:23,599
okay you're going to need something that

1055
00:37:27,589 --> 00:37:25,359
enables you to dig

1056
00:37:29,589 --> 00:37:27,599
and digging into ice that is that hard

1057
00:37:30,790 --> 00:37:29,599
frozen is hard to do and then if you

1058
00:37:33,349 --> 00:37:30,800
want to do things like make rocket

1059
00:37:35,349 --> 00:37:33,359
propellants yeah you can split uh water

1060
00:37:37,270 --> 00:37:35,359
into hydrogen and oxygen and those are

1061
00:37:39,990 --> 00:37:37,280
terrific rocket propellants but it takes

1062
00:37:42,150 --> 00:37:40,000
a lot of energy to do that so

1063
00:37:44,550 --> 00:37:42,160

the energy problem has to be solved but

1064
00:37:46,630 --> 00:37:44,560
is the resource there yeah and is it

1065
00:37:48,550 --> 00:37:46,640
accessible yeah

1066
00:37:50,310 --> 00:37:48,560
yeah i think we're going to find as

1067
00:37:51,990 --> 00:37:50,320
curiosity and other rovers go that

1068
00:37:55,030 --> 00:37:52,000
they're going to find

1069
00:37:56,950 --> 00:37:55,040
the the resource of of water and other

1070
00:37:58,230 --> 00:37:56,960
other aspects are actually a lot closer

1071
00:37:59,829 --> 00:37:58,240
and a lot more accessible than we

1072
00:38:01,430 --> 00:37:59,839
currently think there's been this

1073
00:38:03,190 --> 00:38:01,440
constant oscillation in our

1074
00:38:05,270 --> 00:38:03,200
understanding of mars

1075
00:38:06,390 --> 00:38:05,280
where as i showed you know a hundred

1076
00:38:08,470 --> 00:38:06,400
years ago we thought there were

1077
00:38:10,150 --> 00:38:08,480
civilizations there then we thought it

1078
00:38:11,030 --> 00:38:10,160
was so dry

1079
00:38:13,990 --> 00:38:11,040
if

1080
00:38:16,150 --> 00:38:14,000
then it swung back

1081
00:38:17,750 --> 00:38:16,160
so now i think we're zeroing in on what

1082
00:38:19,349 --> 00:38:17,760
the reality is but i think there's still

1083
00:38:20,870 --> 00:38:19,359
a lot to learn and i

1084
00:38:22,230 --> 00:38:20,880
think we should take a shovel on one of

1085
00:38:23,990 --> 00:38:22,240
these rovers right because in some

1086
00:38:25,589 --> 00:38:24,000
places i think if we dig just below the

1087
00:38:26,950 --> 00:38:25,599
surface we might actually find something

1088
00:38:28,390 --> 00:38:26,960

really compelling yeah we could dig

1089
00:38:29,990 --> 00:38:28,400
trenches with the wheels the problem

1090
00:38:31,349 --> 00:38:30,000
with our rovers is because the solar

1091
00:38:33,670 --> 00:38:31,359
power they had to land close to the

1092
00:38:34,710 --> 00:38:33,680
equator yeah and close to the equator

1093
00:38:37,349 --> 00:38:34,720
you've got to dig pretty deep so we

1094
00:38:39,430 --> 00:38:37,359
haven't found in the ice

1095
00:38:41,829 --> 00:38:39,440
question over here yeah you started the

1096
00:38:43,750 --> 00:38:41,839
touch on my question uh as i understand

1097
00:38:45,750 --> 00:38:43,760
it microphone sure thank you

1098
00:38:47,589 --> 00:38:45,760
as i understand that the radiation

1099
00:38:50,150 --> 00:38:47,599
environment is pretty bad on the surface

1100
00:38:52,069 --> 00:38:50,160
and plus with the the dust devils and

1101
00:38:55,670 --> 00:38:52,079
everything that's almost i guess akin to

1102
00:38:57,750 --> 00:38:55,680
sandblasting the entire surface

1103
00:39:00,950 --> 00:38:57,760
so answering i guess the second part of

1104
00:39:04,230 --> 00:39:00,960
our title seeking signs of life how far

1105
00:39:06,550 --> 00:39:04,240
down do you suppose we would have to dig

1106
00:39:08,710 --> 00:39:06,560
to actually find evidence that there may

1107
00:39:10,310 --> 00:39:08,720
have been life on the planet and is that

1108
00:39:12,230 --> 00:39:10,320
feasible with our current technology

1109
00:39:14,069 --> 00:39:12,240
that's a good question um what he's

1110
00:39:15,910 --> 00:39:14,079
referring to the radiation environment

1111
00:39:18,230 --> 00:39:15,920
there are cosmic rays from space that

1112
00:39:20,950 --> 00:39:18,240
constantly bombard

1113
00:39:23,510 --> 00:39:20,960

the surface of mars and those can change

1114
00:39:25,910 --> 00:39:23,520
the chemistry of molecules if there are

1115
00:39:29,589 --> 00:39:25,920
organic molecules beneath the surface

1116
00:39:31,910 --> 00:39:29,599
of these cosmic rays can break chemical

1117
00:39:33,589 --> 00:39:31,920
bonds and can change the can basically

1118
00:39:36,470 --> 00:39:33,599
destroy the evidence of what might have

1119
00:39:37,990 --> 00:39:36,480
been life in the past so you want to get

1120
00:39:39,349 --> 00:39:38,000
deep enough

1121
00:39:40,950 --> 00:39:39,359
that uh

1122
00:39:42,390 --> 00:39:40,960
that you're going to be able to

1123
00:39:43,510 --> 00:39:42,400
to find that stuff

1124
00:39:44,950 --> 00:39:43,520
um

1125
00:39:46,310 --> 00:39:44,960
you got to do calculations you got to

1126
00:39:47,990 --> 00:39:46,320
basically guess and people have done

1127
00:39:49,430 --> 00:39:48,000
these calculations and the distance the

1128
00:39:50,870 --> 00:39:49,440
depths you get are not crazy deep

1129
00:39:53,430 --> 00:39:50,880
they're a meter or two you know they're

1130
00:39:55,270 --> 00:39:53,440
like this okay and so if you can find a

1131
00:39:57,109 --> 00:39:55,280
way to get that far down you have a

1132
00:39:58,870 --> 00:39:57,119
chance of finding what you're looking

1133
00:40:00,550 --> 00:39:58,880
for the other thing is that you you

1134
00:40:03,109 --> 00:40:00,560
mentioned sandblasting okay there are

1135
00:40:05,589 --> 00:40:03,119
places where erosion takes place on mars

1136
00:40:07,510 --> 00:40:05,599
and rather than having to drill or dig

1137
00:40:09,990 --> 00:40:07,520
through a meter or two of stuff you can

1138
00:40:11,670 --> 00:40:10,000

rely on mars to erode stuff away fast

1139
00:40:13,430 --> 00:40:11,680
enough faster than the cosmic rays can

1140
00:40:15,670 --> 00:40:13,440
change the chemistry and then you pick

1141
00:40:18,309 --> 00:40:15,680
up rocks at that location so i think our

1142
00:40:21,030 --> 00:40:18,319
chances of finding rocks that have not

1143
00:40:22,309 --> 00:40:21,040
been severely modified by radiation are

1144
00:40:24,390 --> 00:40:22,319
pretty decent but you got to go to the

1145
00:40:25,910 --> 00:40:24,400
right place with the right tools and

1146
00:40:27,349 --> 00:40:25,920
there are these new discoveries that

1147
00:40:28,870 --> 00:40:27,359
have been coming out in the last several

1148
00:40:30,230 --> 00:40:28,880
years and

1149
00:40:32,550 --> 00:40:30,240
we're debating this a lot in the

1150
00:40:35,430 --> 00:40:32,560
community is the presence of a trace gas

1151
00:40:37,829 --> 00:40:35,440
methane we're all familiar with methane

1152
00:40:39,910 --> 00:40:37,839
on earth it is a part of the changing of

1153
00:40:42,390 --> 00:40:39,920
the climate on earth the primary source

1154
00:40:45,270 --> 00:40:42,400
of methane is enteric fermentation

1155
00:40:48,069 --> 00:40:45,280
that's a fancy word for

1156
00:40:51,270 --> 00:40:48,079
cows having a gassy day

1157
00:40:53,829 --> 00:40:51,280
so um what were so so this is really

1158
00:40:55,510 --> 00:40:53,839
interesting is the presence of methane

1159
00:40:59,430 --> 00:40:55,520
and as i said it's controversial in fact

1160
00:41:01,910 --> 00:40:59,440
in um in 2016

1161
00:41:03,030 --> 00:41:01,920
europe and nasa together are going to

1162
00:41:05,510 --> 00:41:03,040
send a

1163
00:41:07,829 --> 00:41:05,520

actual spacecraft to try and look at

1164
00:41:10,230 --> 00:41:07,839
these trace gases so there might be

1165
00:41:12,150 --> 00:41:10,240
the evidence of that today

1166
00:41:14,150 --> 00:41:12,160
where we might not have to dig as deep

1167
00:41:16,550 --> 00:41:14,160
letting the planet just give off its

1168
00:41:18,790 --> 00:41:16,560
gases that we can sniff so

1169
00:41:20,710 --> 00:41:18,800
stay tuned i would say

1170
00:41:23,030 --> 00:41:20,720
thank you question over here

1171
00:41:25,430 --> 00:41:23,040
yeah so um you talked about the

1172
00:41:27,349 --> 00:41:25,440
different environments that we uh that

1173
00:41:28,710 --> 00:41:27,359
marsh could have been like in the past

1174
00:41:30,470 --> 00:41:28,720
and you had those three pictures up at

1175
00:41:31,910 --> 00:41:30,480
the bottom of the slide and i was

1176
00:41:33,510 --> 00:41:31,920
wondering if there could be a

1177
00:41:35,430 --> 00:41:33,520
possibility of an environment that we

1178
00:41:36,950 --> 00:41:35,440
haven't seen before so we're sort of

1179
00:41:38,950 --> 00:41:36,960
basing it on stuff that we've seen on

1180
00:41:40,710 --> 00:41:38,960
earth what are the characteristics that

1181
00:41:42,790 --> 00:41:40,720
could have been on mars

1182
00:41:44,150 --> 00:41:42,800
however many years ago that we haven't

1183
00:41:47,030 --> 00:41:44,160
seen before and could create a new

1184
00:41:48,550 --> 00:41:47,040
environment that we don't know at all

1185
00:41:50,710 --> 00:41:48,560
that's an awesome question an awesome

1186
00:41:52,390 --> 00:41:50,720
concept and it's one of the things that

1187
00:41:54,470 --> 00:41:52,400
we tend to

1188
00:41:56,710 --> 00:41:54,480

work with what we know and it's hard to

1189
00:41:59,430 --> 00:41:56,720
kind of step too far beyond that and

1190
00:42:00,870 --> 00:41:59,440
we're trying uh to imagine different

1191
00:42:02,790 --> 00:42:00,880
types of environments that may have

1192
00:42:04,309 --> 00:42:02,800
supported life and one of the

1193
00:42:06,550 --> 00:42:04,319
interesting things again we use the

1194
00:42:09,270 --> 00:42:06,560
earth as a as our

1195
00:42:11,510 --> 00:42:09,280
basis of knowledge is as we expand the

1196
00:42:13,750 --> 00:42:11,520
realm of where life can be possible

1197
00:42:16,150 --> 00:42:13,760
we're starting to understand on earth

1198
00:42:18,710 --> 00:42:16,160
the most extreme places you could

1199
00:42:21,829 --> 00:42:18,720
imagine where life exists and in fact in

1200
00:42:23,430 --> 00:42:21,839
the radioactive waste of some of our

1201
00:42:24,950 --> 00:42:23,440
some of our nuclear waste deposits

1202
00:42:26,230 --> 00:42:24,960
actually there's life that that exists

1203
00:42:28,710 --> 00:42:26,240
there so we're learning that the limits

1204
00:42:30,390 --> 00:42:28,720
of life go far beyond what we would have

1205
00:42:31,750 --> 00:42:30,400
thought 20 years ago

1206
00:42:33,510 --> 00:42:31,760
and this is the kind of research that we

1207
00:42:35,030 --> 00:42:33,520
need to do to think about

1208
00:42:37,030 --> 00:42:35,040
possible environments but those kind of

1209
00:42:38,630 --> 00:42:37,040
questions are are where we're heading i

1210
00:42:40,230 --> 00:42:38,640
would say yeah i worry about your

1211
00:42:41,829 --> 00:42:40,240
question all the time because we have to

1212
00:42:44,069 --> 00:42:41,839
use our rovers to look at the rocks and

1213
00:42:45,750 --> 00:42:44,079

try to interpret what we see and we do

1214
00:42:47,510 --> 00:42:45,760
our interpretation based on our own

1215
00:42:50,550 --> 00:42:47,520
experience here on earth

1216
00:42:52,390 --> 00:42:50,560
what we see at the rover sites is things

1217
00:42:55,270 --> 00:42:52,400
that we recognize minerals that we think

1218
00:42:57,030 --> 00:42:55,280
we know about like hematite

1219
00:42:58,230 --> 00:42:57,040
geologic features that we think we know

1220
00:43:00,870 --> 00:42:58,240
about like the little ripples and the

1221
00:43:02,950 --> 00:43:00,880
rocks so they're all basically familiar

1222
00:43:05,190 --> 00:43:02,960
but they're arranged together in ways

1223
00:43:06,710 --> 00:43:05,200
that are uniquely martian nowhere on

1224
00:43:08,790 --> 00:43:06,720
earth can you find a place that is like

1225
00:43:10,390 --> 00:43:08,800
either one of those landing sites

1226
00:43:11,829 --> 00:43:10,400
okay we've got time for just one more

1227
00:43:13,910 --> 00:43:11,839
question i'm afraid i know there are

1228
00:43:16,069 --> 00:43:13,920
others but i'll turn it over here for

1229
00:43:18,230 --> 00:43:16,079
our last you showed a slide that had the

1230
00:43:20,630 --> 00:43:18,240
much larger polar caps which is

1231
00:43:22,550 --> 00:43:20,640
associated with the obliquity cycle my

1232
00:43:24,309 --> 00:43:22,560
question is what's our current

1233
00:43:26,630 --> 00:43:24,319
understanding briefly of the obliquity

1234
00:43:28,069 --> 00:43:26,640
cycle and specifically in ten thousand

1235
00:43:30,069 --> 00:43:28,079
years or a hundred thousand years will

1236
00:43:33,109 --> 00:43:30,079
we be warmer wetter or it will be colder

1237
00:43:35,109 --> 00:43:33,119
drier or what on mars on mars right so

1238
00:43:37,589 --> 00:43:35,119

because there's the earth well

1239
00:43:39,430 --> 00:43:37,599
as an amazing uh new results have come

1240
00:43:41,109 --> 00:43:39,440
out about how the

1241
00:43:43,190 --> 00:43:41,119
what he's making reference to is what's

1242
00:43:44,790 --> 00:43:43,200
the tilt of the planet this is one of

1243
00:43:46,870 --> 00:43:44,800
these weird things about mars and the

1244
00:43:49,030 --> 00:43:46,880
earth mars and the earth have the same

1245
00:43:49,990 --> 00:43:49,040
tilt more or less today

1246
00:43:52,309 --> 00:43:50,000
but

1247
00:43:54,790 --> 00:43:52,319
100 000 years maybe 5 million years ago

1248
00:43:57,589 --> 00:43:54,800
the tilt of mars was more

1249
00:44:00,309 --> 00:43:57,599
quite a bit more like 45 degrees and

1250
00:44:02,790 --> 00:44:00,319
this what happens is it causes the poles

1251
00:44:04,630 --> 00:44:02,800
to change their size as they move the

1252
00:44:06,390 --> 00:44:04,640
water ice is evaporated from the poles

1253
00:44:08,710 --> 00:44:06,400
and moved

1254
00:44:10,870 --> 00:44:08,720
so we have very good calculations of how

1255
00:44:12,950 --> 00:44:10,880
the tilt of mars has changed and now

1256
00:44:14,230 --> 00:44:12,960
it's up to the models to then predict

1257
00:44:15,910 --> 00:44:14,240
where the water would go as a

1258
00:44:18,390 --> 00:44:15,920
consequence but it is an absolutely

1259
00:44:20,150 --> 00:44:18,400
amazing thing the amount of tilt that

1260
00:44:23,510 --> 00:44:20,160
we've had on the earth and how that's

1261
00:44:26,069 --> 00:44:23,520
led to clock ice ages on mars that tilt

1262
00:44:29,349 --> 00:44:26,079
has been so much greater and so many

1263
00:44:32,150 --> 00:44:29,359

different things have come from that

1264
00:44:34,150 --> 00:44:32,160
okay i'd like to take a second and thank

1265
00:44:35,670 --> 00:44:34,160
both of our panel members here for a

1266
00:44:37,829 --> 00:44:35,680
really exciting update on mars

1267
00:44:44,550 --> 00:44:37,839
discoveries

1268
00:44:47,510 --> 00:44:45,829
we're going to move on to the second

1269
00:44:49,910 --> 00:44:47,520
part of our three-part program at this

1270
00:44:52,230 --> 00:44:49,920
point and to kick that off i'm going to

1271
00:44:54,630 --> 00:44:52,240
reintroduce doug mcquitchen

1272
00:44:55,990 --> 00:44:54,640
who's going to introduce the second set

1273
00:44:57,990 --> 00:44:56,000
of discussions

1274
00:45:00,630 --> 00:44:58,000
and tell you a little bit about upcoming

1275
00:45:02,309 --> 00:45:00,640
mars missions and uh what's in store

1276
00:45:06,630 --> 00:45:02,319
doug

1277
00:45:09,430 --> 00:45:08,470
okay i'm back

1278
00:45:11,510 --> 00:45:09,440
um

1279
00:45:13,030 --> 00:45:11,520
so you've heard what we've been finding

1280
00:45:14,710 --> 00:45:13,040
and here in a moment you're going to

1281
00:45:17,030 --> 00:45:14,720
hear from myself and as soon as you get

1282
00:45:19,510 --> 00:45:17,040
a mic on marcelo you'll hear from my esa

1283
00:45:20,630 --> 00:45:19,520
colleague about how we find this stuff

1284
00:45:22,069 --> 00:45:20,640
out how do we see it you've seen the

1285
00:45:24,470 --> 00:45:22,079
images you've seen the pictures you got

1286
00:45:27,190 --> 00:45:24,480
a little glimpse of of opportunity there

1287
00:45:28,309 --> 00:45:27,200
in that in that panorama but uh but

1288
00:45:29,990 --> 00:45:28,319

we'll show you a little bit more about

1289
00:45:38,069 --> 00:45:30,000
what we do and how we do it so can i get

1290
00:45:41,829 --> 00:45:39,750
yeah

1291
00:45:43,270 --> 00:45:41,839
so i said we've had a permanent human

1292
00:45:45,430 --> 00:45:43,280
presence

1293
00:45:46,710 --> 00:45:45,440
at mars for the last 10 years well you

1294
00:45:48,230 --> 00:45:46,720
know steve is one of those main people

1295
00:45:50,230 --> 00:45:48,240
living on mars most of the time he gets

1296
00:45:51,510 --> 00:45:50,240
the weather reports and you know most of

1297
00:45:53,270 --> 00:45:51,520
the things he looks at is not out the

1298
00:45:54,710 --> 00:45:53,280
window but on his screen which is mars

1299
00:45:56,550 --> 00:45:54,720
so we've got a lot of people that kind

1300
00:45:58,390 --> 00:45:56,560
of live this and we've done that through

1301
00:46:00,390 --> 00:45:58,400
all these missions

1302
00:46:02,309 --> 00:46:00,400
probably the big the pivotal missions

1303
00:46:03,670 --> 00:46:02,319
that started was in the 1970s and i

1304
00:46:06,069 --> 00:46:03,680
would encourage everybody to look at the

1305
00:46:07,750 --> 00:46:06,079
viking models that are out there awesome

1306
00:46:09,349 --> 00:46:07,760
piece of machinery we learned a lot from

1307
00:46:11,430 --> 00:46:09,359
those two viking missions those two

1308
00:46:12,829 --> 00:46:11,440
viking landers and their orbiters as

1309
00:46:14,390 --> 00:46:12,839
well

1310
00:46:16,630 --> 00:46:14,400
um

1311
00:46:17,829 --> 00:46:16,640
surface i'm going to talk about the

1312
00:46:19,510 --> 00:46:17,839
orbiters again here in a little bit and

1313
00:46:21,510 --> 00:46:19,520

so is marcelo so i'm going to i'm going

1314
00:46:23,190 --> 00:46:21,520
to move to the landers for a second so

1315
00:46:24,390 --> 00:46:23,200
the vikings as i mentioned you can see

1316
00:46:26,950 --> 00:46:24,400
those here

1317
00:46:29,510 --> 00:46:26,960
pathfinder in the late 90s really kind

1318
00:46:31,910 --> 00:46:29,520
of started our current era of missions

1319
00:46:33,270 --> 00:46:31,920
on the surface that technique for

1320
00:46:35,589 --> 00:46:33,280
getting to the ground which i'll talk

1321
00:46:37,109 --> 00:46:35,599
about again here in just a few minutes

1322
00:46:39,270 --> 00:46:37,119
has been very successful it's gotten

1323
00:46:41,190 --> 00:46:39,280
both of the opportunity missions

1324
00:46:43,270 --> 00:46:41,200
excuse me both opportunity and spirit to

1325
00:46:44,950 --> 00:46:43,280
the ground and it's also got going to

1326
00:46:48,230 --> 00:46:44,960
get

1327
00:46:54,150 --> 00:46:48,240
the mars science laboratory rover called

1328
00:46:59,670 --> 00:46:56,790
that must have been meant for me i guess

1329
00:47:00,950 --> 00:46:59,680
no playing in the museum okay darn

1330
00:47:04,550 --> 00:47:00,960
um

1331
00:47:06,309 --> 00:47:04,560
and the landing site for curiosity

1332
00:47:07,670 --> 00:47:06,319
hasn't quite been chosen yet and i think

1333
00:47:09,109 --> 00:47:07,680
you might hear about that in a little

1334
00:47:11,030 --> 00:47:09,119
bit so i won't go into that from the

1335
00:47:13,589 --> 00:47:11,040
next panel so if we'll go to the next

1336
00:47:15,829 --> 00:47:13,599
slide please

1337
00:47:17,670 --> 00:47:15,839
i apologize for the lack of years on

1338
00:47:18,870 --> 00:47:17,680

this at the top but going from left to

1339
00:47:22,150 --> 00:47:18,880
right you'll see

1340
00:47:23,750 --> 00:47:22,160
the curiosity rover is our 2011 mission

1341
00:47:24,390 --> 00:47:23,760
we'll launch at the end of this calendar

1342
00:47:26,230 --> 00:47:24,400
year

1343
00:47:27,990 --> 00:47:26,240
uh the day after thanksgiving actually

1344
00:47:30,549 --> 00:47:28,000
is the beginning of the window and mars

1345
00:47:33,990 --> 00:47:30,559
is interesting because to get to mars uh

1346
00:47:36,069 --> 00:47:34,000
earth and mars line up the best every 26

1347
00:47:37,829 --> 00:47:36,079
months so we can't go well we can go

1348
00:47:40,069 --> 00:47:37,839
every year but is most efficient from a

1349
00:47:42,790 --> 00:47:40,079
fuel perspective and from a transit time

1350
00:47:45,589 --> 00:47:42,800
perspective of every 26 months so in

1351
00:47:47,750 --> 00:47:45,599
2013 we'll send a mission called uh

1352
00:47:49,430 --> 00:47:47,760
maven which is the which is an aeronauty

1353
00:47:50,710 --> 00:47:49,440
mission you've heard about

1354
00:47:52,870 --> 00:47:50,720
mars being

1355
00:47:54,870 --> 00:47:52,880
wetter and warmer in the past

1356
00:47:56,390 --> 00:47:54,880
and now colder and drier part of that is

1357
00:47:58,309 --> 00:47:56,400
a loss of atmosphere and we don't

1358
00:47:59,910 --> 00:47:58,319
exactly understand what happened and why

1359
00:48:01,670 --> 00:47:59,920
it happened and the rate at which that

1360
00:48:03,990 --> 00:48:01,680
happens and so that mission is going to

1361
00:48:07,510 --> 00:48:04,000
try to help us understand that

1362
00:48:09,190 --> 00:48:07,520
in 2016 and then in 2018 we're going to

1363
00:48:11,190 --> 00:48:09,200

start working jointly with the european

1364
00:48:14,309 --> 00:48:11,200
space agency as i mentioned before which

1365
00:48:16,549 --> 00:48:14,319
is a perfect segue to uh to marcelo

1366
00:48:18,630 --> 00:48:16,559
so now that he's all miked up uh i'd

1367
00:48:20,950 --> 00:48:18,640
like to introduce marcelo coradini he's

1368
00:48:23,750 --> 00:48:20,960
uh from the european space agency and he

1369
00:48:26,710 --> 00:48:23,760
is our esa he is our esa program

1370
00:48:30,950 --> 00:48:26,720
coordinator based at the jet propulsion

1371
00:48:30,960 --> 00:48:35,910
shall we sit down

1372
00:48:39,349 --> 00:48:37,589
so marcelo actually is going to talk

1373
00:48:41,430 --> 00:48:39,359
more about the 16 and the 18 missions

1374
00:48:43,030 --> 00:48:41,440
here in just a little bit also but also

1375
00:48:45,670 --> 00:48:43,040
a little bit of history because we heard

1376
00:48:47,910 --> 00:48:45,680
so much about the water but i want to

1377
00:48:50,390 --> 00:48:47,920
take you by the end in the last 40 years

1378
00:48:52,069 --> 00:48:50,400
of exploration of mars comparing a

1379
00:48:53,829 --> 00:48:52,079
little bit the evolution of the

1380
00:48:55,190 --> 00:48:53,839
satellites and the evolution of the

1381
00:48:57,589 --> 00:48:55,200
understanding

1382
00:48:59,589 --> 00:48:57,599
of the planet and everything started

1383
00:49:01,589 --> 00:48:59,599
basically at the end of the 60s

1384
00:49:04,710 --> 00:49:01,599
beginning of the 70s

1385
00:49:06,150 --> 00:49:04,720
you were you know still in the sky and

1386
00:49:08,470 --> 00:49:06,160
your parents were not even thinking

1387
00:49:11,430 --> 00:49:08,480
about you at that time

1388
00:49:14,549 --> 00:49:11,440

and the vision that we have we had at

1389
00:49:17,030 --> 00:49:14,559
that time of planet mars was after all

1390
00:49:19,670 --> 00:49:17,040
rudimental as it was rudimental the

1391
00:49:21,670 --> 00:49:19,680
technology we had here on earth for you

1392
00:49:23,589 --> 00:49:21,680
it's difficult to imagine a society

1393
00:49:25,510 --> 00:49:23,599
without internet without digital

1394
00:49:29,430 --> 00:49:25,520
photography without

1395
00:49:31,670 --> 00:49:29,440
cell phones without facebook well

1396
00:49:33,829 --> 00:49:31,680
we lived we survived in a time when we

1397
00:49:36,710 --> 00:49:33,839
didn't have those kind of things and

1398
00:49:37,750 --> 00:49:36,720
still we were able to send satellites to

1399
00:49:39,349 --> 00:49:37,760
mars

1400
00:49:42,390 --> 00:49:39,359
but the problem is that when we got

1401
00:49:45,270 --> 00:49:42,400
there because the technology was not as

1402
00:49:47,430 --> 00:49:45,280
advanced as today we had a kind of a

1403
00:49:48,950 --> 00:49:47,440
biased view at the very beginning of the

1404
00:49:51,589 --> 00:49:48,960
red planet

1405
00:49:53,349 --> 00:49:51,599
and it looked uh with the first missions

1406
00:49:56,230 --> 00:49:53,359
very similar to the moon

1407
00:49:58,790 --> 00:49:56,240
lots of craters lots of dust lots of

1408
00:50:01,030 --> 00:49:58,800
deserts and nothing else

1409
00:50:02,950 --> 00:50:01,040
so at the beginning we were really a

1410
00:50:05,589 --> 00:50:02,960
kind of you know a little bit of a

1411
00:50:07,670 --> 00:50:05,599
delusion because we heard so much in the

1412
00:50:09,670 --> 00:50:07,680
40s and the 50s

1413
00:50:12,390 --> 00:50:09,680

still in the 60s at the beginning people

1414
00:50:13,829 --> 00:50:12,400
were talking about you know forests and

1415
00:50:16,069 --> 00:50:13,839
rivers

1416
00:50:18,309 --> 00:50:16,079
cities and civilization on mars we get

1417
00:50:21,190 --> 00:50:18,319
there with the first satellites and we

1418
00:50:23,589 --> 00:50:21,200
just see desert and nothing else

1419
00:50:25,430 --> 00:50:23,599
maybe i uh if we can have

1420
00:50:26,950 --> 00:50:25,440
nice lights it would have a little bit

1421
00:50:28,950 --> 00:50:26,960
my presentation say this but i got a

1422
00:50:32,470 --> 00:50:28,960
couple to go here before you get your

1423
00:50:34,630 --> 00:50:32,480
slides all right so you you'll go ahead

1424
00:50:35,750 --> 00:50:34,640
maybe not maybe not maybe not i was

1425
00:50:37,829 --> 00:50:35,760
going to talk about orbiters for a

1426
00:50:38,829 --> 00:50:37,839
second can we go back to my set please

1427
00:50:41,430 --> 00:50:38,839
no

1428
00:50:42,549 --> 00:50:41,440
problem let's see if they can follow

1429
00:50:44,069 --> 00:50:42,559
that

1430
00:50:45,829 --> 00:50:44,079
if we can follow the weather on mars

1431
00:50:47,270 --> 00:50:45,839
maybe we can follow your presentation as

1432
00:50:48,870 --> 00:50:47,280
well yes

1433
00:50:50,549 --> 00:50:48,880
and if you can't just go to marcelo's if

1434
00:50:51,510 --> 00:50:50,559
that's easier that's fine let's see what

1435
00:50:54,790 --> 00:50:51,520
happens

1436
00:50:57,510 --> 00:50:54,800
oh well it's me go for it okay so uh

1437
00:50:59,829 --> 00:50:57,520
next one uh so this is the title well

1438
00:51:02,390 --> 00:50:59,839

basically i already introduced it well

1439
00:51:05,030 --> 00:51:02,400
this cartoon basically summarized very

1440
00:51:07,270 --> 00:51:05,040
simply how

1441
00:51:09,349 --> 00:51:07,280
the understanding that we have a water

1442
00:51:11,030 --> 00:51:09,359
on mars evolved with time

1443
00:51:13,990 --> 00:51:11,040
so as i said the first time we went

1444
00:51:16,150 --> 00:51:14,000
there in the 70s we had the idea that

1445
00:51:18,630 --> 00:51:16,160
mars was a kind of a desert obviously

1446
00:51:21,270 --> 00:51:18,640
even if you go to the sahara desert

1447
00:51:23,829 --> 00:51:21,280
or or the mojave desert

1448
00:51:25,829 --> 00:51:23,839
it looks very dry but actually if you go

1449
00:51:27,990 --> 00:51:25,839
really searching for water you find a

1450
00:51:29,829 --> 00:51:28,000
little bit of humidity here and there

1451
00:51:32,549 --> 00:51:29,839
and so that was the impression we had on

1452
00:51:34,470 --> 00:51:32,559
mars and then we timed the following

1453
00:51:36,069 --> 00:51:34,480
missions a second wave of missions in

1454
00:51:39,190 --> 00:51:36,079
the 80s

1455
00:51:40,790 --> 00:51:39,200
we realized that mars was not so dry

1456
00:51:43,589 --> 00:51:40,800
actually there was a little bit of

1457
00:51:46,470 --> 00:51:43,599
meteorology we saw clouds etc

1458
00:51:48,150 --> 00:51:46,480
and eventually 10 years after 10 years

1459
00:51:50,790 --> 00:51:48,160
our understanding of the presence of

1460
00:51:53,030 --> 00:51:50,800
waters on mars has evolved dramatically

1461
00:51:55,349 --> 00:51:53,040
to the point that today we can even

1462
00:51:58,069 --> 00:51:55,359
imagine that once on mars the worst

1463
00:52:00,150 --> 00:51:58,079

almost oceans not as many oceans as as

1464
00:52:03,270 --> 00:52:00,160
much water as we have on this planet on

1465
00:52:05,990 --> 00:52:03,280
planet earth but at least enough water

1466
00:52:09,030 --> 00:52:06,000
to have created rivers and lakes and

1467
00:52:11,109 --> 00:52:09,040
maybe even oceans small oceans or sea

1468
00:52:13,190 --> 00:52:11,119
you can have the next lightness

1469
00:52:15,430 --> 00:52:13,200
okay so this is uh

1470
00:52:17,670 --> 00:52:15,440
what we saw in in the 70s with the

1471
00:52:20,230 --> 00:52:17,680
mariner 9 that was already mentioned

1472
00:52:22,390 --> 00:52:20,240
that was a satellite that was designed

1473
00:52:24,870 --> 00:52:22,400
when the technology here we not even had

1474
00:52:27,109 --> 00:52:24,880
color televisions on earth okay

1475
00:52:29,270 --> 00:52:27,119
forget about flat screen so that was a

1476
00:52:32,390 --> 00:52:29,280
dream that was science fiction we had

1477
00:52:34,790 --> 00:52:32,400
big bulky televisions in black and white

1478
00:52:37,190 --> 00:52:34,800
bad sounds and big

1479
00:52:39,190 --> 00:52:37,200
cameras and so we had to use that

1480
00:52:42,309 --> 00:52:39,200
technology to go to mars and the results

1481
00:52:43,750 --> 00:52:42,319
was that yes we discovered polar caps

1482
00:52:45,510 --> 00:52:43,760
but nothing else

1483
00:52:47,670 --> 00:52:45,520
and then

1484
00:52:48,870 --> 00:52:47,680
obviously technology advanced very

1485
00:52:51,430 --> 00:52:48,880
rapidly

1486
00:52:53,510 --> 00:52:51,440
and in the next slides you may see that

1487
00:52:55,510 --> 00:52:53,520
there was a gigantic step forward with

1488
00:52:58,470 --> 00:52:55,520

the viking missions

1489
00:53:02,230 --> 00:52:58,480
basically with the analysis of the data

1490
00:53:03,990 --> 00:53:02,240
that continue into the into the 80s so

1491
00:53:05,990 --> 00:53:04,000
this was something which is still

1492
00:53:09,270 --> 00:53:06,000
unprecedented i i guess you agree that

1493
00:53:12,950 --> 00:53:09,280
today if we uh are asked together nasa

1494
00:53:14,150 --> 00:53:12,960
nissa to do the viking mission

1495
00:53:16,470 --> 00:53:14,160
we would have today um

1496
00:53:18,470 --> 00:53:16,480
problem in doing it again so at that

1497
00:53:20,309 --> 00:53:18,480
time our colleagues at that time

1498
00:53:22,630 --> 00:53:20,319
probably there they were kind of a

1499
00:53:25,349 --> 00:53:22,640
better of us i must say it's a kind of

1500
00:53:27,589 --> 00:53:25,359
embarrassing to say but in the uh

1501
00:53:32,069 --> 00:53:27,599
it was at the end of the 70s two

1502
00:53:34,870 --> 00:53:32,079
gigantic lenders landed softly on mars

1503
00:53:36,230 --> 00:53:34,880
and then they were supported by two big

1504
00:53:38,150 --> 00:53:36,240
orbiters

1505
00:53:40,309 --> 00:53:38,160
and with these devices

1506
00:53:43,190 --> 00:53:40,319
what we understood on mars completely

1507
00:53:47,109 --> 00:53:43,200
changed we even saw frost the forming on

1508
00:53:49,589 --> 00:53:47,119
the surface we saw clouds we saw uh fog

1509
00:53:50,790 --> 00:53:49,599
forming in the canyons so we understood

1510
00:53:53,589 --> 00:53:50,800
that mars

1511
00:53:56,710 --> 00:53:53,599
from a meteorological point of view was

1512
00:53:59,990 --> 00:53:56,720
a kind of a very lively planet it was

1513
00:54:01,829 --> 00:54:00,000

not this big rock of sand and craters as

1514
00:54:03,910 --> 00:54:01,839
we thought 10 years before

1515
00:54:07,430 --> 00:54:03,920
and then our understanding of mars

1516
00:54:10,309 --> 00:54:07,440
continue to evolve in the next slide

1517
00:54:13,109 --> 00:54:10,319
this is a mars global surveyor this is

1518
00:54:14,069 --> 00:54:13,119
when really we started to see

1519
00:54:17,030 --> 00:54:14,079
uh

1520
00:54:19,430 --> 00:54:17,040
clear characteristics of water flowing

1521
00:54:22,069 --> 00:54:19,440
on mars the big question is now we all

1522
00:54:24,069 --> 00:54:22,079
understand with this mission in the 90s

1523
00:54:25,670 --> 00:54:24,079
that there was water flowing on mars but

1524
00:54:27,910 --> 00:54:25,680
the big question and still we are not

1525
00:54:30,950 --> 00:54:27,920
able to answer this question is

1526
00:54:33,270 --> 00:54:30,960
when this water was flowing on mars well

1527
00:54:34,390 --> 00:54:33,280
this is a real challenge

1528
00:54:37,030 --> 00:54:34,400
and

1529
00:54:40,309 --> 00:54:37,040
with the advancement of technology we

1530
00:54:42,309 --> 00:54:40,319
had more missions and in the 2000 we're

1531
00:54:44,470 --> 00:54:42,319
getting close to our age in the next

1532
00:54:46,950 --> 00:54:44,480
slide

1533
00:54:50,150 --> 00:54:46,960
so this is the time when even europe

1534
00:54:52,150 --> 00:54:50,160
woke up and eventually we joined nasa

1535
00:54:53,670 --> 00:54:52,160
and america in the exploration and

1536
00:54:55,910 --> 00:54:53,680
russia a little bit they have been not

1537
00:54:57,829 --> 00:54:55,920
so lagging in going to mars because they

1538
00:54:59,109 --> 00:54:57,839

sent lots of spacecraft and and they

1539
00:55:01,349 --> 00:54:59,119
lost them all

1540
00:55:03,349 --> 00:55:01,359
so we were really afraid of making

1541
00:55:05,190 --> 00:55:03,359
mistakes in europe we've been thinking

1542
00:55:07,109 --> 00:55:05,200
and thinking and thinking about making

1543
00:55:10,069 --> 00:55:07,119
emissions to mars and eventually we did

1544
00:55:11,990 --> 00:55:10,079
it we launched it in 2003 and because

1545
00:55:13,990 --> 00:55:12,000
now we understood that at the time of

1546
00:55:16,470 --> 00:55:14,000
launch of mars express that is the first

1547
00:55:18,950 --> 00:55:16,480
european mission to mars that water was

1548
00:55:21,750 --> 00:55:18,960
an important thing we decided to really

1549
00:55:24,309 --> 00:55:21,760
design a spacecraft that could monitor

1550
00:55:26,309 --> 00:55:24,319
what we call the water cycle of mars in

1551
00:55:27,829 --> 00:55:26,319
other words we wanted to go from the

1552
00:55:31,430 --> 00:55:27,839
underground

1553
00:55:32,789 --> 00:55:31,440
to the surface to the atmosphere and to

1554
00:55:35,990 --> 00:55:32,799
what mars

1555
00:55:38,309 --> 00:55:36,000
loses continuously towards outer space

1556
00:55:40,549 --> 00:55:38,319
and try to understand where the water is

1557
00:55:43,430 --> 00:55:40,559
coming from where it goes and how it

1558
00:55:46,390 --> 00:55:43,440
disappears and so this mission is really

1559
00:55:49,190 --> 00:55:46,400
very focused in understanding the water

1560
00:55:51,829 --> 00:55:49,200
cycle but this is also the mission that

1561
00:55:53,670 --> 00:55:51,839
for the first time measure methane in

1562
00:55:55,910 --> 00:55:53,680
the atmosphere of mars it was a big

1563
00:55:58,789 --> 00:55:55,920

debate no it's a mistake it's an

1564
00:56:00,630 --> 00:55:58,799
interpretation error but eventually most

1565
00:56:01,589 --> 00:56:00,640
of the scientific community agreed that

1566
00:56:04,150 --> 00:56:01,599
mars

1567
00:56:06,230 --> 00:56:04,160
with an instrument that is called psf

1568
00:56:09,270 --> 00:56:06,240
discovered for the first time traces of

1569
00:56:11,589 --> 00:56:09,280
meta in on mars does that imply

1570
00:56:13,430 --> 00:56:11,599
as jack said before that we have cows on

1571
00:56:16,789 --> 00:56:13,440
mars having problems with their

1572
00:56:19,430 --> 00:56:16,799
digestion i don't think so methane can

1573
00:56:21,990 --> 00:56:19,440
be produced geologically with volcanoes

1574
00:56:24,390 --> 00:56:22,000
and so on but the question is if we can

1575
00:56:26,470 --> 00:56:24,400
find much more methane

1576
00:56:29,829 --> 00:56:26,480
does have that discovery have an

1577
00:56:31,990 --> 00:56:29,839
implication on possible life forms maybe

1578
00:56:34,630 --> 00:56:32,000
somewhere in the depth of mars we don't

1579
00:56:37,430 --> 00:56:34,640
know so that's why we have to go back to

1580
00:56:38,870 --> 00:56:37,440
mars and this time because the

1581
00:56:41,910 --> 00:56:38,880
uh

1582
00:56:44,630 --> 00:56:41,920
the technology and the complexity of the

1583
00:56:47,270 --> 00:56:44,640
mission is huge we really need to do it

1584
00:56:49,349 --> 00:56:47,280
together i mean nasa by itself european

1585
00:56:52,069 --> 00:56:49,359
space agency by itself we don't have the

1586
00:56:54,470 --> 00:56:52,079
capability of continuing a major effort

1587
00:56:55,910 --> 00:56:54,480
of exploration on mars so we gotta do it

1588
00:56:58,309 --> 00:56:55,920

together on mars and we will do it

1589
00:57:00,230 --> 00:56:58,319
together at least for the next 20 years

1590
00:57:01,109 --> 00:57:00,240
so in the next slide

1591
00:57:03,430 --> 00:57:01,119
uh

1592
00:57:06,950 --> 00:57:03,440
oh that that is funny because it tells

1593
00:57:09,589 --> 00:57:06,960
us uh how when we start penetrating with

1594
00:57:11,270 --> 00:57:09,599
this penetrating graders into the

1595
00:57:13,190 --> 00:57:11,280
surface of mars we find out that

1596
00:57:14,950 --> 00:57:13,200
probably there is a lot of water in the

1597
00:57:18,230 --> 00:57:14,960
underground on mars so the little man

1598
00:57:20,390 --> 00:57:18,240
now has become a scuba diver but not on

1599
00:57:23,030 --> 00:57:20,400
the surface of mars in the underground

1600
00:57:26,069 --> 00:57:23,040
on mars okay so there is where we want

1601
00:57:28,870 --> 00:57:26,079
to go looking for water and maybe life

1602
00:57:30,630 --> 00:57:28,880
forms why so deep because first of all

1603
00:57:32,950 --> 00:57:30,640
you need water and secondly you need to

1604
00:57:34,710 --> 00:57:32,960
be protected against the radiation if

1605
00:57:36,309 --> 00:57:34,720
you are on the surface

1606
00:57:38,309 --> 00:57:36,319
everything gets sterilized and

1607
00:57:39,589 --> 00:57:38,319
everything dies in a matter of minutes

1608
00:57:42,069 --> 00:57:39,599
so if you want to go looking for

1609
00:57:44,150 --> 00:57:42,079
something that exists excellent life on

1610
00:57:46,470 --> 00:57:44,160
mars we gotta go deep and so with the

1611
00:57:48,390 --> 00:57:46,480
next missions we will try to do that

1612
00:57:50,390 --> 00:57:48,400
next slide please

1613
00:57:53,109 --> 00:57:50,400

okay we can skip that because anyhow

1614
00:57:55,349 --> 00:57:53,119
that's to show how intense is the effort

1615
00:57:57,589 --> 00:57:55,359
of exploration on mars and it will

1616
00:57:58,630 --> 00:57:57,599
continue even more we hope with new

1617
00:58:00,390 --> 00:57:58,640
budgets

1618
00:58:02,710 --> 00:58:00,400
that's the plan at least if the

1619
00:58:05,109 --> 00:58:02,720
politicians allow us to have the badges

1620
00:58:08,510 --> 00:58:05,119
to go to mars but you never know next

1621
00:58:12,150 --> 00:58:08,520
slide please okay and now this is in

1622
00:58:14,789 --> 00:58:12,160
2016 where uh really nasa and isa will

1623
00:58:17,430 --> 00:58:14,799
work together will be at the same time

1624
00:58:19,670 --> 00:58:17,440
in orbit and on the surface with two

1625
00:58:22,069 --> 00:58:19,680
major robots and so we're going to

1626
00:58:24,470 --> 00:58:22,079
search for methane in the atmosphere and

1627
00:58:25,270 --> 00:58:24,480
at the same time we'll be able to drill

1628
00:58:28,069 --> 00:58:25,280
for

1629
00:58:30,950 --> 00:58:28,079
few meters into the ground on mars

1630
00:58:32,309 --> 00:58:30,960
looking for possible life forms or maybe

1631
00:58:35,030 --> 00:58:32,319
looking for

1632
00:58:36,470 --> 00:58:35,040
sources of methane so this is a major

1633
00:58:38,589 --> 00:58:36,480
mission these two missions will be

1634
00:58:41,510 --> 00:58:38,599
working together in the

1635
00:58:43,910 --> 00:58:41,520
2018-2019 time frame the orbiter will be

1636
00:58:46,230 --> 00:58:43,920
launched in 2016 is under construction

1637
00:58:48,630 --> 00:58:46,240
in this very moment and the two rovers

1638
00:58:50,230 --> 00:58:48,640

maxi and exomars will be launched in

1639
00:58:53,190 --> 00:58:50,240
2018

1640
00:58:55,750 --> 00:58:53,200
and will arrive to mars six months later

1641
00:58:57,510 --> 00:58:55,760
and so this is a major step forward uh

1642
00:58:58,549 --> 00:58:57,520
in the exploration of mars and maybe we

1643
00:59:00,549 --> 00:58:58,559
will have

1644
00:59:02,710 --> 00:59:00,559
answer to these fundamental questions

1645
00:59:04,870 --> 00:59:02,720
where the water comes from is there any

1646
00:59:07,510 --> 00:59:04,880
life together with the water

1647
00:59:09,510 --> 00:59:07,520
is life producing methane or it's just a

1648
00:59:12,710 --> 00:59:09,520
geological process

1649
00:59:15,109 --> 00:59:12,720
but we cannot stop there and after 2018

1650
00:59:16,710 --> 00:59:15,119
we have to continue the exploration on

1651
00:59:19,589 --> 00:59:16,720
mars and we'll continue to do it

1652
00:59:21,829 --> 00:59:19,599
together in the next slide

1653
00:59:23,750 --> 00:59:21,839
you see what's going to happen after

1654
00:59:26,870 --> 00:59:23,760
2018.

1655
00:59:30,549 --> 00:59:26,880
one major step is a mission where we'll

1656
00:59:33,270 --> 00:59:30,559
be able to land on mars get a sample

1657
00:59:35,430 --> 00:59:33,280
half a pound a pound of rocks

1658
00:59:38,710 --> 00:59:35,440
and bring them back to the surface of

1659
00:59:40,870 --> 00:59:38,720
the earth now you hear uh often on

1660
00:59:42,710 --> 00:59:40,880
televisions or on the press or whereve

1661
00:59:44,789 --> 00:59:42,720
everywhere on internet that we should

1662
00:59:47,349 --> 00:59:44,799
send astronauts to mars

1663
00:59:50,630 --> 00:59:47,359

for the time being for us

1664
00:59:54,710 --> 00:59:50,640
nasa and isa it's a major challenge to

1665
00:59:57,430 --> 00:59:54,720
go to mars and return a pound of rocks

1666
00:59:59,349 --> 00:59:57,440
imagine returning hundreds of kilograms

1667
01:00:02,069 --> 00:59:59,359
of human flesh without killing that

1668
01:00:04,390 --> 01:00:02,079
human flesh so that's why

1669
01:00:06,710 --> 01:00:04,400
i put the question mark who knows when

1670
01:00:09,109 --> 01:00:06,720
we'll be able to send astronauts there

1671
01:00:11,990 --> 01:00:09,119
but anyhow one day we will do it and it

1672
01:00:14,470 --> 01:00:12,000
will be a major effort and maybe is your

1673
01:00:18,309 --> 01:00:14,480
future work in a space mission that will

1674
01:00:24,710 --> 01:00:18,319
take astronauts to mars thank you

1675
01:00:28,309 --> 01:00:26,710
so i'm going to pick it back up and talk

1676
01:00:30,309 --> 01:00:28,319
a little bit about the hardware that

1677
01:00:31,910 --> 01:00:30,319
allows us to do all these things to find

1678
01:00:34,390 --> 01:00:31,920
all these discoveries to understand

1679
01:00:37,430 --> 01:00:34,400
these things um and how we get them

1680
01:00:39,430 --> 01:00:37,440
there what they can do for us

1681
01:00:42,630 --> 01:00:39,440
as i mentioned uh

1682
01:00:44,150 --> 01:00:42,640
earlier uh the curiosity rover otherwise

1683
01:00:45,670 --> 01:00:44,160
known as the mars science laboratory

1684
01:00:47,670 --> 01:00:45,680
which is the overall mission the rover

1685
01:00:50,230 --> 01:00:47,680
is called curiosity

1686
01:00:51,990 --> 01:00:50,240
is going at the end of 2011.

1687
01:00:54,230 --> 01:00:52,000
i'm going to talk mainly about that it's

1688
01:00:56,309 --> 01:00:54,240

an excellent example of hardware

1689
01:00:57,589 --> 01:00:56,319
and this is as i said earlier at the

1690
01:00:58,710 --> 01:00:57,599
introduction there's a little bit of

1691
01:00:59,990 --> 01:00:58,720
science a little bit of engineering a

1692
01:01:02,230 --> 01:01:00,000
little bit of everything for folks so

1693
01:01:04,710 --> 01:01:02,240
this will be the engineering part

1694
01:01:06,230 --> 01:01:04,720
um let's go ahead so

1695
01:01:07,990 --> 01:01:06,240
so this is what the rover looks like

1696
01:01:09,829 --> 01:01:08,000
this is a large rover

1697
01:01:12,789 --> 01:01:09,839
steve mentioned that spirit and

1698
01:01:15,270 --> 01:01:12,799
opportunity are about 300 pounds this is

1699
01:01:17,190 --> 01:01:15,280
nearly 2 000 pounds this is the size of

1700
01:01:19,430 --> 01:01:17,200
a small car i'm going to show you some

1701
01:01:21,829 --> 01:01:19,440
actual footage of it and some images of

1702
01:01:23,349 --> 01:01:21,839
what goes into making something like

1703
01:01:25,430 --> 01:01:23,359
this it looks fairly simple on the

1704
01:01:27,829 --> 01:01:25,440
outside but it's actually a pretty

1705
01:01:29,750 --> 01:01:27,839
impressive engineering feat what i first

1706
01:01:31,270 --> 01:01:29,760
like to do however is run a short movie

1707
01:01:32,710 --> 01:01:31,280
and introduce you to a gentleman named

1708
01:01:35,910 --> 01:01:32,720
dave gruel

1709
01:01:38,150 --> 01:01:35,920
dave is the head of the test team

1710
01:01:39,270 --> 01:01:38,160
at jpl which is where this is being

1711
01:01:40,549 --> 01:01:39,280
built and he is going to take you

1712
01:01:41,750 --> 01:01:40,559
through a quick about a minute and a

1713
01:01:44,069 --> 01:01:41,760

half tour

1714
01:01:45,190 --> 01:01:44,079
of the assembly process that's going on

1715
01:01:47,349 --> 01:01:45,200
right now

1716
01:01:49,349 --> 01:01:47,359
for the curiosity rover on your

1717
01:01:52,069 --> 01:01:49,359
brochures there's actually a website

1718
01:01:54,309 --> 01:01:52,079
link and you can go watch this happen

1719
01:01:55,910 --> 01:01:54,319
real time on a thing called curiosity

1720
01:01:58,230 --> 01:01:55,920
cam which i encourage you to do after

1721
01:02:00,390 --> 01:01:58,240
this so if you roll the video please

1722
01:02:02,309 --> 01:02:00,400
hi my name is dave gruel and i lead the

1723
01:02:03,990 --> 01:02:02,319
team responsible for assembling testing

1724
01:02:06,390 --> 01:02:04,000
and launching the next rover to land on

1725
01:02:07,990 --> 01:02:06,400
the surface of mars curiosity

1726
01:02:09,670 --> 01:02:08,000
the team just recently installed the

1727
01:02:12,069 --> 01:02:09,680
mobility system onto the sides of the

1728
01:02:14,390 --> 01:02:12,079
rover that's the wheels there's six

1729
01:02:16,150 --> 01:02:14,400
wheels three on each side that all have

1730
01:02:17,750 --> 01:02:16,160
to be verified that the actuators work

1731
01:02:19,109 --> 01:02:17,760
and then there's steering actuators too

1732
01:02:21,270 --> 01:02:19,119
which is what we use to actually turn

1733
01:02:23,349 --> 01:02:21,280
the rover when it's on the surface

1734
01:02:24,870 --> 01:02:23,359
there are 10 small little motors that

1735
01:02:26,789 --> 01:02:24,880
make up that mobility system and what

1736
01:02:28,150 --> 01:02:26,799
the team is doing right now is they're

1737
01:02:29,829 --> 01:02:28,160
going through and making sure that each

1738
01:02:31,829 --> 01:02:29,839

of those wheels spins forward and

1739
01:02:33,510 --> 01:02:31,839
backwards and rotates if necessary from

1740
01:02:34,870 --> 01:02:33,520
a steering point of view so that when

1741
01:02:37,029 --> 01:02:34,880
the rover gets down to the surface of

1742
01:02:38,470 --> 01:02:37,039
mars it can successfully navigate itself

1743
01:02:40,390 --> 01:02:38,480
over the rocks and the terrain that are

1744
01:02:41,829 --> 01:02:40,400
actually there on the surface as soon as

1745
01:02:43,510 --> 01:02:41,839
we finish up the mobility checkout

1746
01:02:45,510 --> 01:02:43,520
they'll be putting the mast on the top

1747
01:02:47,190 --> 01:02:45,520
deck of the rover and the mast is more

1748
01:02:49,029 --> 01:02:47,200
cameras and imaging that allows us to

1749
01:02:50,870 --> 01:02:49,039
take stereo pictures off in the distance

1750
01:02:52,789 --> 01:02:50,880
of mars just like your eyes work in a

1751
01:02:54,710 --> 01:02:52,799
stereo pair this camera will also return

1752
01:02:55,910 --> 01:02:54,720
a stereo imagery from the surface of

1753
01:02:58,150 --> 01:02:55,920
mars

1754
01:02:59,750 --> 01:02:58,160
once that's complete then the front deck

1755
01:03:01,910 --> 01:02:59,760
of the rover which is empty right now is

1756
01:03:03,829 --> 01:03:01,920
where we'll put the robotic arm the

1757
01:03:05,750 --> 01:03:03,839
robotic arm is a device that reaches out

1758
01:03:07,750 --> 01:03:05,760
six feet or so and actually touches the

1759
01:03:08,870 --> 01:03:07,760
surface takes samples and then deposits

1760
01:03:10,390 --> 01:03:08,880
those samples

1761
01:03:12,150 --> 01:03:10,400
back into the innards of the rover for

1762
01:03:13,190 --> 01:03:12,160
the science instruments to analyze and

1763
01:03:16,309 --> 01:03:13,200

determine what the elemental

1764
01:03:17,589 --> 01:03:16,319
compositions are of the surface of mars

1765
01:03:19,029 --> 01:03:17,599
over here on my left you'll see the

1766
01:03:22,549 --> 01:03:19,039
descent stage

1767
01:03:23,910 --> 01:03:22,559
test where they actually shook it just

1768
01:03:25,990 --> 01:03:23,920
like it would experience when it's out

1769
01:03:27,430 --> 01:03:26,000
going through the launch

1770
01:03:28,710 --> 01:03:27,440
and they wanted to make sure that the

1771
01:03:29,990 --> 01:03:28,720
the design held together and then

1772
01:03:32,710 --> 01:03:30,000
nothing broke and everything was

1773
01:03:33,829 --> 01:03:32,720
successful with that test too

1774
01:03:36,150 --> 01:03:33,839
this has been your update on the

1775
01:03:37,670 --> 01:03:36,160
assembly of the curiosity vehicle as you

1776
01:03:39,430 --> 01:03:37,680
can see curiosity is looking more and

1777
01:03:41,349 --> 01:03:39,440
more like a rover every day and the team

1778
01:03:46,390 --> 01:03:41,359
is working hard as we aim for our launch

1779
01:03:49,750 --> 01:03:47,990
okay so if we go to the next slide

1780
01:03:51,589 --> 01:03:49,760
please

1781
01:03:53,349 --> 01:03:51,599
so you saw a little bit of a animation

1782
01:03:55,109 --> 01:03:53,359
of it you've seen it from a distance now

1783
01:03:56,470 --> 01:03:55,119
let's kind of get up close and personal

1784
01:03:58,630 --> 01:03:56,480
with some of the hardware here on the

1785
01:04:00,230 --> 01:03:58,640
mars science laboratory so this is what

1786
01:04:02,549 --> 01:04:00,240
it looks like you'll see that in that

1787
01:04:04,789 --> 01:04:02,559
masthead there's not only the eyes but

1788
01:04:06,549 --> 01:04:04,799

there's a thing called chemistry camera

1789
01:04:07,910 --> 01:04:06,559
which is really cool i hope we can get

1790
01:04:09,109 --> 01:04:07,920
sound effects from it you'll actually

1791
01:04:10,950 --> 01:04:09,119
see it in a little bit in another

1792
01:04:13,270 --> 01:04:10,960
animation but it's got a laser in it so

1793
01:04:15,430 --> 01:04:13,280
it stands off and 20 feet away it can

1794
01:04:17,270 --> 01:04:15,440
zap that laser at a rock

1795
01:04:19,109 --> 01:04:17,280
create a plasma from that rock and then

1796
01:04:20,390 --> 01:04:19,119
analyze what's in that and decide

1797
01:04:21,910 --> 01:04:20,400
whether it's worth driving over there to

1798
01:04:24,549 --> 01:04:21,920
look at it

1799
01:04:26,630 --> 01:04:24,559
the main rims is actually an instrument

1800
01:04:28,390 --> 01:04:26,640
that provides meteorological data wind

1801
01:04:29,589 --> 01:04:28,400
speed pressure temperature things like

1802
01:04:30,950 --> 01:04:29,599
that we had a question earlier about

1803
01:04:32,549 --> 01:04:30,960
meteorology we're going to measure it

1804
01:04:34,710 --> 01:04:32,559
directly just like we had a question

1805
01:04:36,390 --> 01:04:34,720
about radiation there's an instrument on

1806
01:04:38,230 --> 01:04:36,400
here called rad that measures the

1807
01:04:39,670 --> 01:04:38,240
radiation at the surface of the planet

1808
01:04:42,150 --> 01:04:39,680
so we will get our first really good

1809
01:04:44,230 --> 01:04:42,160
solid data set for that

1810
01:04:46,069 --> 01:04:44,240
and then inside is really where the

1811
01:04:47,990 --> 01:04:46,079
hardest working and and the most

1812
01:04:49,990 --> 01:04:48,000
complicated instruments are

1813
01:04:51,750 --> 01:04:50,000

and essentially we've taken a chemistry

1814
01:04:54,069 --> 01:04:51,760
laboratory and we've squished it down

1815
01:04:56,870 --> 01:04:54,079
into a couple of small boxes stuck it

1816
01:04:59,270 --> 01:04:56,880
inside this rover and the arm is going

1817
01:05:01,430 --> 01:04:59,280
to actually drill holes in rocks and

1818
01:05:03,589 --> 01:05:01,440
move that material into those chemistry

1819
01:05:05,430 --> 01:05:03,599
labs to understand what's in that the

1820
01:05:08,710 --> 01:05:05,440
whole idea is that you had the word

1821
01:05:10,549 --> 01:05:08,720
earlier habitability big long word for

1822
01:05:12,870 --> 01:05:10,559
is this an area that could have been a

1823
01:05:15,750 --> 01:05:12,880
habitat or is it a habitat that's the

1824
01:05:16,710 --> 01:05:15,760
key msl is the scientific transition

1825
01:05:17,510 --> 01:05:16,720
mission

1826
01:05:19,109 --> 01:05:17,520
from

1827
01:05:21,109 --> 01:05:19,119
understanding the water cycles on the

1828
01:05:23,430 --> 01:05:21,119
planet to understanding if things could

1829
01:05:26,870 --> 01:05:23,440
or could have survived on the planet

1830
01:05:30,789 --> 01:05:28,950
to get to the surface though it has an

1831
01:05:32,710 --> 01:05:30,799
atmosphere some of you remember many of

1832
01:05:34,470 --> 01:05:32,720
you remember the apollo programs

1833
01:05:36,150 --> 01:05:34,480
everybody remembers the shovel program

1834
01:05:37,510 --> 01:05:36,160
because we're still doing it that you

1835
01:05:39,510 --> 01:05:37,520
have an atmosphere you have to get

1836
01:05:41,109 --> 01:05:39,520
through mars has an atmosphere we have

1837
01:05:42,549 --> 01:05:41,119
to get through

1838
01:05:44,789 --> 01:05:42,559

so getting things from the top of that

1839
01:05:46,470 --> 01:05:44,799
atmosphere to the surface safely is a

1840
01:05:47,589 --> 01:05:46,480
big challenge and as marcelo had

1841
01:05:49,670 --> 01:05:47,599
mentioned

1842
01:05:51,910 --> 01:05:49,680
many of us have tried and the u.s hasn't

1843
01:05:53,670 --> 01:05:51,920
been successful every time either the

1844
01:05:55,190 --> 01:05:53,680
success rate for everybody on the earth

1845
01:05:57,829 --> 01:05:55,200
trying to get to the surface is in the

1846
01:05:59,349 --> 01:05:57,839
60 to 70 percent category so it's really

1847
01:06:00,950 --> 01:05:59,359
a tough thing to do

1848
01:06:02,870 --> 01:06:00,960
just enough atmosphere you have to worry

1849
01:06:04,950 --> 01:06:02,880
about it not enough atmosphere to help

1850
01:06:06,789 --> 01:06:04,960
you like here on earth where it's nice

1851
01:06:08,230 --> 01:06:06,799
and thick and you can slow down easily

1852
01:06:10,390 --> 01:06:08,240
these are the pieces the thing on the

1853
01:06:12,470 --> 01:06:10,400
top is the cruise stage that keeps the

1854
01:06:13,670 --> 01:06:12,480
spacecraft and everything alive provides

1855
01:06:15,910 --> 01:06:13,680
power

1856
01:06:17,510 --> 01:06:15,920
and and other support systems on the way

1857
01:06:18,710 --> 01:06:17,520
to mars which is about an eight month

1858
01:06:21,270 --> 01:06:18,720
journey

1859
01:06:23,190 --> 01:06:21,280
the top white thing just below the

1860
01:06:25,589 --> 01:06:23,200
cruise stage and then the dark thing at

1861
01:06:28,309 --> 01:06:25,599
the bottom are the aeroshell so just

1862
01:06:30,470 --> 01:06:28,319
like the old apollo capsules the rover

1863
01:06:32,789 --> 01:06:30,480

is encased just like the astronauts were

1864
01:06:35,109 --> 01:06:32,799
in this device and that dark brown thing

1865
01:06:37,510 --> 01:06:35,119
that heat shield takes all the heat on

1866
01:06:39,589 --> 01:06:37,520
the entry through the mars atmosphere

1867
01:06:42,069 --> 01:06:39,599
the next thing down looks kind of like a

1868
01:06:43,990 --> 01:06:42,079
spider is called a sky crane

1869
01:06:45,750 --> 01:06:44,000
or otherwise known as the descent stage

1870
01:06:47,829 --> 01:06:45,760
you saw it in dave's picture or his

1871
01:06:49,910 --> 01:06:47,839
video a minute ago that actually is

1872
01:06:51,670 --> 01:06:49,920
essentially a rocket-powered helicopter

1873
01:06:53,029 --> 01:06:51,680
and that's going to land the rover and

1874
01:06:55,349 --> 01:06:53,039
then the rover which doesn't look much

1875
01:06:57,029 --> 01:06:55,359
like a rover in this is the next thing

1876
01:06:59,109 --> 01:06:57,039
down it's all folded up to be able to

1877
01:07:00,950 --> 01:06:59,119
fit into this clam shell i'm going to

1878
01:07:02,950 --> 01:07:00,960
show you a video at the end of how all

1879
01:07:04,870 --> 01:07:02,960
this stuff unpacks and walk you through

1880
01:07:06,230 --> 01:07:04,880
it as we get to the surface which is in

1881
01:07:08,390 --> 01:07:06,240
my opinion

1882
01:07:09,430 --> 01:07:08,400
probably one of the greatest engineering

1883
01:07:11,270 --> 01:07:09,440
feats

1884
01:07:12,950 --> 01:07:11,280
that's ever been actually invented it's

1885
01:07:15,349 --> 01:07:12,960
absolutely unbelievable when you see it

1886
01:07:17,190 --> 01:07:15,359
so next slide please

1887
01:07:18,230 --> 01:07:17,200
i told you it was big that's a mini

1888
01:07:20,390 --> 01:07:18,240

cooper

1889
01:07:21,990 --> 01:07:20,400
and that's the back shell that i showed

1890
01:07:23,670 --> 01:07:22,000
you was white in the previous picture so

1891
01:07:25,109 --> 01:07:23,680
you can see how big this is as a matter

1892
01:07:26,390 --> 01:07:25,119
of fact the apollo capsule and there's

1893
01:07:29,109 --> 01:07:26,400
one of those on the floor you should go

1894
01:07:30,789 --> 01:07:29,119
look at easily fits inside this and you

1895
01:07:32,789 --> 01:07:30,799
can close it up you could probably put

1896
01:07:34,069 --> 01:07:32,799
six or seven astronauts in this thing

1897
01:07:35,589 --> 01:07:34,079
but we couldn't get them back so they

1898
01:07:37,670 --> 01:07:35,599
probably don't want to go next one

1899
01:07:40,069 --> 01:07:37,680
please

1900
01:07:42,069 --> 01:07:40,079
this is the inside of the rover so the

1901
01:07:43,430 --> 01:07:42,079
rover looks nice got four sides six

1902
01:07:45,510 --> 01:07:43,440
sides excuse me

1903
01:07:47,190 --> 01:07:45,520
you know looks like a nice box there's a

1904
01:07:49,349 --> 01:07:47,200
lot of stuff inside this these are what

1905
01:07:51,750 --> 01:07:49,359
we call the avionics so these boxes are

1906
01:07:54,069 --> 01:07:51,760
the brains of the thing the computers

1907
01:07:56,069 --> 01:07:54,079
are in there the power control systems

1908
01:07:57,910 --> 01:07:56,079
are in there because of the temperatures

1909
01:07:59,190 --> 01:07:57,920
at mars that you heard from jack and and

1910
01:08:01,029 --> 01:07:59,200
steve about

1911
01:08:03,270 --> 01:08:01,039
there's heating control systems in there

1912
01:08:07,029 --> 01:08:03,280
there's batteries in there

1913
01:08:08,950 --> 01:08:07,039

and then this has a small nuclear

1914
01:08:11,190 --> 01:08:08,960
generator on it that creates heat and we

1915
01:08:12,950 --> 01:08:11,200
use that for both heat and energy and

1916
01:08:15,190 --> 01:08:12,960
the control electronics for that are in

1917
01:08:16,870 --> 01:08:15,200
there that big empty cavern in the top

1918
01:08:19,189 --> 01:08:16,880
right is actually where one of those

1919
01:08:20,630 --> 01:08:19,199
chemistry laboratory instruments goes

1920
01:08:23,189 --> 01:08:20,640
i'm going to show you that next next

1921
01:08:24,789 --> 01:08:23,199
slide please

1922
01:08:26,630 --> 01:08:24,799
this is two pictures from two different

1923
01:08:28,870 --> 01:08:26,640
angles of the same instrument called

1924
01:08:30,630 --> 01:08:28,880
sample analysis at mars

1925
01:08:31,590 --> 01:08:30,640
for the students who've had chemistry

1926
01:08:33,669 --> 01:08:31,600
lab

1927
01:08:35,990 --> 01:08:33,679
those are essentially a whole ring of

1928
01:08:39,030 --> 01:08:36,000
test tubes there and we have the ability

1929
01:08:40,709 --> 01:08:39,040
to sample over 70 individual samples on

1930
01:08:42,390 --> 01:08:40,719
the surface of mars so we're going to

1931
01:08:43,829 --> 01:08:42,400
have a drill and we're going to drill

1932
01:08:45,669 --> 01:08:43,839
holes we're going to process that

1933
01:08:47,430 --> 01:08:45,679
material and it's going to come back and

1934
01:08:48,630 --> 01:08:47,440
go through all these different chemistry

1935
01:08:50,709 --> 01:08:48,640
steps

1936
01:08:52,630 --> 01:08:50,719
in this device this is an amazingly

1937
01:08:54,950 --> 01:08:52,640
complicated thing this usually will hand

1938
01:08:56,709 --> 01:08:54,960

up be a couple of stand-up racks in a

1939
01:08:58,390 --> 01:08:56,719
chemistry laboratory but we've crammed

1940
01:09:00,070 --> 01:08:58,400
it down into this little box that's

1941
01:09:03,269 --> 01:09:00,080
about this big

1942
01:09:04,550 --> 01:09:03,279
inside inside msl curiosity rover next

1943
01:09:05,829 --> 01:09:04,560
slide please

1944
01:09:08,390 --> 01:09:05,839
and this is what's going to do the

1945
01:09:10,390 --> 01:09:08,400
drilling this is a complicated looking

1946
01:09:12,470 --> 01:09:10,400
device because it actually is

1947
01:09:14,229 --> 01:09:12,480
on the right end you'll see two fingers

1948
01:09:16,470 --> 01:09:14,239
sticking out in between those is the

1949
01:09:18,229 --> 01:09:16,480
drill itself

1950
01:09:20,470 --> 01:09:18,239
on the other side i'm sorry you can't

1951
01:09:23,269 --> 01:09:20,480
see it is actually the processing system

1952
01:09:25,110 --> 01:09:23,279
that will sieve and and will sieve the

1953
01:09:26,070 --> 01:09:25,120
material and route it around and get it

1954
01:09:31,669 --> 01:09:26,080
into

1955
01:09:33,990 --> 01:09:31,679
box that's facing you is actually a

1956
01:09:35,510 --> 01:09:34,000
device to take clean dust and things off

1957
01:09:37,269 --> 01:09:35,520
of rocks so that you don't sample the

1958
01:09:39,910 --> 01:09:37,279
surface dust you actually are able to

1959
01:09:41,269 --> 01:09:39,920
sample the rock itself and then just

1960
01:09:43,510 --> 01:09:41,279
behind it there's a little black box

1961
01:09:45,829 --> 01:09:43,520
with a big silver colored cable that

1962
01:09:49,269 --> 01:09:45,839
goes into it that's a microscope we call

1963
01:09:50,950 --> 01:09:49,279

it a hand lens imager and uh and and so

1964
01:09:52,630 --> 01:09:50,960
that's another tool that we'll use this

1965
01:09:54,870 --> 01:09:52,640
weighs about a hundred pounds and it's

1966
01:09:56,470 --> 01:09:54,880
at the end of a six foot arm so it's

1967
01:10:00,070 --> 01:09:56,480
quite quite a piece of engineering to

1968
01:10:03,510 --> 01:10:01,910
this is actually the descent stage or

1969
01:10:05,189 --> 01:10:03,520
the sky crane

1970
01:10:07,030 --> 01:10:05,199
with the rover

1971
01:10:08,390 --> 01:10:07,040
wrapped up and packed up underneath it

1972
01:10:09,830 --> 01:10:08,400
you can see one wheel in it but i want

1973
01:10:11,189 --> 01:10:09,840
to show you that because i think the

1974
01:10:12,950 --> 01:10:11,199
next slide is we're going to go into an

1975
01:10:15,750 --> 01:10:12,960
animation i'm sorry we have one more

1976
01:10:17,110 --> 01:10:15,760
slide next one please this is the whole

1977
01:10:19,270 --> 01:10:17,120
thing put together i showed you the

1978
01:10:21,510 --> 01:10:19,280
cartoon of it broken apart this is what

1979
01:10:22,870 --> 01:10:21,520
we call the stack every once in a while

1980
01:10:24,550 --> 01:10:22,880
to make sure everything works together

1981
01:10:26,550 --> 01:10:24,560
we put it all together and test it as a

1982
01:10:28,310 --> 01:10:26,560
single unit and that's the stack if you

1983
01:10:30,790 --> 01:10:28,320
look at the bottom you can see

1984
01:10:32,149 --> 01:10:30,800
pic little guys down there in uh in

1985
01:10:33,350 --> 01:10:32,159
their bunny suits as we call them

1986
01:10:34,870 --> 01:10:33,360
walking around so it gives you an idea

1987
01:10:35,990 --> 01:10:34,880
how big this is

1988
01:10:37,669 --> 01:10:36,000

so the next thing i'm going to show you

1989
01:10:39,590 --> 01:10:37,679
is an animation

1990
01:10:41,669 --> 01:10:39,600
and and this animation is actually

1991
01:10:43,990 --> 01:10:41,679
beginning at the top of the atmosphere

1992
01:10:46,229 --> 01:10:44,000
and this is how we get the curiosity

1993
01:10:48,070 --> 01:10:46,239
rover unpacked and to the ground this

1994
01:10:49,110 --> 01:10:48,080
whole thing is called the six minutes of

1995
01:10:50,550 --> 01:10:49,120
terror

1996
01:10:52,470 --> 01:10:50,560
i have yet to learn how to hold my

1997
01:10:54,470 --> 01:10:52,480
breath for six minutes

1998
01:10:56,790 --> 01:10:54,480
i'm working on it i tried it on phoenix

1999
01:10:58,390 --> 01:10:56,800
when we did that in 2008 and i turned

2000
01:11:00,070 --> 01:10:58,400
blue and didn't work well

2001
01:11:01,669 --> 01:11:00,080
so we're going to give it another try

2002
01:11:03,430 --> 01:11:01,679
here but this is an amazing sequence i'm

2003
01:11:05,110 --> 01:11:03,440
going to walk you through it

2004
01:11:10,070 --> 01:11:05,120
so we start at the top of the atmosphere

2005
01:11:13,990 --> 01:11:12,390
as it comes through about the atmosphere

2006
01:11:14,709 --> 01:11:14,000
the heat shield takes

2007
01:11:17,270 --> 01:11:14,719
up

2008
01:11:19,430 --> 01:11:17,280
about 95 of the energy of getting to the

2009
01:11:22,229 --> 01:11:19,440
ground when we are around supersonic a

2010
01:11:24,149 --> 01:11:22,239
parachute comes out this takes out about

2011
01:11:27,189 --> 01:11:24,159
four percent of the remaining five

2012
01:11:29,669 --> 01:11:27,199
percent heat shield comes off the rover

2013
01:11:32,229 --> 01:11:29,679

wheels come down

2014
01:11:34,310 --> 01:11:32,239
wait for it

2015
01:11:36,390 --> 01:11:34,320
it comes out of the back shell

2016
01:11:37,750 --> 01:11:36,400
okay so the sky crane and the rover are

2017
01:11:39,590 --> 01:11:37,760
attached to each other so this is a

2018
01:11:40,790 --> 01:11:39,600
rocket powered helicopter now on the way

2019
01:11:42,470 --> 01:11:40,800
to the ground

2020
01:11:44,390 --> 01:11:42,480
horizontally it's barely moving

2021
01:11:46,950 --> 01:11:44,400
vertically it's it's a meter or so a

2022
01:11:49,350 --> 01:11:46,960
second now it's going to roll

2023
01:11:51,590 --> 01:11:49,360
the rover down on a set of cables from

2024
01:11:53,189 --> 01:11:51,600
the sky crane

2025
01:11:54,550 --> 01:11:53,199
it's now going to slowly descend it's

2026
01:11:56,390 --> 01:11:54,560
going to touch down

2027
01:11:58,070 --> 01:11:56,400
when it recognizes touchdown and the

2028
01:12:04,950 --> 01:11:58,080
rover is the one to tell itself that

2029
01:12:09,189 --> 01:12:07,430
sky crane goes away and just crashes off

2030
01:12:12,149 --> 01:12:09,199
in the distance don't need it anymore

2031
01:12:17,350 --> 01:12:12,159
this job is done out of fuel basically

2032
01:12:21,990 --> 01:12:18,870
so that sequence that you just saw in

2033
01:12:23,430 --> 01:12:22,000
about 40 seconds is about is six minutes

2034
01:12:26,229 --> 01:12:23,440
long

2035
01:12:28,149 --> 01:12:26,239
so it's because the light time the radio

2036
01:12:29,910 --> 01:12:28,159
time between mars and earth is around

2037
01:12:31,750 --> 01:12:29,920
seven minutes or eight minutes this

2038
01:12:34,550 --> 01:12:31,760

whole thing happens before we even see

2039
01:12:36,630 --> 01:12:34,560
it start so we don't know the end until

2040
01:12:38,550 --> 01:12:36,640
it's all over

2041
01:12:39,830 --> 01:12:38,560
so i'm going to let this run for another

2042
01:12:42,149 --> 01:12:39,840
minute or so

2043
01:12:44,149 --> 01:12:42,159
you will see it drive off it will you

2044
01:12:45,830 --> 01:12:44,159
can keep an eye on this it's going to

2045
01:12:48,470 --> 01:12:45,840
actually show you how chemcam is going

2046
01:12:49,990 --> 01:12:48,480
to work which is kind of fun but this is

2047
01:12:51,750 --> 01:12:50,000
the end of the presentations and i'm

2048
01:12:53,669 --> 01:12:51,760
going to open it up for questions we got

2049
01:13:03,270 --> 01:12:53,679
a couple of got enough time for just a

2050
01:13:03,280 --> 01:13:07,910
i think you were first

2051
01:13:12,149 --> 01:13:10,790
if i look at the at the mass of the

2052
01:13:20,070 --> 01:13:12,159
rover

2053
01:13:25,669 --> 01:13:21,350
the

2054
01:13:27,750 --> 01:13:25,679
atmosphere is a little over three

2055
01:13:30,390 --> 01:13:27,760
thousand kilograms

2056
01:13:34,310 --> 01:13:30,400
and the landed mass which is the rover

2057
01:13:35,750 --> 01:13:34,320
and all the instruments is around 970

2058
01:13:38,550 --> 01:13:35,760
kilograms

2059
01:13:40,550 --> 01:13:38,560
so it's about a three to one ratio

2060
01:13:43,430 --> 01:13:40,560
okay

2061
01:13:45,510 --> 01:13:43,440
if you were to do aeronomy on the

2062
01:13:47,189 --> 01:13:45,520
surface of mars in this

2063
01:13:49,350 --> 01:13:47,199

future exploration

2064
01:13:51,110 --> 01:13:49,360
have you considered the use of

2065
01:13:53,189 --> 01:13:51,120
uav style

2066
01:13:55,270 --> 01:13:53,199
devices to help you sample different

2067
01:13:57,910 --> 01:13:55,280
layers of the atmosphere is that part of

2068
01:13:59,189 --> 01:13:57,920
the planning is that

2069
01:14:00,630 --> 01:13:59,199
many things have been looked at and i'll

2070
01:14:02,470 --> 01:14:00,640
let you answer part of this but i mean

2071
01:14:03,669 --> 01:14:02,480
we've looked at balloons and we've

2072
01:14:06,790 --> 01:14:03,679
looked at

2073
01:14:09,030 --> 01:14:06,800
mars airplanes and things like that

2074
01:14:10,390 --> 01:14:09,040
they're difficult to inflate

2075
01:14:12,310 --> 01:14:10,400
because there's

2076
01:14:14,709 --> 01:14:12,320
not enough air for propellers and jet

2077
01:14:16,470 --> 01:14:14,719
engines and things like that

2078
01:14:18,630 --> 01:14:16,480
you know you're you're rocket powered so

2079
01:14:21,189 --> 01:14:18,640
your lifetime is short

2080
01:14:24,149 --> 01:14:21,199
and so there's issues with doing that

2081
01:14:25,510 --> 01:14:24,159
and you also only cover a very small

2082
01:14:27,590 --> 01:14:25,520
area

2083
01:14:29,350 --> 01:14:27,600
through by flying through it

2084
01:14:31,590 --> 01:14:29,360
if you had an airplane or you can't

2085
01:14:34,310 --> 01:14:31,600
control it because a balloon just drifts

2086
01:14:35,910 --> 01:14:34,320
so right now it seems like a space board

2087
01:14:37,990 --> 01:14:35,920
satellite based seems to be more

2088
01:14:40,229 --> 01:14:38,000

efficient you want to add to that

2089
01:14:42,630 --> 01:14:40,239
maybe in a future

2090
01:14:44,630 --> 01:14:42,640
effort of exploration some terrestrial

2091
01:14:47,189 --> 01:14:44,640
technique could be used for instance

2092
01:14:49,669 --> 01:14:47,199
having at the same time a satellite and

2093
01:14:52,070 --> 01:14:49,679
a lighter on the surface of mars

2094
01:14:54,630 --> 01:14:52,080
pointing with a laser towards

2095
01:14:56,630 --> 01:14:54,640
the sky and so you have a double probing

2096
01:14:59,510 --> 01:14:56,640
top down and bottom up in order to study

2097
01:15:02,070 --> 01:14:59,520
all possible composition and turbulence

2098
01:15:03,910 --> 01:15:02,080
and wind speed and wind fields etc for

2099
01:15:06,310 --> 01:15:03,920
the time being we have to be content

2100
01:15:08,390 --> 01:15:06,320
with the very sophisticated orbiters

2101
01:15:10,229 --> 01:15:08,400
that with new technologies new

2102
01:15:13,189 --> 01:15:10,239
spectrometers can provide us with a lot

2103
01:15:15,510 --> 01:15:13,199
of information on composition and

2104
01:15:17,590 --> 01:15:15,520
dynamics of the atmosphere of mars

2105
01:15:19,350 --> 01:15:17,600
thanks one more quick thought really

2106
01:15:21,030 --> 01:15:19,360
quick really quick

2107
01:15:23,270 --> 01:15:21,040
mars sample return

2108
01:15:25,990 --> 01:15:23,280
are you considering the use of in-situ

2109
01:15:28,229 --> 01:15:26,000
resources to throw your samples back to

2110
01:15:29,910 --> 01:15:28,239
save you a lot of mass um the question

2111
01:15:31,830 --> 01:15:29,920
was whether we're looking for to use

2112
01:15:34,070 --> 01:15:31,840
in-situ resources in other words make

2113
01:15:35,350 --> 01:15:34,080

things their fuel and other things and

2114
01:15:36,950 --> 01:15:35,360
right now the answer is we don't think

2115
01:15:39,189 --> 01:15:36,960
we have to do that

2116
01:15:39,990 --> 01:15:39,199
to uh to be able to execute that mission

2117
01:15:41,590 --> 01:15:40,000
so

2118
01:15:44,470 --> 01:15:41,600
next question please

2119
01:15:46,630 --> 01:15:44,480
uh yes um i'm curious about

2120
01:15:48,390 --> 01:15:46,640
the delay from ground control on earth

2121
01:15:49,910 --> 01:15:48,400
whenever you're uh

2122
01:15:52,470 --> 01:15:49,920
creating a sequence

2123
01:15:55,669 --> 01:15:52,480
of like operations for the rover

2124
01:15:58,550 --> 01:15:55,679
you expect like how long of a delay

2125
01:16:01,030 --> 01:15:58,560
i'm just i'm curious

2126
01:16:02,470 --> 01:16:01,040
let me talk about yoga okay uh

2127
01:16:03,910 --> 01:16:02,480
so let's take rovers i think you

2128
01:16:05,430 --> 01:16:03,920
mentioned rovers as an example so

2129
01:16:06,790 --> 01:16:05,440
typically what we do is you build a

2130
01:16:08,790 --> 01:16:06,800
command load

2131
01:16:10,070 --> 01:16:08,800
of software commands things you want the

2132
01:16:11,830 --> 01:16:10,080
rover to do

2133
01:16:14,709 --> 01:16:11,840
and then you upload those to the rover

2134
01:16:16,709 --> 01:16:14,719
the rover will not execute those in real

2135
01:16:18,229 --> 01:16:16,719
time you typically load them on

2136
01:16:20,470 --> 01:16:18,239
make sure that all the things loaded

2137
01:16:22,070 --> 01:16:20,480
properly and then execute those commands

2138
01:16:23,990 --> 01:16:22,080

at a different time the next because

2139
01:16:26,550 --> 01:16:24,000
you're not always in contact with it now

2140
01:16:28,470 --> 01:16:26,560
we do use the orbiters uh for most of

2141
01:16:29,750 --> 01:16:28,480
the communications relay but we don't

2142
01:16:32,070 --> 01:16:29,760
see them all the time because both

2143
01:16:34,149 --> 01:16:32,080
planets are rotating so then it goes off

2144
01:16:35,830 --> 01:16:34,159
and it does the execution

2145
01:16:37,830 --> 01:16:35,840
and then when you talk to it the next

2146
01:16:39,910 --> 01:16:37,840
time you get the data set back so we

2147
01:16:41,830 --> 01:16:39,920
don't try to do things tele-robotically

2148
01:16:44,709 --> 01:16:41,840
because that light time is the problem

2149
01:16:45,910 --> 01:16:44,719
right so it's basically a sequence of of

2150
01:16:47,510 --> 01:16:45,920
programs and

2151
01:16:49,270 --> 01:16:47,520
things like that that carry out the the

2152
01:16:51,350 --> 01:16:49,280
different operations that's right that's

2153
01:16:53,189 --> 01:16:51,360
right and to make things efficient the

2154
01:16:54,709 --> 01:16:53,199
smarter the rover can be such as

2155
01:16:56,709 --> 01:16:54,719
understanding what's a hazard what it

2156
01:16:59,030 --> 01:16:56,719
can and cannot drive over

2157
01:17:01,990 --> 01:16:59,040
um and we have those smarts now on

2158
01:17:03,430 --> 01:17:02,000
spirit and opportunity we didn't before

2159
01:17:05,350 --> 01:17:03,440
you can actually do more because the

2160
01:17:07,590 --> 01:17:05,360
rover itself is smarter

2161
01:17:08,470 --> 01:17:07,600
so that's how we improve things

2162
01:17:13,270 --> 01:17:08,480
thank you

2163
01:17:13,280 --> 01:17:24,310

what um

2164
01:17:27,590 --> 01:17:25,750
i hope we can answer your question

2165
01:17:29,270 --> 01:17:27,600
that's going to be the hard part

2166
01:17:30,470 --> 01:17:29,280
what's going to be the difference

2167
01:17:32,310 --> 01:17:30,480
between

2168
01:17:44,070 --> 01:17:32,320
the

2169
01:17:46,709 --> 01:17:44,080
have have very limited payloads has very

2170
01:17:48,149 --> 01:17:46,719
few science instruments has a camera and

2171
01:17:50,229 --> 01:17:48,159
a couple of meteor a couple of

2172
01:17:51,669 --> 01:17:50,239
instruments for looking at minerals

2173
01:17:53,669 --> 01:17:51,679
so it doesn't have this chemistry

2174
01:17:56,310 --> 01:17:53,679
laboratory that's the big deal about

2175
01:17:58,390 --> 01:17:56,320
mars science lab and curiosity is it is

2176
01:18:01,270 --> 01:17:58,400
a laboratory it's a chemistry laboratory

2177
01:18:03,350 --> 01:18:01,280
on on the surface of mars

2178
01:18:04,709 --> 01:18:03,360
it's a good question yeah nice

2179
01:18:07,350 --> 01:18:04,719
you got a follow-up

2180
01:18:09,669 --> 01:18:07,360
well the other question was so

2181
01:18:12,630 --> 01:18:09,679
what's the difference in speed as far as

2182
01:18:14,790 --> 01:18:12,640
will msl curiosity cover more ground in

2183
01:18:15,990 --> 01:18:14,800
a shorter period of time that's also a

2184
01:18:18,790 --> 01:18:16,000
good question

2185
01:18:19,830 --> 01:18:18,800
they actually drive at about the same

2186
01:18:23,030 --> 01:18:19,840
speed

2187
01:18:25,669 --> 01:18:23,040
msl curiosity is not really any faster

2188
01:18:28,390 --> 01:18:25,679

but it's designed to drive farther

2189
01:18:29,590 --> 01:18:28,400
so as you heard from steve squires

2190
01:18:31,350 --> 01:18:29,600
spirit and opportunity were only

2191
01:18:33,830 --> 01:18:31,360
designed we only planned them going

2192
01:18:35,910 --> 01:18:33,840
about 600 meters

2193
01:18:38,229 --> 01:18:35,920
curiosity is designed to do 20

2194
01:18:40,310 --> 01:18:38,239
kilometers so it's designed to live a

2195
01:18:41,510 --> 01:18:40,320
couple of years and drive 20 kilometers

2196
01:18:45,590 --> 01:18:41,520
which is

2197
01:18:52,630 --> 01:18:47,590
okay thank you very much marchello thank

2198
01:18:56,790 --> 01:18:55,110
so the next panel is on

2199
01:18:58,470 --> 01:18:56,800
uh where we're going scientifically in

2200
01:19:00,390 --> 01:18:58,480
the future what we think we might find

2201
01:19:02,149 --> 01:19:00,400
and our future aspirations and

2202
01:19:03,669 --> 01:19:02,159
expectations and hopes

2203
01:19:05,830 --> 01:19:03,679
to lead that panel i'd like to introduce

2204
01:19:07,669 --> 01:19:05,840
michael meyer who's the chief scientist

2205
01:19:09,270 --> 01:19:07,679
for the mars program at nasa

2206
01:19:10,550 --> 01:19:09,280
headquarters michael

2207
01:19:15,430 --> 01:19:10,560
thank you

2208
01:19:19,030 --> 01:19:17,189
now

2209
01:19:21,270 --> 01:19:19,040
and we're going to move from

2210
01:19:23,350 --> 01:19:21,280
following the water to

2211
01:19:25,510 --> 01:19:23,360
toward the idea of looking for signs of

2212
01:19:28,149 --> 01:19:25,520
life and

2213
01:19:30,149 --> 01:19:28,159

basically it was back in about 1995 that

2214
01:19:32,790 --> 01:19:30,159
we recognize that looking for life on

2215
01:19:34,790 --> 01:19:32,800
another planet is an extremely difficult

2216
01:19:37,669 --> 01:19:34,800
and challenging problem so we

2217
01:19:39,750 --> 01:19:37,679
commissioned a report and was published

2218
01:19:41,990 --> 01:19:39,760
basically an exobiology strategy

2219
01:19:44,390 --> 01:19:42,000
strategy for exploring mars

2220
01:19:47,189 --> 01:19:44,400
and what it did it recommended

2221
01:19:48,709 --> 01:19:47,199
a series of missions

2222
01:19:51,030 --> 01:19:48,719
where you start with orbital

2223
01:19:53,350 --> 01:19:51,040
reconnaissance you send rovers to the

2224
01:19:55,189 --> 01:19:53,360
planet to confirm what you thought you

2225
01:19:57,510 --> 01:19:55,199
saw from orbit and also do some

2226
01:19:59,270 --> 01:19:57,520
exploration on their own and you iterate

2227
01:20:01,350 --> 01:19:59,280
this several times as you improve your

2228
01:20:03,910 --> 01:20:01,360
knowledge about the planet because you

2229
01:20:05,590 --> 01:20:03,920
can't understand the possibility of life

2230
01:20:08,149 --> 01:20:05,600
unless you understand the planetary

2231
01:20:10,390 --> 01:20:08,159
context so you have to know the planet

2232
01:20:12,070 --> 01:20:10,400
before you can reasonably ask a question

2233
01:20:14,149 --> 01:20:12,080
whether or not it is ever possible to

2234
01:20:16,229 --> 01:20:14,159
have life there and where you might look

2235
01:20:17,910 --> 01:20:16,239
for it so with that you do orbital

2236
01:20:19,590 --> 01:20:17,920
reconnaissance you go to the surface and

2237
01:20:21,350 --> 01:20:19,600
explore confirm what you thought you

2238
01:20:23,590 --> 01:20:21,360

learned from orbit

2239
01:20:25,110 --> 01:20:23,600
study in detail and then eventually one

2240
01:20:26,870 --> 01:20:25,120
of the things that we would like to do

2241
01:20:28,950 --> 01:20:26,880
is do sample returns so we can put our

2242
01:20:30,709 --> 01:20:28,960
best instruments here on earth on that

2243
01:20:33,990 --> 01:20:30,719
thing to understand whether or not a

2244
01:20:34,870 --> 01:20:34,000
particular planet has evolved life

2245
01:20:36,550 --> 01:20:34,880
so

2246
01:20:38,390 --> 01:20:36,560
with that

2247
01:20:41,669 --> 01:20:38,400
understanding and that

2248
01:20:43,750 --> 01:20:41,679
strategy laid out over 15 years ago we

2249
01:20:46,550 --> 01:20:43,760
have been following that and a good

2250
01:20:48,950 --> 01:20:46,560
portion of that strategy is encompassed

2251
01:20:50,470 --> 01:20:48,960
in the eye to follow the water

2252
01:20:52,790 --> 01:20:50,480
and you know what

2253
01:20:55,030 --> 01:20:52,800
we can check that box we found water we

2254
01:20:57,110 --> 01:20:55,040
found in several different places we now

2255
01:20:59,669 --> 01:20:57,120
have an understanding where water was on

2256
01:21:02,470 --> 01:20:59,679
the planet not only in place but some

2257
01:21:05,270 --> 01:21:02,480
degree in time

2258
01:21:07,430 --> 01:21:05,280
now comes the challenging part

2259
01:21:10,149 --> 01:21:07,440
if their water was there

2260
01:21:12,310 --> 01:21:10,159
did that actually create an environment

2261
01:21:15,510 --> 01:21:12,320
that's amenable to life

2262
01:21:17,430 --> 01:21:15,520
and if that environment really did exist

2263
01:21:19,030 --> 01:21:17,440

the life actually start

2264
01:21:19,750 --> 01:21:19,040
and evolve there

2265
01:21:21,430 --> 01:21:19,760
so

2266
01:21:23,030 --> 01:21:21,440
with that we're going to start the third

2267
01:21:24,310 --> 01:21:23,040
panel and what i want to do we have

2268
01:21:26,470 --> 01:21:24,320
assembled

2269
01:21:28,149 --> 01:21:26,480
three experts that cover a wide range of

2270
01:21:29,910 --> 01:21:28,159
expertise that are going to tell us

2271
01:21:31,830 --> 01:21:29,920
about astrobiology approaches the kind

2272
01:21:35,030 --> 01:21:31,840
of how you look for life

2273
01:21:36,950 --> 01:21:35,040
talk about places on mars that we think

2274
01:21:39,110 --> 01:21:36,960
had water on the surface and it may be

2275
01:21:41,270 --> 01:21:39,120
places that are potentially amenable to

2276
01:21:43,270 --> 01:21:41,280
life and then also part of the approach

2277
01:21:46,149 --> 01:21:43,280
of how we explore the planet

2278
01:21:48,870 --> 01:21:46,159
so first up i want to introduce mary

2279
01:21:50,149 --> 01:21:48,880
voitek she's the head

2280
01:21:53,669 --> 01:21:50,159
of the

2281
01:21:55,590 --> 01:21:53,679
astrobiology program at nasa

2282
01:22:00,709 --> 01:21:55,600
and

2283
01:22:03,110 --> 01:22:00,719
her background she comes from the

2284
01:22:06,390 --> 01:22:03,120
u.s geological survey but she's a micro

2285
01:22:08,790 --> 01:22:06,400
microbial ecologist and a bio biochemist

2286
01:22:10,790 --> 01:22:08,800
and she's been looking at life

2287
01:22:12,870 --> 01:22:10,800
in a couple of different ranges and

2288
01:22:15,830 --> 01:22:12,880

studying things anywhere from potable

2289
01:22:17,590 --> 01:22:15,840
water to life in extreme environments to

2290
01:22:19,750 --> 01:22:17,600
the deep biosphere

2291
01:22:21,830 --> 01:22:19,760
our next panelist is john grant who

2292
01:22:23,590 --> 01:22:21,840
you've heard about before

2293
01:22:25,830 --> 01:22:23,600
and he's

2294
01:22:27,510 --> 01:22:25,840
he's the chair

2295
01:22:30,229 --> 01:22:27,520
of the center of earth and planetary

2296
01:22:33,030 --> 01:22:30,239
studies here at the air and space museum

2297
01:22:34,950 --> 01:22:33,040
he's also been as you heard uh very much

2298
01:22:36,310 --> 01:22:34,960
involved in the rover exploration on

2299
01:22:38,790 --> 01:22:36,320
mars now

2300
01:22:40,709 --> 01:22:38,800
but the more important part of why he's

2301
01:22:43,590 --> 01:22:40,719
here is that he's been leading the

2302
01:22:45,990 --> 01:22:43,600
scientific community effort to find

2303
01:22:49,830 --> 01:22:46,000
scientifically the most promising places

2304
01:22:51,669 --> 01:22:49,840
on mars and uh where we should go

2305
01:22:53,590 --> 01:22:51,679
and whether or not it'd be safe so a

2306
01:22:56,070 --> 01:22:53,600
very important aspect of where to go on

2307
01:22:58,629 --> 01:22:56,080
the planet and then the third panelist

2308
01:23:03,830 --> 01:22:58,639
we have is jen eigenbone

2309
01:23:09,030 --> 01:23:06,470
she's a bio geochemist

2310
01:23:10,070 --> 01:23:09,040
and at goddard space flight center

2311
01:23:11,910 --> 01:23:10,080
and

2312
01:23:13,350 --> 01:23:11,920
she has been interested in helping with

2313
01:23:15,830 --> 01:23:13,360

the development some of the instruments

2314
01:23:17,750 --> 01:23:15,840
were going to march particularly sam

2315
01:23:18,790 --> 01:23:17,760
but and she's been looking for the signs

2316
01:23:21,590 --> 01:23:18,800
of life

2317
01:23:24,229 --> 01:23:21,600
here on ancient earth and how to apply

2318
01:23:26,709 --> 01:23:24,239
that approach to when we go to other

2319
01:23:29,110 --> 01:23:26,719
planets such as mars so with that what

2320
01:23:30,950 --> 01:23:29,120
i'd like to do is start the panel off

2321
01:23:32,870 --> 01:23:30,960
with mary wojtek to tell us about

2322
01:23:35,030 --> 01:23:32,880
astrobiology and approach for looking

2323
01:23:37,110 --> 01:23:35,040
for life elsewhere thank you mike

2324
01:23:39,750 --> 01:23:37,120
you have my first slide

2325
01:23:41,830 --> 01:23:39,760
so astrobiology at nasa and as a

2326
01:23:43,750 --> 01:23:41,840
scientific discipline is the study of

2327
01:23:46,070 --> 01:23:43,760
the origin and evolution of life on this

2328
01:23:48,470 --> 01:23:46,080
planet in order to understand what

2329
01:23:51,430 --> 01:23:48,480
controls the distribution of life here

2330
01:23:54,470 --> 01:23:51,440
on earth as well as other places in our

2331
01:23:56,149 --> 01:23:54,480
solar system and beyond

2332
01:23:57,750 --> 01:23:56,159
the study includes

2333
01:23:59,750 --> 01:23:57,760
research that's near and dear to my

2334
01:24:02,070 --> 01:23:59,760
heart which is looking at the limits to

2335
01:24:04,310 --> 01:24:02,080
life where organisms can grow what they

2336
01:24:06,149 --> 01:24:04,320
require to grow

2337
01:24:07,669 --> 01:24:06,159
finding out that you know what we

2338
01:24:09,270 --> 01:24:07,679

consider habitable and that the

2339
01:24:11,430 --> 01:24:09,280
temperatures for example that we keep

2340
01:24:13,350 --> 01:24:11,440
our homes at is not at all what

2341
01:24:15,510 --> 01:24:13,360
organisms can withstand they can grow

2342
01:24:16,390 --> 01:24:15,520
very cold temperatures minus 20 degrees

2343
01:24:20,310 --> 01:24:16,400
c

2344
01:24:22,470 --> 01:24:20,320
above the the temperature that water

2345
01:24:25,430 --> 01:24:22,480
will boil they can grow in acid

2346
01:24:28,070 --> 01:24:25,440
environments and base environments very

2347
01:24:30,870 --> 01:24:28,080
dry environments it's really remarkable

2348
01:24:34,629 --> 01:24:30,880
with and without oxygen where they can

2349
01:24:37,189 --> 01:24:34,639
grow and and thrive and so astrobiology

2350
01:24:39,350 --> 01:24:37,199
looks at what defines those limits so

2351
01:24:41,750 --> 01:24:39,360
that we can actually define what an uh

2352
01:24:43,110 --> 01:24:41,760
how an environment could support life

2353
01:24:44,709 --> 01:24:43,120
and what would make it habitable we've

2354
01:24:45,830 --> 01:24:44,719
been talking a lot about habitability

2355
01:24:48,790 --> 01:24:45,840
here

2356
01:24:52,709 --> 01:24:48,800
now the field of study has really been

2357
01:24:54,470 --> 01:24:52,719
informing nasa's program to search for

2358
01:24:56,790 --> 01:24:54,480
signs of life

2359
01:24:59,270 --> 01:24:56,800
both because it studies this information

2360
01:25:01,910 --> 01:24:59,280
about earth organisms and because it

2361
01:25:03,990 --> 01:25:01,920
spends a lot of time looking at

2362
01:25:06,310 --> 01:25:04,000
other alternative environments or the

2363
01:25:08,709 --> 01:25:06,320

environments of alternative bodies in

2364
01:25:11,030 --> 01:25:08,719
our solar system so that combination of

2365
01:25:13,669 --> 01:25:11,040
information allows us to answer some

2366
01:25:14,790 --> 01:25:13,679
fundamental questions of where did we

2367
01:25:17,270 --> 01:25:14,800
come from

2368
01:25:19,110 --> 01:25:17,280
on this planet and are we alone is there

2369
01:25:20,870 --> 01:25:19,120
life elsewhere so we're gonna have the

2370
01:25:22,470 --> 01:25:20,880
next slide

2371
01:25:25,110 --> 01:25:22,480
so some of the fundamental things that

2372
01:25:27,590 --> 01:25:25,120
we know about life life as we know it is

2373
01:25:30,070 --> 01:25:27,600
number one it needs water and that has

2374
01:25:31,830 --> 01:25:30,080
certainly been the mantra for nasa's a

2375
01:25:34,629 --> 01:25:31,840
lot of nasa's and other agencies

2376
01:25:37,110 --> 01:25:34,639
explorations of the solar system looking

2377
01:25:38,790 --> 01:25:37,120
for that water and we've discovered not

2378
01:25:40,790 --> 01:25:38,800
only on mars is there quite a bit of

2379
01:25:43,189 --> 01:25:40,800
water nearly everywhere we look it seems

2380
01:25:45,189 --> 01:25:43,199
these days but also that that water is

2381
01:25:47,669 --> 01:25:45,199
very common throughout the the solar

2382
01:25:49,750 --> 01:25:47,679
system and beyond we find ices

2383
01:25:52,470 --> 01:25:49,760
many places

2384
01:25:54,470 --> 01:25:52,480
in addition to that um we know that all

2385
01:25:57,030 --> 01:25:54,480
life on earth is made up of carbon

2386
01:25:59,430 --> 01:25:57,040
hydrogen nitrogen oxygen phosphorus and

2387
01:26:01,030 --> 01:25:59,440
sulfur these are elements that make up

2388
01:26:03,590 --> 01:26:01,040

all the components that go into the

2389
01:26:05,910 --> 01:26:03,600
molecules or the building blocks of life

2390
01:26:07,669 --> 01:26:05,920
and we also find those

2391
01:26:09,830 --> 01:26:07,679
those elements as well as some of those

2392
01:26:12,950 --> 01:26:09,840
very building blocks distributed

2393
01:26:15,669 --> 01:26:12,960
throughout the solar system and beyond

2394
01:26:16,709 --> 01:26:15,679
in addition life needs to build the cell

2395
01:26:17,510 --> 01:26:16,719
it needs

2396
01:26:19,590 --> 01:26:17,520
to

2397
01:26:21,510 --> 01:26:19,600
define itself

2398
01:26:23,990 --> 01:26:21,520
and the picture on the upper right on on

2399
01:26:25,270 --> 01:26:24,000
my figure there is actually a fossil

2400
01:26:26,149 --> 01:26:25,280
cell

2401
01:26:27,990 --> 01:26:26,159
and so

2402
01:26:29,669 --> 01:26:28,000
um we know that cells need to define

2403
01:26:31,830 --> 01:26:29,679
again itself

2404
01:26:34,629 --> 01:26:31,840
itself from its environment in order to

2405
01:26:36,470 --> 01:26:34,639
do the business to to grow reproduce and

2406
01:26:37,990 --> 01:26:36,480
and do its metabolism

2407
01:26:39,990 --> 01:26:38,000
in addition in the lower left there's a

2408
01:26:42,149 --> 01:26:40,000
representation of cells all life on

2409
01:26:44,629 --> 01:26:42,159
earth needs energy and that energy can

2410
01:26:47,910 --> 01:26:44,639
come from a variety of sources it often

2411
01:26:50,870 --> 01:26:47,920
leads a leaves a a signature behind

2412
01:26:53,669 --> 01:26:50,880
that's based on its ability to exploit

2413
01:26:55,189 --> 01:26:53,679

gradients in chemistry gradients in

2414
01:26:56,629 --> 01:26:55,199
energy itself

2415
01:26:58,550 --> 01:26:56,639
and that's something that's critical a

2416
01:27:00,550 --> 01:26:58,560
critical component of all life as we

2417
01:27:02,790 --> 01:27:00,560
know it and then the final thing i'll

2418
01:27:05,669 --> 01:27:02,800
just mention is that we've come to

2419
01:27:09,110 --> 01:27:05,679
discover or firmly believe that all life

2420
01:27:11,750 --> 01:27:09,120
on earth requires a two-component system

2421
01:27:13,510 --> 01:27:11,760
that involves nucleic acids like dna and

2422
01:27:16,229 --> 01:27:13,520
rna that can

2423
01:27:18,070 --> 01:27:16,239
store the basic blueprint for life

2424
01:27:19,830 --> 01:27:18,080
that's all the information a cell needs

2425
01:27:22,149 --> 01:27:19,840
to do all of its business

2426
01:27:24,550 --> 01:27:22,159
and that there's a mechanism to convert

2427
01:27:26,229 --> 01:27:24,560
that information well to reproduce it

2428
01:27:28,390 --> 01:27:26,239
convert that information into things

2429
01:27:31,110 --> 01:27:28,400
like proteins that actually carry out

2430
01:27:33,350 --> 01:27:31,120
all of that activity that it needs to do

2431
01:27:34,629 --> 01:27:33,360
to maintain itself and to grow and

2432
01:27:36,790 --> 01:27:34,639
thrive

2433
01:27:39,669 --> 01:27:36,800
and that that these particular molecules

2434
01:27:42,790 --> 01:27:39,679
or this system as a whole is able to

2435
01:27:45,669 --> 01:27:42,800
respond to darwinian evolution so that

2436
01:27:47,910 --> 01:27:45,679
allows uh on this planet has allowed the

2437
01:27:50,149 --> 01:27:47,920
great diversification that we see of

2438
01:27:52,870 --> 01:27:50,159

life on this planet from things as small

2439
01:27:55,270 --> 01:27:52,880
as single cell bacteria

2440
01:27:57,510 --> 01:27:55,280
all the way up to ourselves and and a

2441
01:28:00,390 --> 01:27:57,520
wide variety of eukaryotes which are the

2442
01:28:01,830 --> 01:28:00,400
multicellular animals or those

2443
01:28:02,950 --> 01:28:01,840
and plants and

2444
01:28:04,870 --> 01:28:02,960
that i'm sure all of you have learned

2445
01:28:06,709 --> 01:28:04,880
about in school

2446
01:28:09,030 --> 01:28:06,719
so one of the challenges in looking for

2447
01:28:10,709 --> 01:28:09,040
life elsewhere is first of all i've just

2448
01:28:13,510 --> 01:28:10,719
talked to you about what we know about

2449
01:28:15,750 --> 01:28:13,520
life here and and as many people have

2450
01:28:17,830 --> 01:28:15,760
said our search is based on what we know

2451
01:28:20,310 --> 01:28:17,840
because that's the information that we

2452
01:28:21,669 --> 01:28:20,320
have our laboratory has been the earth

2453
01:28:23,750 --> 01:28:21,679
that's what we know

2454
01:28:25,110 --> 01:28:23,760
how do you expand what we know about

2455
01:28:26,870 --> 01:28:25,120
life here on earth to be more

2456
01:28:29,030 --> 01:28:26,880
generalized so that we can think about

2457
01:28:32,149 --> 01:28:29,040
life is we don't know it and so i'm just

2458
01:28:33,990 --> 01:28:32,159
going to do a little ad here for a

2459
01:28:35,590 --> 01:28:34,000
study that was done by the

2460
01:28:37,270 --> 01:28:35,600
national academy of sciences and it's

2461
01:28:39,750 --> 01:28:37,280
called the limits of organic life and

2462
01:28:41,350 --> 01:28:39,760
planetary systems it's been nicknamed

2463
01:28:44,149 --> 01:28:41,360

the weird life book

2464
01:28:46,229 --> 01:28:44,159
and basically we had a number of

2465
01:28:48,310 --> 01:28:46,239
permanent scientists get together and

2466
01:28:50,709 --> 01:28:48,320
discuss what are other possibilities can

2467
01:28:53,990 --> 01:28:50,719
we use something else besides water can

2468
01:28:58,310 --> 01:28:54,000
things grow in other solvents

2469
01:29:02,629 --> 01:28:58,320
we saw that there's lakes of methane

2470
01:29:04,470 --> 01:29:02,639
uh on titan which is uh uh one of the

2471
01:29:07,030 --> 01:29:04,480
excuse me uh one of the bodies that

2472
01:29:10,229 --> 01:29:07,040
we're interested in could life grow in

2473
01:29:11,669 --> 01:29:10,239
in a solvent like a liquid methane

2474
01:29:13,590 --> 01:29:11,679
they also considered other sorts of

2475
01:29:15,189 --> 01:29:13,600
chemistry the replacement of those basic

2476
01:29:18,149 --> 01:29:15,199
building blocks that that i mentioned

2477
01:29:19,990 --> 01:29:18,159
earlier other types of energy and so

2478
01:29:21,830 --> 01:29:20,000
scientists are really trying to expand

2479
01:29:24,550 --> 01:29:21,840
it to make the search for life in other

2480
01:29:26,229 --> 01:29:24,560
places as broad as possible the worst

2481
01:29:29,189 --> 01:29:26,239
thing in the world would be for us to go

2482
01:29:31,030 --> 01:29:29,199
somewhere have such a narrow

2483
01:29:32,470 --> 01:29:31,040
definition of what we were looking for

2484
01:29:34,629 --> 01:29:32,480
and instruments that would measure that

2485
01:29:36,790 --> 01:29:34,639
that we could completely miss

2486
01:29:38,149 --> 01:29:36,800
something that would would later or if

2487
01:29:39,590 --> 01:29:38,159
it were here and we found it we might

2488
01:29:42,229 --> 01:29:39,600

consider to be life so it's very

2489
01:29:43,990 --> 01:29:42,239
important that we keep our search broad

2490
01:29:45,830 --> 01:29:44,000
all of these uh things that i've

2491
01:29:48,310 --> 01:29:45,840
mentioned in terms of life as we know it

2492
01:29:50,790 --> 01:29:48,320
we have been considering how do we then

2493
01:29:52,790 --> 01:29:50,800
look for it if it's not present now but

2494
01:29:54,229 --> 01:29:52,800
might be in the past and how are we

2495
01:29:56,870 --> 01:29:54,239
going to distinguish it from other

2496
01:29:59,030 --> 01:29:56,880
sources that might have formed those

2497
01:30:01,270 --> 01:29:59,040
those features we tend to call some of

2498
01:30:04,310 --> 01:30:01,280
these things biosignatures a fossil is a

2499
01:30:05,990 --> 01:30:04,320
biosignature it's a remnant of an

2500
01:30:08,229 --> 01:30:06,000
evidence of life having been there and

2501
01:30:10,390 --> 01:30:08,239
and my uh colleague jen is going to talk

2502
01:30:12,470 --> 01:30:10,400
a little bit more about that

2503
01:30:13,750 --> 01:30:12,480
um and and that's one of the challenges

2504
01:30:15,189 --> 01:30:13,760
because there are many things that might

2505
01:30:17,430 --> 01:30:15,199
look like a fossil there are many kind

2506
01:30:19,030 --> 01:30:17,440
of organic com compounds that are found

2507
01:30:20,550 --> 01:30:19,040
in cells but that are also made other

2508
01:30:22,709 --> 01:30:20,560
ways and so this is going to be part of

2509
01:30:24,149 --> 01:30:22,719
the challenge as well so you may hear a

2510
01:30:25,430 --> 01:30:24,159
little bit more about biosignatures i

2511
01:30:27,430 --> 01:30:25,440
thought it introduced it to you so you

2512
01:30:29,669 --> 01:30:27,440
can think about that think about how we

2513
01:30:31,189 --> 01:30:29,679

might abstract this for the search

2514
01:30:33,110 --> 01:30:31,199
i think in addition to what we know

2515
01:30:34,870 --> 01:30:33,120
about life on earth too and this concept

2516
01:30:36,629 --> 01:30:34,880
of habitability

2517
01:30:38,470 --> 01:30:36,639
i'm going to turn this over very quickly

2518
01:30:40,149 --> 01:30:38,480
to to john who's going to talk to you

2519
01:30:42,470 --> 01:30:40,159
about how we consider looking for

2520
01:30:44,229 --> 01:30:42,480
targets what do we need to know about

2521
01:30:45,990 --> 01:30:44,239
the places that we're going that match

2522
01:30:47,350 --> 01:30:46,000
to what we understand about habitability

2523
01:30:49,270 --> 01:30:47,360
in order to make it something that we

2524
01:30:51,110 --> 01:30:49,280
might select or something we can predict

2525
01:30:52,070 --> 01:30:51,120
would provide useful information and

2526
01:30:53,990 --> 01:30:52,080
with that

2527
01:30:55,430 --> 01:30:54,000
it's your turn okay thank you very much

2528
01:30:56,390 --> 01:30:55,440
mary too much

2529
01:30:57,910 --> 01:30:56,400
i'm going to talk to you a little bit

2530
01:31:00,070 --> 01:30:57,920
about one of the first steps along the

2531
01:31:02,229 --> 01:31:00,080
way towards seeking signs of life on

2532
01:31:04,149 --> 01:31:02,239
mars and that is where do you go to

2533
01:31:06,149 --> 01:31:04,159
understand the range and potential

2534
01:31:07,990 --> 01:31:06,159
habitability of the planet and if i

2535
01:31:09,110 --> 01:31:08,000
could get the first graphic up

2536
01:31:11,270 --> 01:31:09,120
i'll tell you a little bit about how

2537
01:31:12,629 --> 01:31:11,280
we're going about doing that

2538
01:31:14,870 --> 01:31:12,639

as you've heard from some of the

2539
01:31:16,629 --> 01:31:14,880
speakers here earlier there's been

2540
01:31:18,950 --> 01:31:16,639
discoveries of a lot of water and a lot

2541
01:31:20,550 --> 01:31:18,960
of different inventories on mars

2542
01:31:22,790 --> 01:31:20,560
and we've also understood that it's it's

2543
01:31:24,310 --> 01:31:22,800
a complex world i mean there's a lot of

2544
01:31:26,709 --> 01:31:24,320
territory to cover

2545
01:31:28,470 --> 01:31:26,719
so where do you put down this curiosity

2546
01:31:29,430 --> 01:31:28,480
rover to get the biggest bang for your

2547
01:31:31,430 --> 01:31:29,440
buck

2548
01:31:33,510 --> 01:31:31,440
well this graphic basically shows you a

2549
01:31:35,910 --> 01:31:33,520
map of mars but it's been changed from

2550
01:31:36,870 --> 01:31:35,920
what you saw from what jack mustard

2551
01:31:38,950 --> 01:31:36,880
showed you

2552
01:31:41,510 --> 01:31:38,960
what you see here is a map where

2553
01:31:43,750 --> 01:31:41,520
everything that is above an elevation of

2554
01:31:45,510 --> 01:31:43,760
zero kilometers which you can sort of

2555
01:31:48,149 --> 01:31:45,520
think of in this regard although it's

2556
01:31:50,870 --> 01:31:48,159
not a sort of sea level a datum if you

2557
01:31:53,669 --> 01:31:50,880
will that we can't land above because if

2558
01:31:55,990 --> 01:31:53,679
we do we don't have all of the time and

2559
01:31:58,149 --> 01:31:56,000
space literally that we need to complete

2560
01:32:00,709 --> 01:31:58,159
the steps that doug mcquitchen described

2561
01:32:02,390 --> 01:32:00,719
in terms of landing the curiosity rover

2562
01:32:04,709 --> 01:32:02,400
in addition there's places that are too

2563
01:32:06,629 --> 01:32:04,719

far north and too far south and that's

2564
01:32:08,629 --> 01:32:06,639
masked out by the white areas that you

2565
01:32:11,590 --> 01:32:08,639
see in this graphic so we're sort of

2566
01:32:14,229 --> 01:32:11,600
limited here as you see to a band but a

2567
01:32:16,550 --> 01:32:14,239
very wide band between 30 north and 30

2568
01:32:18,629 --> 01:32:16,560
south on the planet of the surface and

2569
01:32:21,430 --> 01:32:18,639
fortunately that covers an incredible

2570
01:32:23,430 --> 01:32:21,440
diversity of potential landing sites

2571
01:32:25,430 --> 01:32:23,440
how do we do this well i wouldn't

2572
01:32:28,149 --> 01:32:25,440
pretend for a second to know enough

2573
01:32:30,070 --> 01:32:28,159
about our planet much less mars to be

2574
01:32:32,310 --> 01:32:30,080
able to say this is the place you ought

2575
01:32:35,189 --> 01:32:32,320
to go the way you do that is you bring

2576
01:32:36,310 --> 01:32:35,199
in a variety of expertise you bring in

2577
01:32:38,070 --> 01:32:36,320
the people that are involved in the

2578
01:32:39,750 --> 01:32:38,080
mission you bring in people in the

2579
01:32:41,830 --> 01:32:39,760
scientific community that are involved

2580
01:32:43,270 --> 01:32:41,840
in the analysis of the data that's been

2581
01:32:45,510 --> 01:32:43,280
collected by all the missions that have

2582
01:32:47,910 --> 01:32:45,520
been described here today and what we've

2583
01:32:50,149 --> 01:32:47,920
done through that process is identify a

2584
01:32:52,390 --> 01:32:50,159
whole range of candidate landing sites

2585
01:32:54,390 --> 01:32:52,400
those are shown by these red dots the

2586
01:32:56,229 --> 01:32:54,400
red dots that you see in this graphic

2587
01:32:58,550 --> 01:32:56,239
and they range from the floor of alice

2588
01:33:00,790 --> 01:32:58,560

marineris this huge canyon system that

2589
01:33:02,629 --> 01:33:00,800
john muster described to areas that are

2590
01:33:04,790 --> 01:33:02,639
very much right next door to where the

2591
01:33:07,030 --> 01:33:04,800
opportunity rover that steve squires

2592
01:33:09,030 --> 01:33:07,040
talked about is today

2593
01:33:10,790 --> 01:33:09,040
the places that we've converged upon for

2594
01:33:12,310 --> 01:33:10,800
the final four if you will we haven't

2595
01:33:14,950 --> 01:33:12,320
picked the final landing site yet but

2596
01:33:16,470 --> 01:33:14,960
will later this year are shown in blue

2597
01:33:18,149 --> 01:33:16,480
and what i'd like to do for just a

2598
01:33:20,310 --> 01:33:18,159
second is give you an outline of how

2599
01:33:22,470 --> 01:33:20,320
those four sites are perceived to fit

2600
01:33:24,550 --> 01:33:22,480
into the template that mary has outlined

2601
01:33:26,390 --> 01:33:24,560
for you about habitability and the goals

2602
01:33:28,629 --> 01:33:26,400
of the curiosity rover so could i have

2603
01:33:30,229 --> 01:33:28,639
the next graphic please

2604
01:33:32,950 --> 01:33:30,239
so what you see in this graphic on the

2605
01:33:34,870 --> 01:33:32,960
left hand side is a zoom in view of

2606
01:33:36,229 --> 01:33:34,880
places on mars corresponding to those

2607
01:33:37,510 --> 01:33:36,239
four blue circles you saw on the

2608
01:33:39,189 --> 01:33:37,520
previous slide

2609
01:33:41,910 --> 01:33:39,199
and what you see in the colors here is

2610
01:33:43,510 --> 01:33:41,920
the elevation the topography blue is low

2611
01:33:46,070 --> 01:33:43,520
red is high green is somewhere in the

2612
01:33:48,950 --> 01:33:46,080
middle and so the landing sites shown in

2613
01:33:52,149 --> 01:33:48,960

those sort of oval or lip shaped white

2614
01:33:54,229 --> 01:33:52,159
lines are basically within impact

2615
01:33:56,149 --> 01:33:54,239
craters in all but one example

2616
01:33:59,030 --> 01:33:56,159
the four final candidate sites are from

2617
01:34:00,390 --> 01:33:59,040
top to bottom ebersvaldi crater

2618
01:34:03,830 --> 01:34:00,400
gale crater

2619
01:34:05,350 --> 01:34:03,840
holden crater and marth

2620
01:34:06,950 --> 01:34:05,360
what we're looking at in these various

2621
01:34:08,550 --> 01:34:06,960
locations starting with ebersvaldi

2622
01:34:10,790 --> 01:34:08,560
crater on the top

2623
01:34:13,830 --> 01:34:10,800
are examples of places where

2624
01:34:16,390 --> 01:34:13,840
habitability can be evaluated and to do

2625
01:34:18,629 --> 01:34:16,400
that a record of past conditions is

2626
01:34:20,870 --> 01:34:18,639
likely to be preserved

2627
01:34:23,189 --> 01:34:20,880
so with ebersvaldi crater shown in the

2628
01:34:24,390 --> 01:34:23,199
yellow box to the left and then blown up

2629
01:34:26,950 --> 01:34:24,400
in the middle

2630
01:34:28,950 --> 01:34:26,960
is an area where it appears that a river

2631
01:34:31,750 --> 01:34:28,960
flowed into this crater creating a lake

2632
01:34:33,990 --> 01:34:31,760
and depositing sediments in a delta much

2633
01:34:35,750 --> 01:34:34,000
like you would see in a larger version

2634
01:34:38,229 --> 01:34:35,760
in the mississippi river delta here on

2635
01:34:40,790 --> 01:34:38,239
earth those sediments preserve and

2636
01:34:43,430 --> 01:34:40,800
record the depositional conditions and

2637
01:34:45,750 --> 01:34:43,440
processes and if curiosity can go there

2638
01:34:48,229 --> 01:34:45,760

and evaluate those we can say something

2639
01:34:50,870 --> 01:34:48,239
perhaps about habitability on mars

2640
01:34:52,470 --> 01:34:50,880
now we would land away from this delta

2641
01:34:54,550 --> 01:34:52,480
in an area further out on the crater

2642
01:34:56,550 --> 01:34:54,560
floor which is shown to the top right

2643
01:34:58,629 --> 01:34:56,560
where we see evidence of past rivers

2644
01:35:00,310 --> 01:34:58,639
that have drained down into this crater

2645
01:35:01,350 --> 01:35:00,320
before it filled with water with the

2646
01:35:03,030 --> 01:35:01,360
delta

2647
01:35:04,790 --> 01:35:03,040
you heard john mustard talk a little bit

2648
01:35:07,510 --> 01:35:04,800
about gale crater the reason for going

2649
01:35:10,149 --> 01:35:07,520
here is this incredibly thick sequence

2650
01:35:12,390 --> 01:35:10,159
of materials five kilometers thick that

2651
01:35:13,510 --> 01:35:12,400
record that transition from earlier sort

2652
01:35:15,109 --> 01:35:13,520
of neutral

2653
01:35:17,430 --> 01:35:15,119
conditions where clays were forming to

2654
01:35:19,350 --> 01:35:17,440
more acidic dry conditions

2655
01:35:21,270 --> 01:35:19,360
at holden crater which is the third one

2656
01:35:24,229 --> 01:35:21,280
down from the left it's a very large

2657
01:35:26,390 --> 01:35:24,239
crater about 150 kilometers in diameter

2658
01:35:28,470 --> 01:35:26,400
and what we've got there is a sequence

2659
01:35:30,310 --> 01:35:28,480
of alluvial fans much like you might see

2660
01:35:32,470 --> 01:35:30,320
along the sides of death valley or other

2661
01:35:34,390 --> 01:35:32,480
valleys out in the southwestern united

2662
01:35:36,870 --> 01:35:34,400
states and we would land on those as

2663
01:35:38,709 --> 01:35:36,880

shown to the third one down on the right

2664
01:35:40,790 --> 01:35:38,719
however the the ultimate goal of our

2665
01:35:43,030 --> 01:35:40,800
exploration here is shown in the third

2666
01:35:44,870 --> 01:35:43,040
down in the middle and that is these

2667
01:35:46,950 --> 01:35:44,880
finely layered sediments that we see on

2668
01:35:49,510 --> 01:35:46,960
the floor of holden that probably were

2669
01:35:52,470 --> 01:35:49,520
deposited in a lake a standing body of

2670
01:35:55,189 --> 01:35:52,480
water or in a very distal portion of

2671
01:35:57,030 --> 01:35:55,199
those alluvial fans and those fans much

2672
01:35:59,030 --> 01:35:57,040
like the delta and ebersvaldi would

2673
01:36:00,870 --> 01:35:59,040
record this sequence this history of

2674
01:36:02,870 --> 01:36:00,880
depositional activity and the

2675
01:36:04,629 --> 01:36:02,880
habitability that may have occurred

2676
01:36:07,030 --> 01:36:04,639
there and then finally marth vallas

2677
01:36:09,270 --> 01:36:07,040
shown on the bottom left is an area

2678
01:36:11,030 --> 01:36:09,280
that's up north of all of the other

2679
01:36:12,870 --> 01:36:11,040
three that i've described and it

2680
01:36:14,629 --> 01:36:12,880
straddles a very ancient sequence of

2681
01:36:16,709 --> 01:36:14,639
stratigraphy layers on mars that were

2682
01:36:18,870 --> 01:36:16,719
deposited in this very early history

2683
01:36:20,790 --> 01:36:18,880
that john muster described clays are

2684
01:36:22,390 --> 01:36:20,800
widespread here and there's a very

2685
01:36:24,709 --> 01:36:22,400
definite sequence in which they're

2686
01:36:26,229 --> 01:36:24,719
layered and those layers will tell us

2687
01:36:28,310 --> 01:36:26,239
something about the conditions

2688
01:36:30,470 --> 01:36:28,320

responsible for their formation and

2689
01:36:32,629 --> 01:36:30,480
again in turn about the habitability

2690
01:36:33,990 --> 01:36:32,639
that may a potential that those layers

2691
01:36:36,149 --> 01:36:34,000
may have recorded

2692
01:36:37,669 --> 01:36:36,159
we would basically land on those layers

2693
01:36:39,750 --> 01:36:37,679
and so what you see in the bottom middle

2694
01:36:41,590 --> 01:36:39,760
and bottom right are examples of how

2695
01:36:43,830 --> 01:36:41,600
that stratigraphy varies from location

2696
01:36:45,910 --> 01:36:43,840
to location by exploring those

2697
01:36:47,510 --> 01:36:45,920
differences and by understanding them we

2698
01:36:49,270 --> 01:36:47,520
can tell something about how conditions

2699
01:36:50,950 --> 01:36:49,280
might have changed over time

2700
01:36:52,550 --> 01:36:50,960
so that's sort of a thumbnail sketch if

2701
01:36:54,629 --> 01:36:52,560
we can go to the last

2702
01:36:56,870 --> 01:36:54,639
graphic here of where we would be going

2703
01:36:59,910 --> 01:36:56,880
with curiosity but you heard doug and

2704
01:37:01,669 --> 01:36:59,920
marcelo describe future missions and

2705
01:37:03,830 --> 01:37:01,679
we're using our orbital assets that we

2706
01:37:05,830 --> 01:37:03,840
have now to look ahead there's a variety

2707
01:37:07,350 --> 01:37:05,840
of places on mars that are being imaged

2708
01:37:10,310 --> 01:37:07,360
as we speak

2709
01:37:11,750 --> 01:37:10,320
to be considered as future landing sites

2710
01:37:13,350 --> 01:37:11,760
there's interpretation of what the

2711
01:37:15,430 --> 01:37:13,360
features are that tell us something

2712
01:37:17,910 --> 01:37:15,440
about their merits for future sample

2713
01:37:19,750 --> 01:37:17,920

return for example those could include

2714
01:37:22,790 --> 01:37:19,760
possible spring deposits shown in the

2715
01:37:24,709 --> 01:37:22,800
northern plains by the box on the left

2716
01:37:26,950 --> 01:37:24,719
putative chloride deposits which may

2717
01:37:29,189 --> 01:37:26,960
represent this sort of drying up lakes

2718
01:37:31,590 --> 01:37:29,199
or drying up bodies of water similar to

2719
01:37:33,430 --> 01:37:31,600
what jack described earlier or finally

2720
01:37:35,350 --> 01:37:33,440
in transitions over here in an area

2721
01:37:37,669 --> 01:37:35,360
known as northeast serdis we see an

2722
01:37:40,229 --> 01:37:37,679
incredible diversity of mineralogical

2723
01:37:42,149 --> 01:37:40,239
mineralogy that says something about how

2724
01:37:44,390 --> 01:37:42,159
water has interacted with the rocks over

2725
01:37:46,790 --> 01:37:44,400
time and when it occurred was across

2726
01:37:48,709 --> 01:37:46,800
this boundary from wet and more neutral

2727
01:37:50,070 --> 01:37:48,719
to drier more acidic

2728
01:37:51,430 --> 01:37:50,080
and with that i'll turn it over to jen

2729
01:37:53,830 --> 01:37:51,440
eigenbroad to tell us something a little

2730
01:37:58,229 --> 01:37:53,840
bit about the curiosity mission okay

2731
01:38:02,310 --> 01:38:00,470
well the mars science laboratory the

2732
01:38:04,709 --> 01:38:02,320
rover's curiosity it's called a

2733
01:38:06,790 --> 01:38:04,719
laboratory for a reason it has a full

2734
01:38:08,950 --> 01:38:06,800
set of instruments on board that can

2735
01:38:11,109 --> 01:38:08,960
tell us all about the rocks that we're

2736
01:38:12,470 --> 01:38:11,119
going to encounter with that rover now

2737
01:38:13,910 --> 01:38:12,480
one if you pull up the first slide

2738
01:38:16,550 --> 01:38:13,920

please

2739
01:38:18,149 --> 01:38:16,560
one of the key questions that we are

2740
01:38:20,390 --> 01:38:18,159
looking for one of the key questions

2741
01:38:22,629 --> 01:38:20,400
we're asking is where are the organic

2742
01:38:25,189 --> 01:38:22,639
molecules now why would we search for

2743
01:38:27,030 --> 01:38:25,199
organic molecules on mars we're we're

2744
01:38:29,109 --> 01:38:27,040
seeking signs of life

2745
01:38:30,709 --> 01:38:29,119
on a planet that's very close to home

2746
01:38:33,270 --> 01:38:30,719
and that at one point

2747
01:38:34,950 --> 01:38:33,280
during the evolution of the solar system

2748
01:38:37,430 --> 01:38:34,960
we think that it might have been

2749
01:38:39,510 --> 01:38:37,440
habitable in terms of being close enough

2750
01:38:42,390 --> 01:38:39,520
to the sun to receive enough energy to

2751
01:38:44,229 --> 01:38:42,400
be warm enough for life to exist there

2752
01:38:45,750 --> 01:38:44,239
okay the atmosphere was very different

2753
01:38:47,350 --> 01:38:45,760
and there was probably water on mars

2754
01:38:49,189 --> 01:38:47,360
we've already covered that a lot with

2755
01:38:51,669 --> 01:38:49,199
some of the other presentations

2756
01:38:53,910 --> 01:38:51,679
now organic molecules can be both

2757
01:38:56,070 --> 01:38:53,920
nutrients for organisms but they can

2758
01:38:58,470 --> 01:38:56,080
also be parts of the organisms they

2759
01:39:01,030 --> 01:38:58,480
might be waste products of organisms

2760
01:39:02,870 --> 01:39:01,040
in either way organic molecules are

2761
01:39:04,629 --> 01:39:02,880
fundamental part of understanding

2762
01:39:06,790 --> 01:39:04,639
whether or not the

2763
01:39:08,790 --> 01:39:06,800

environments that we look at in mars

2764
01:39:11,350 --> 01:39:08,800
might have been habitable meaning they

2765
01:39:13,189 --> 01:39:11,360
either supported life or

2766
01:39:14,390 --> 01:39:13,199
they could have supported life

2767
01:39:16,550 --> 01:39:14,400
next

2768
01:39:18,229 --> 01:39:16,560
slide please

2769
01:39:19,669 --> 01:39:18,239
now on earth

2770
01:39:21,669 --> 01:39:19,679
we find

2771
01:39:23,750 --> 01:39:21,679
organic molecules throughout the

2772
01:39:25,830 --> 01:39:23,760
geological rock record

2773
01:39:27,990 --> 01:39:25,840
here's an example of a rock that is

2774
01:39:29,830 --> 01:39:28,000
billions of years old

2775
01:39:31,430 --> 01:39:29,840
and in this we find evidence of

2776
01:39:34,070 --> 01:39:31,440
microorganisms

2777
01:39:35,750 --> 01:39:34,080
and we find that evidence in terms of

2778
01:39:38,790 --> 01:39:35,760
both the organic molecules that are

2779
01:39:41,350 --> 01:39:38,800
present but also in terms of the

2780
01:39:43,510 --> 01:39:41,360
package of chemistry and features that

2781
01:39:45,910 --> 01:39:43,520
we see in the rocks some of those

2782
01:39:47,830 --> 01:39:45,920
features might even be things that look

2783
01:39:49,430 --> 01:39:47,840
like microorganisms things that you

2784
01:39:51,109 --> 01:39:49,440
might find under a

2785
01:39:53,189 --> 01:39:51,119
microscope

2786
01:39:55,750 --> 01:39:53,199
next slide please

2787
01:39:58,390 --> 01:39:55,760
here's an example of how we would find

2788
01:40:00,229 --> 01:39:58,400

such a molecule take an example of a

2789
01:40:01,189 --> 01:40:00,239
polar bear we're all familiar with polar

2790
01:40:02,950 --> 01:40:01,199
bears

2791
01:40:04,950 --> 01:40:02,960
they live in the arctic you don't want

2792
01:40:07,109 --> 01:40:04,960
to encounter one at close range

2793
01:40:09,510 --> 01:40:07,119
when it dies it's going to leave behind

2794
01:40:11,750 --> 01:40:09,520
a fossil skeleton and we might find that

2795
01:40:13,910 --> 01:40:11,760
fossil skeleton in the rock record

2796
01:40:15,910 --> 01:40:13,920
well in a similar way microorganisms

2797
01:40:18,470 --> 01:40:15,920
have all sorts of organic molecules that

2798
01:40:20,229 --> 01:40:18,480
make up their cells and some of those in

2799
01:40:22,229 --> 01:40:20,239
particular would be lipids that make up

2800
01:40:23,510 --> 01:40:22,239
the membrane the membrane is the outer

2801
01:40:26,629 --> 01:40:23,520
portion

2802
01:40:29,030 --> 01:40:26,639
of of the cell or it makes up the the

2803
01:40:31,189 --> 01:40:29,040
walls of the nucleus and other

2804
01:40:34,629 --> 01:40:31,199
organelles inside the cell

2805
01:40:36,310 --> 01:40:34,639
those lipids are complex molecules they

2806
01:40:38,470 --> 01:40:36,320
have carbon carbon-carbon bonds and in

2807
01:40:41,750 --> 01:40:38,480
this image that i'm showing you every

2808
01:40:44,390 --> 01:40:41,760
line represents a carbon-carbon bond

2809
01:40:45,910 --> 01:40:44,400
okay so this is a big molecule and it

2810
01:40:47,830 --> 01:40:45,920
has all sorts of

2811
01:40:49,590 --> 01:40:47,840
oxygens hanging off of it might have

2812
01:40:52,550 --> 01:40:49,600
phosphorus it might have sulfur

2813
01:40:54,870 --> 01:40:52,560

nitrogens it can be kind of complex

2814
01:40:57,510 --> 01:40:54,880
well that molecule will get put into the

2815
01:41:00,070 --> 01:40:57,520
rock record when the microorganism dies

2816
01:41:02,310 --> 01:41:00,080
and under certain conditions

2817
01:41:03,590 --> 01:41:02,320
that carbon-carbon structure can get

2818
01:41:05,990 --> 01:41:03,600
preserved

2819
01:41:08,629 --> 01:41:06,000
even for billions of years

2820
01:41:11,990 --> 01:41:08,639
and we can uncover that type of molecule

2821
01:41:13,750 --> 01:41:12,000
and we call that a molecular fossil

2822
01:41:16,149 --> 01:41:13,760
so when we go to mars

2823
01:41:18,790 --> 01:41:16,159
with curiosity we're taking with us an

2824
01:41:21,350 --> 01:41:18,800
instrument that can actually look for

2825
01:41:24,070 --> 01:41:21,360
organic molecules it is capable of

2826
01:41:25,910 --> 01:41:24,080
detecting a fossil

2827
01:41:28,390 --> 01:41:25,920
molecular fossil that we might

2828
01:41:30,229 --> 01:41:28,400
anticipate from an organism as small as

2829
01:41:31,830 --> 01:41:30,239
a microorganism

2830
01:41:33,750 --> 01:41:31,840
and we're going to look for those to the

2831
01:41:34,950 --> 01:41:33,760
next slide

2832
01:41:37,669 --> 01:41:34,960
and we're going to look for those in the

2833
01:41:40,070 --> 01:41:37,679
ancient rock record now this is an image

2834
01:41:42,070 --> 01:41:40,080
it's an artist's rendition of the

2835
01:41:44,470 --> 01:41:42,080
mourinho area

2836
01:41:46,709 --> 01:41:44,480
and it shows water in

2837
01:41:48,550 --> 01:41:46,719
the crater there this was uh this is

2838
01:41:50,310 --> 01:41:48,560

taken from a website called space for

2839
01:41:53,109 --> 01:41:50,320
case so you can find it on the web at

2840
01:41:55,350 --> 01:41:53,119
www.spaceforcase.com

2841
01:41:58,470 --> 01:41:55,360
and uh what's interesting about it is it

2842
01:42:00,629 --> 01:41:58,480
kind of presents this idea this creative

2843
01:42:01,750 --> 01:42:00,639
conception of what it might have been

2844
01:42:04,790 --> 01:42:01,760
like

2845
01:42:07,109 --> 01:42:04,800
years billions of years ago on mars

2846
01:42:09,750 --> 01:42:07,119
and these are the types of environments

2847
01:42:12,070 --> 01:42:09,760
here a crater filled with water places

2848
01:42:14,390 --> 01:42:12,080
where all the other elements of

2849
01:42:17,109 --> 01:42:14,400
habitability are essential source of

2850
01:42:19,430 --> 01:42:17,119
water possible sources of energy

2851
01:42:20,950 --> 01:42:19,440
maybe organic molecules

2852
01:42:23,910 --> 01:42:20,960
these are the things that we're looking

2853
01:42:24,790 --> 01:42:23,920
for this is what makes up a habitable

2854
01:42:27,750 --> 01:42:24,800
place

2855
01:42:30,070 --> 01:42:27,760
and we're looking for the rock record

2856
01:42:31,910 --> 01:42:30,080
that represents a

2857
01:42:33,750 --> 01:42:31,920
environment like this

2858
01:42:35,750 --> 01:42:33,760
these are the types of places that we

2859
01:42:37,990 --> 01:42:35,760
might actually succeed in finding

2860
01:42:39,270 --> 01:42:38,000
organic molecules and this is what john

2861
01:42:41,030 --> 01:42:39,280
was talking about with the different

2862
01:42:43,750 --> 01:42:41,040
landing sites all of them kind of

2863
01:42:45,189 --> 01:42:43,760

fulfilled these uh this niche

2864
01:42:47,910 --> 01:42:45,199
what we're hoping to do is find those

2865
01:42:50,229 --> 01:42:47,920
organic molecules next slide

2866
01:42:52,390 --> 01:42:50,239
and those organic molecules could tell

2867
01:42:54,390 --> 01:42:52,400
us a variety of things one is they can

2868
01:42:57,750 --> 01:42:54,400
tell us about different sources those

2869
01:42:59,830 --> 01:42:57,760
sources might be meteorite sources

2870
01:43:01,910 --> 01:42:59,840
they could be geological the actual

2871
01:43:05,350 --> 01:43:01,920
processes that happen by a planet can

2872
01:43:06,870 --> 01:43:05,360
produce organic molecules and perhaps

2873
01:43:09,750 --> 01:43:06,880
they're coming from life

2874
01:43:11,750 --> 01:43:09,760
we don't know yet so we have three

2875
01:43:13,510 --> 01:43:11,760
categories of sources

2876
01:43:15,669 --> 01:43:13,520
but then on top of that all those

2877
01:43:18,149 --> 01:43:15,679
organic molecules go through other types

2878
01:43:20,550 --> 01:43:18,159
of processes and sometimes they they

2879
01:43:22,390 --> 01:43:20,560
keep a record of those processes they

2880
01:43:23,990 --> 01:43:22,400
might tell you about surface processes

2881
01:43:26,470 --> 01:43:24,000
things that have happened since they

2882
01:43:27,830 --> 01:43:26,480
were originally formed we're going to

2883
01:43:30,870 --> 01:43:27,840
try and

2884
01:43:33,109 --> 01:43:30,880
un resolve what those molecules actually

2885
01:43:36,149 --> 01:43:33,119
say if we find them

2886
01:43:38,470 --> 01:43:36,159
this is an image here of the mars

2887
01:43:40,470 --> 01:43:38,480
science laboratory rover curiosity

2888
01:43:42,149 --> 01:43:40,480

and it's actually you can see the beam

2889
01:43:44,550 --> 01:43:42,159
of the laser beam pointing off of it

2890
01:43:45,590 --> 01:43:44,560
that's the chem cam instrument zapping a

2891
01:43:47,350 --> 01:43:45,600
rock

2892
01:43:49,590 --> 01:43:47,360
and what it's going to do is it's going

2893
01:43:52,470 --> 01:43:49,600
to look as a way it's a tool that we're

2894
01:43:54,149 --> 01:43:52,480
using to survey the types of

2895
01:43:55,990 --> 01:43:54,159
elements that are in those rocks we're

2896
01:43:57,350 --> 01:43:56,000
going to be looking for variations in

2897
01:43:58,629 --> 01:43:57,360
those elements

2898
01:44:00,390 --> 01:43:58,639
we're also going to be looking at

2899
01:44:02,070 --> 01:44:00,400
features of the rocks they can tell us

2900
01:44:03,590 --> 01:44:02,080
different things about the energy of the

2901
01:44:05,590 --> 01:44:03,600
environment that form the rocks in the

2902
01:44:07,910 --> 01:44:05,600
first place they can tell us all sorts

2903
01:44:09,590 --> 01:44:07,920
of things about what the chemistry of

2904
01:44:12,550 --> 01:44:09,600
that environment was like what to have

2905
01:44:14,550 --> 01:44:12,560
expected was it a lake was it a delta

2906
01:44:15,669 --> 01:44:14,560
was it a river channel we don't know but

2907
01:44:17,030 --> 01:44:15,679
we'll be able to figure those types of

2908
01:44:18,950 --> 01:44:17,040
things out

2909
01:44:21,669 --> 01:44:18,960
all of that information becomes the

2910
01:44:24,070 --> 01:44:21,679
context for understanding

2911
01:44:26,950 --> 01:44:24,080
the other features that we see which

2912
01:44:29,270 --> 01:44:26,960
could include organic molecules

2913
01:44:31,830 --> 01:44:29,280

we need to have that full package of

2914
01:44:34,070 --> 01:44:31,840
information in order to address the

2915
01:44:36,149 --> 01:44:34,080
questions of habitability to actually

2916
01:44:37,990 --> 01:44:36,159
seek signs of life requires more than

2917
01:44:39,350 --> 01:44:38,000
just organic molecules it requires a

2918
01:44:41,990 --> 01:44:39,360
whole package of chemistry and

2919
01:44:43,910 --> 01:44:42,000
morphologies and structures of the rocks

2920
01:44:45,590 --> 01:44:43,920
we're going to be able to do that

2921
01:44:47,510 --> 01:44:45,600
so after zapping the rocks with the

2922
01:44:49,590 --> 01:44:47,520
camcam laser and taking pictures and

2923
01:44:52,390 --> 01:44:49,600
everything will go up to a rock we can

2924
01:44:54,229 --> 01:44:52,400
drill it and we can put that into the

2925
01:44:56,470 --> 01:44:54,239
sam instrument which is in the belly of

2926
01:44:58,550 --> 01:44:56,480
the rover and that instrument allows us

2927
01:45:00,470 --> 01:44:58,560
to look for organic molecules it has

2928
01:45:01,669 --> 01:45:00,480
what's called a gas chromatograph mass

2929
01:45:03,350 --> 01:45:01,679
spectrometer

2930
01:45:06,310 --> 01:45:03,360
and we'll be able to separate out the

2931
01:45:08,470 --> 01:45:06,320
different molecules and see what's there

2932
01:45:10,149 --> 01:45:08,480
the discovery of an organic molecule on

2933
01:45:11,590 --> 01:45:10,159
mars will be a big deal right now we

2934
01:45:13,910 --> 01:45:11,600
don't have any evidence of organic

2935
01:45:16,470 --> 01:45:13,920
molecules on mars itself there is

2936
01:45:18,390 --> 01:45:16,480
suggestions from meteorites that maybe

2937
01:45:20,390 --> 01:45:18,400
organic molecules are there

2938
01:45:22,149 --> 01:45:20,400

so finding organic molecule all on its

2939
01:45:23,990 --> 01:45:22,159
own is a big discovery

2940
01:45:26,790 --> 01:45:24,000
whether if we don't find organic

2941
01:45:29,030 --> 01:45:26,800
molecules on mars it's not a full loss

2942
01:45:30,870 --> 01:45:29,040
if you think about every single mars

2943
01:45:33,270 --> 01:45:30,880
mission that we have had

2944
01:45:35,750 --> 01:45:33,280
every single one has completely changed

2945
01:45:37,590 --> 01:45:35,760
our perspective of the red planet

2946
01:45:39,750 --> 01:45:37,600
we have always discovered something and

2947
01:45:42,149 --> 01:45:39,760
this time around we're going with a

2948
01:45:43,830 --> 01:45:42,159
whole laboratory of instruments we're

2949
01:45:45,350 --> 01:45:43,840
going to be looking at these rocks in a

2950
01:45:47,270 --> 01:45:45,360
way we've never been able to look at

2951
01:45:49,270 --> 01:45:47,280
them before and because of that we're

2952
01:45:50,870 --> 01:45:49,280
going to be discovering new things and

2953
01:45:52,790 --> 01:45:50,880
all of those ideas that have been

2954
01:45:55,030 --> 01:45:52,800
presented about what we think happened

2955
01:45:56,790 --> 01:45:55,040
on mars they're going to change

2956
01:45:58,950 --> 01:45:56,800
they're going to evolve into something

2957
01:46:01,109 --> 01:45:58,960
new and nobody can predict what that is

2958
01:46:02,390 --> 01:46:01,119
yet but where our perception of mars

2959
01:46:04,629 --> 01:46:02,400
will change and we are going to have

2960
01:46:09,910 --> 01:46:04,639
some discoveries

2961
01:46:13,510 --> 01:46:11,990
we have time for a few questions and

2962
01:46:16,470 --> 01:46:13,520
while we're waiting for people to come

2963
01:46:19,910 --> 01:46:16,480

up uh the word of the day is alluvial

2964
01:46:25,430 --> 01:46:22,149
sorry about that

2965
01:46:27,750 --> 01:46:25,440
alluvial is a deposit that's created by

2966
01:46:30,149 --> 01:46:27,760
a river flowing down and dumping its

2967
01:46:32,550 --> 01:46:30,159
sediment as it does and in the form that

2968
01:46:34,709 --> 01:46:32,560
i used it that's in a sort of dry

2969
01:46:36,390 --> 01:46:34,719
setting like you'd see out in the

2970
01:46:38,470 --> 01:46:36,400
mountainous southwest where a

2971
01:46:40,149 --> 01:46:38,480
thunderstorm erodes the sediment it

2972
01:46:41,990 --> 01:46:40,159
flashes down out of the mountains and is

2973
01:46:43,590 --> 01:46:42,000
deposited in a fan near the base of

2974
01:46:45,910 --> 01:46:43,600
those mountains

2975
01:46:47,910 --> 01:46:45,920
great thanks john um

2976
01:46:50,149 --> 01:46:47,920
question

2977
01:46:52,390 --> 01:46:50,159
uh of the four possible landing sites

2978
01:46:54,550 --> 01:46:52,400
for curiosity are there any that

2979
01:46:56,790 --> 01:46:54,560
people are particularly leaning towards

2980
01:46:58,070 --> 01:46:56,800
um or is it pretty much an even bet for

2981
01:47:00,229 --> 01:46:58,080
all four

2982
01:47:02,470 --> 01:47:00,239
i'm sorry i'm just part of the question

2983
01:47:05,189 --> 01:47:02,480
of the four possible landing sites for

2984
01:47:07,590 --> 01:47:05,199
curiosity are there any that people are

2985
01:47:09,669 --> 01:47:07,600
particularly leaning towards or is it

2986
01:47:11,510 --> 01:47:09,679
fairly even for all four is there a

2987
01:47:12,870 --> 01:47:11,520
preferred landing if you ask four

2988
01:47:14,390 --> 01:47:12,880

different people you will get four

2989
01:47:17,430 --> 01:47:14,400
different answers

2990
01:47:20,390 --> 01:47:17,440
we have had a very very

2991
01:47:22,790 --> 01:47:20,400
structured but vigorous discussion about

2992
01:47:25,510 --> 01:47:22,800
the merits of each site and one thing

2993
01:47:27,350 --> 01:47:25,520
that everyone agrees on is that any of

2994
01:47:29,990 --> 01:47:27,360
the four were it to be picked for

2995
01:47:31,109 --> 01:47:30,000
curiosity would be an excellent landing

2996
01:47:33,030 --> 01:47:31,119
site

2997
01:47:35,750 --> 01:47:33,040
we all have different sort of sense of

2998
01:47:37,590 --> 01:47:35,760
expertise and and our own favorites but

2999
01:47:39,830 --> 01:47:37,600
what we need to factor in and has been

3000
01:47:41,830 --> 01:47:39,840
doing is going on now

3001
01:47:43,750 --> 01:47:41,840
is a sense of how each of those sites

3002
01:47:46,070 --> 01:47:43,760
allows curiosity to get done what it

3003
01:47:48,870 --> 01:47:46,080
needs to and once we sort of feed that

3004
01:47:51,270 --> 01:47:48,880
into the mix i suspect that the science

3005
01:47:53,350 --> 01:47:51,280
coupled with what curiosity can do is

3006
01:47:54,709 --> 01:47:53,360
going to lead to a favorite and that's

3007
01:47:56,070 --> 01:47:54,719
going to that's going to allow us to

3008
01:48:00,950 --> 01:47:56,080
pick

3009
01:48:04,870 --> 01:48:02,629
he's not allowed to say that because

3010
01:48:06,709 --> 01:48:04,880
he's leading the scientific community

3011
01:48:11,270 --> 01:48:06,719
search for which site we were going to

3012
01:48:11,280 --> 01:48:14,470
yes

3013
01:48:19,590 --> 01:48:15,990

i can't remember which mission was on

3014
01:48:22,390 --> 01:48:19,600
but i was fascinated by by the aspect of

3015
01:48:25,109 --> 01:48:22,400
uh perhaps trying to determine uh

3016
01:48:27,669 --> 01:48:25,119
uh microorganism uh life by looking at

3017
01:48:30,629 --> 01:48:27,679
uh uh respiration type

3018
01:48:33,669 --> 01:48:30,639
experiments so where you're actually uh

3019
01:48:34,870 --> 01:48:33,679
either putting in a label uh a carbon-14

3020
01:48:35,750 --> 01:48:34,880
label and looking seeing if you're

3021
01:48:38,950 --> 01:48:35,760
getting

3022
01:48:42,070 --> 01:48:38,960
evolution of labeled carbon dioxide uh

3023
01:48:44,149 --> 01:48:42,080
one first first question is is uh are

3024
01:48:47,109 --> 01:48:44,159
experiments like that being considered

3025
01:48:48,950 --> 01:48:47,119
in this or future missions to try to as

3026
01:48:51,030 --> 01:48:48,960
one handle of determining micro-organism

3027
01:48:52,870 --> 01:48:51,040
content

3028
01:48:54,950 --> 01:48:52,880
please the mission that you're referring

3029
01:48:57,270 --> 01:48:54,960
to is the viking mission

3030
01:48:58,950 --> 01:48:57,280
yep it was viking and um

3031
01:49:01,830 --> 01:48:58,960
my understanding is that uh there

3032
01:49:03,669 --> 01:49:01,840
haven't been many considerations for

3033
01:49:05,990 --> 01:49:03,679
pursuing more of those types of

3034
01:49:07,910 --> 01:49:06,000
experiments on mars and part of the

3035
01:49:10,229 --> 01:49:07,920
reason for that is that the results from

3036
01:49:12,629 --> 01:49:10,239
the first one were very controversial

3037
01:49:15,350 --> 01:49:12,639
and it clearly showed that there were a

3038
01:49:17,350 --> 01:49:15,360

lot of unknowns about the chemistry

3039
01:49:19,189 --> 01:49:17,360
of the rocks and the sediments on the

3040
01:49:22,149 --> 01:49:19,199
surface of mars and without having a

3041
01:49:24,950 --> 01:49:22,159
better grasp of what that chemistry was

3042
01:49:27,270 --> 01:49:24,960
it always kind of throws some questions

3043
01:49:28,470 --> 01:49:27,280
into the mix of what the results really

3044
01:49:30,390 --> 01:49:28,480
mean

3045
01:49:32,070 --> 01:49:30,400
whether it's an abiotic or a biotic

3046
01:49:33,990 --> 01:49:32,080
that's right that's right and so we

3047
01:49:35,750 --> 01:49:34,000
really need to have a better grasp of

3048
01:49:37,750 --> 01:49:35,760
what the chemistry of the rocks and

3049
01:49:39,990 --> 01:49:37,760
sediments is like on mars first my last

3050
01:49:41,669 --> 01:49:40,000
question also just comment on

3051
01:49:43,430 --> 01:49:41,679
mary i was going to add something else

3052
01:49:44,629 --> 01:49:43,440
that a lot of the life detection

3053
01:49:47,350 --> 01:49:44,639
experiments that people have talked

3054
01:49:49,589 --> 01:49:47,360
about again are terran specific

3055
01:49:51,669 --> 01:49:49,599
and i think if nothing else in the last

3056
01:49:54,070 --> 01:49:51,679
decade or so we or certainly since the

3057
01:49:55,510 --> 01:49:54,080
time of those original experiments we

3058
01:49:58,390 --> 01:49:55,520
have learned so much about the

3059
01:49:59,669 --> 01:49:58,400
possibilities of life and what they can

3060
01:50:02,870 --> 01:49:59,679
actually do and what you would be

3061
01:50:04,550 --> 01:50:02,880
looking for so i think again

3062
01:50:06,470 --> 01:50:04,560
we need to be very careful about being

3063
01:50:07,990 --> 01:50:06,480

too specific with an analysis and some

3064
01:50:10,390 --> 01:50:08,000
think that a life detection experiment

3065
01:50:12,310 --> 01:50:10,400
would require more knowledge about our

3066
01:50:13,669 --> 01:50:12,320
target than we actually currently have

3067
01:50:16,149 --> 01:50:13,679
so knowing more about mars than we

3068
01:50:18,709 --> 01:50:16,159
really know now and also it would be

3069
01:50:20,790 --> 01:50:18,719
tailored too much towards

3070
01:50:23,189 --> 01:50:20,800
an experiment that says is there an

3071
01:50:25,669 --> 01:50:23,199
organism that i find in my backyard up

3072
01:50:28,310 --> 01:50:25,679
on mars because we know how it behaves

3073
01:50:31,270 --> 01:50:28,320
and so again there's a it's a little

3074
01:50:33,109 --> 01:50:31,280
risky uh at this point

3075
01:50:35,109 --> 01:50:33,119
the only other question also is just

3076
01:50:37,430 --> 01:50:35,119
give us a comment or two on the

3077
01:50:38,709 --> 01:50:37,440
possibility eventually uh investigating

3078
01:50:42,149 --> 01:50:38,719
or looking for

3079
01:50:43,750 --> 01:50:42,159
dna or rna in any of these samples as a

3080
01:50:45,750 --> 01:50:43,760
as a marker of life is that being

3081
01:50:47,589 --> 01:50:45,760
considered

3082
01:50:50,229 --> 01:50:47,599
well we can both say

3083
01:50:52,629 --> 01:50:50,239
looking at them specifically as in a an

3084
01:50:54,790 --> 01:50:52,639
analysis for dna

3085
01:50:57,510 --> 01:50:54,800
only or specifically is not considered

3086
01:50:59,910 --> 01:50:57,520
for msl and it's not necessarily planned

3087
01:51:01,990 --> 01:50:59,920
for the future however

3088
01:51:03,750 --> 01:51:02,000

jen can speak to the fact that if dna is

3089
01:51:05,189 --> 01:51:03,760
there the instrument that she's involved

3090
01:51:07,750 --> 01:51:05,199
in will see it

3091
01:51:09,910 --> 01:51:07,760
well it will not see dna as a molecule

3092
01:51:11,750 --> 01:51:09,920
all on its own it will see components

3093
01:51:12,790 --> 01:51:11,760
that might make up the dna

3094
01:51:13,830 --> 01:51:12,800
yeah

3095
01:51:15,430 --> 01:51:13,840
evidence

3096
01:51:17,350 --> 01:51:15,440
and you you actually might send an

3097
01:51:18,709 --> 01:51:17,360
experiment that could measure dna as a

3098
01:51:23,030 --> 01:51:18,719
check to make sure you're not sending

3099
01:51:27,990 --> 01:51:25,270
i guess for any and all of the panelists

3100
01:51:30,310 --> 01:51:28,000
there was this little alleged microbe in

3101
01:51:32,390 --> 01:51:30,320
the meteorite okay

3102
01:51:35,270 --> 01:51:32,400
what are your collected or individual

3103
01:51:37,030 --> 01:51:35,280
opinions as to why this little thing was

3104
01:51:39,430 --> 01:51:37,040
not the first data point for

3105
01:51:41,510 --> 01:51:39,440
astrobiology

3106
01:51:44,790 --> 01:51:41,520
so the question that was related to a

3107
01:51:45,830 --> 01:51:44,800
meteorite called alh 84001

3108
01:51:48,310 --> 01:51:45,840
that

3109
01:51:50,550 --> 01:51:48,320
purported evidence of life because it

3110
01:51:52,629 --> 01:51:50,560
came from mars and there are very five

3111
01:51:54,149 --> 01:51:52,639
interesting aspects to it

3112
01:51:56,070 --> 01:51:54,159
essentially the conclusion from that

3113
01:51:57,510 --> 01:51:56,080

meteorite is there's not enough

3114
01:51:59,589 --> 01:51:57,520
information in that meteorite to

3115
01:52:01,990 --> 01:51:59,599
conclude whether or not it is evidence

3116
01:52:04,149 --> 01:52:02,000
of life so it is depends on which

3117
01:52:05,990 --> 01:52:04,159
researcher you talk to whether or not it

3118
01:52:07,750 --> 01:52:06,000
is evidence of life or

3119
01:52:15,669 --> 01:52:07,760
just interesting

3120
01:52:18,070 --> 01:52:16,790
the

3121
01:52:20,229 --> 01:52:18,080
essentially

3122
01:52:22,229 --> 01:52:20,239
one of the important findings is reduce

3123
01:52:24,629 --> 01:52:22,239
carbon in the meteorite

3124
01:52:26,310 --> 01:52:24,639
the problem is it's hard to tell where

3125
01:52:28,790 --> 01:52:26,320
it came from

3126
01:52:30,950 --> 01:52:28,800
and so that's probably the real crux of

3127
01:52:32,790 --> 01:52:30,960
the matter and and part of the issues is

3128
01:52:36,390 --> 01:52:32,800
that we can come up with physical

3129
01:52:38,790 --> 01:52:36,400
chemical processes that will produce

3130
01:52:41,030 --> 01:52:38,800
similar reduced carbon here on earth and

3131
01:52:43,510 --> 01:52:41,040
whether or not that process actually

3132
01:52:44,550 --> 01:52:43,520
that rock experience that process is one

3133
01:52:46,629 --> 01:52:44,560
of the things we don't know we don't

3134
01:52:49,030 --> 01:52:46,639
have a context for where that rock came

3135
01:52:51,990 --> 01:52:49,040
from and one of the real advantages of

3136
01:52:53,669 --> 01:52:52,000
msl is you go to the place you'll know

3137
01:52:55,189 --> 01:52:53,679
the context for your because you're

3138
01:52:57,270 --> 01:52:55,199

studying a region so when you pick up

3139
01:52:58,950 --> 01:52:57,280
something that's interesting you'll know

3140
01:53:00,629 --> 01:52:58,960
what its environment is and jen you

3141
01:53:02,629 --> 01:53:00,639
might want to add

3142
01:53:05,030 --> 01:53:02,639
something yeah so imagine you have a

3143
01:53:06,870 --> 01:53:05,040
rock that gets blasted off of mars it

3144
01:53:08,070 --> 01:53:06,880
travels through space who knows what's

3145
01:53:09,350 --> 01:53:08,080
happening to it when it's traveling

3146
01:53:11,830 --> 01:53:09,360
through space it's certainly going to be

3147
01:53:13,750 --> 01:53:11,840
bombarded by a lot of cosmic radiation

3148
01:53:16,070 --> 01:53:13,760
then it has to pass through the earth

3149
01:53:17,990 --> 01:53:16,080
atmosphere it probably breaks up to some

3150
01:53:19,669 --> 01:53:18,000
degree gets heated up a lot and then

3151
01:53:22,310 --> 01:53:19,679
it's going to land someplace and in this

3152
01:53:24,070 --> 01:53:22,320
case it landed in the ice of antarctica

3153
01:53:25,430 --> 01:53:24,080
once it's in the ice it's going to sit

3154
01:53:27,430 --> 01:53:25,440
there for a while

3155
01:53:29,669 --> 01:53:27,440
who knows how long it's processing is

3156
01:53:31,669 --> 01:53:29,679
processing there are things that happen

3157
01:53:32,870 --> 01:53:31,679
inside ice there are chemical reactions

3158
01:53:35,510 --> 01:53:32,880
that can happen and if there are

3159
01:53:37,430 --> 01:53:35,520
microorganisms around in the ice

3160
01:53:39,589 --> 01:53:37,440
and they see a rock nearby and it's got

3161
01:53:41,830 --> 01:53:39,599
nutrients and food and all sorts of

3162
01:53:43,910 --> 01:53:41,840
other interesting things that it wants

3163
01:53:45,270 --> 01:53:43,920

those can actually come in and make that

3164
01:53:47,910 --> 01:53:45,280
their home

3165
01:53:50,390 --> 01:53:47,920
those are all possibilities and we can't

3166
01:53:52,870 --> 01:53:50,400
constrain any of those the best that we

3167
01:53:55,990 --> 01:53:52,880
can do is try and find features

3168
01:53:58,229 --> 01:53:56,000
the features of the meteorite in analog

3169
01:54:00,950 --> 01:53:58,239
materials of earth and try and

3170
01:54:03,109 --> 01:54:00,960
understand all of the processes that

3171
01:54:05,030 --> 01:54:03,119
might contribute to those features and

3172
01:54:07,270 --> 01:54:05,040
then ask the question could those

3173
01:54:09,270 --> 01:54:07,280
features have happened on earth or on

3174
01:54:10,950 --> 01:54:09,280
mars or maybe both

3175
01:54:12,390 --> 01:54:10,960
and so really it's not it's not

3176
01:54:13,990 --> 01:54:12,400
constrained well enough

3177
01:54:17,109 --> 01:54:14,000
thank you

3178
01:54:20,310 --> 01:54:17,119
last question um well if the media of

3179
01:54:22,229 --> 01:54:20,320
the post is to be believed

3180
01:54:24,350 --> 01:54:22,239
within the last couple of months they

3181
01:54:26,790 --> 01:54:24,360
found uh evidence of a

3182
01:54:30,790 --> 01:54:26,800
non-carbon-based life form

3183
01:54:33,750 --> 01:54:30,800
on this planet and so my question is

3184
01:54:35,109 --> 01:54:33,760
how does that affect uh the experiments

3185
01:54:36,629 --> 01:54:35,119
that you all do

3186
01:54:38,790 --> 01:54:36,639
on mars

3187
01:54:39,990 --> 01:54:38,800
so i'll take that um

3188
01:54:42,310 --> 01:54:40,000

number one

3189
01:54:45,589 --> 01:54:42,320
the finding wasn't a replacement of

3190
01:54:47,109 --> 01:54:45,599
carbon we that organism absolutely is

3191
01:54:49,030 --> 01:54:47,119
carbon-based

3192
01:54:50,870 --> 01:54:49,040
uh the finding was they found an

3193
01:54:52,709 --> 01:54:50,880
organism isolated from mono lake which

3194
01:54:55,109 --> 01:54:52,719
is an extreme environment it's a very

3195
01:54:57,189 --> 01:54:55,119
high ph it's got lots of metals around

3196
01:54:59,510 --> 01:54:57,199
and it has a lot of phosphate as well

3197
01:55:01,510 --> 01:54:59,520
but this particular organism appears to

3198
01:55:03,270 --> 01:55:01,520
be able to grow

3199
01:55:05,109 --> 01:55:03,280
not only with phosphate like all

3200
01:55:07,669 --> 01:55:05,119
organisms on earth grow they need that

3201
01:55:09,990 --> 01:55:07,679
phosphate but they can also grow under

3202
01:55:12,310 --> 01:55:10,000
phosphate limiting conditions where

3203
01:55:14,550 --> 01:55:12,320
there's virtually none there and

3204
01:55:17,109 --> 01:55:14,560
potentially suggesting that in the

3205
01:55:19,109 --> 01:55:17,119
presence of arsenic arsenic is related

3206
01:55:21,510 --> 01:55:19,119
to phosphorus in the periodic table it's

3207
01:55:24,470 --> 01:55:21,520
got the same atomic radii and so there's

3208
01:55:26,950 --> 01:55:24,480
the the question of is this organism

3209
01:55:29,109 --> 01:55:26,960
surviving by taking that arsenic and

3210
01:55:32,470 --> 01:55:29,119
using it in place of phosphate and some

3211
01:55:33,750 --> 01:55:32,480
really important um molecules now that

3212
01:55:35,430 --> 01:55:33,760
being said

3213
01:55:37,030 --> 01:55:35,440

that speaks to the things that we keep

3214
01:55:39,910 --> 01:55:37,040
talking about is about keeping the

3215
01:55:41,270 --> 01:55:39,920
search general enough it absolutely

3216
01:55:42,950 --> 01:55:41,280
sticks a little wedge in our

3217
01:55:45,189 --> 01:55:42,960
understanding and it makes us realize

3218
01:55:47,589 --> 01:55:45,199
that we don't know enough

3219
01:55:49,350 --> 01:55:47,599
even now about our own life to

3220
01:55:50,870 --> 01:55:49,360
categorically be able to predict what we

3221
01:55:53,189 --> 01:55:50,880
should be looking for there i mean we've

3222
01:55:55,030 --> 01:55:53,199
got good ideas we have a strategy but

3223
01:55:57,109 --> 01:55:55,040
we're always learning new things and i

3224
01:55:58,830 --> 01:55:57,119
think that that's what that study is is

3225
01:56:02,070 --> 01:55:58,840
really

3226
01:56:03,750 --> 01:56:02,080
highlights thank you uh last question

3227
01:56:05,030 --> 01:56:03,760
really

3228
01:56:06,550 --> 01:56:05,040
sorry about that

3229
01:56:07,750 --> 01:56:06,560
um i was curious what steps are you

3230
01:56:09,109 --> 01:56:07,760
taking on the current and future

3231
01:56:10,709 --> 01:56:09,119
missions that you weren't necessarily

3232
01:56:12,629 --> 01:56:10,719
taking with viking about avoiding

3233
01:56:15,270 --> 01:56:12,639
contamination of mars with earth-based

3234
01:56:17,109 --> 01:56:15,280
microbes

3235
01:56:18,390 --> 01:56:17,119
well you've been doing contamination

3236
01:56:20,550 --> 01:56:18,400
control

3237
01:56:22,390 --> 01:56:20,560
there is uh what's called the planetary

3238
01:56:24,709 --> 01:56:22,400

protection policies that are in place

3239
01:56:25,990 --> 01:56:24,719
and those are guidelines for what we

3240
01:56:27,669 --> 01:56:26,000
need to do

3241
01:56:29,430 --> 01:56:27,679
to prevent

3242
01:56:31,270 --> 01:56:29,440
the

3243
01:56:34,470 --> 01:56:31,280
bringing microorganisms

3244
01:56:36,310 --> 01:56:34,480
from earth to mars and those have been

3245
01:56:37,750 --> 01:56:36,320
vetted out by lots of scientists and

3246
01:56:39,589 --> 01:56:37,760
everything it's the best that we can do

3247
01:56:42,149 --> 01:56:39,599
to try and prevent

3248
01:56:43,990 --> 01:56:42,159
embedding organisms into the martian and

3249
01:56:46,550 --> 01:56:44,000
environment and so that takes care of

3250
01:56:47,750 --> 01:56:46,560
the microorganism side of things

3251
01:56:49,830 --> 01:56:47,760
with an

3252
01:56:52,550 --> 01:56:49,840
instrument on board that is specifically

3253
01:56:54,709 --> 01:56:52,560
looking at organic molecules we have to

3254
01:56:56,709 --> 01:56:54,719
take that one step further and we have

3255
01:56:59,030 --> 01:56:56,719
to make sure that we know what organic

3256
01:57:00,629 --> 01:56:59,040
molecules we take with us and what might

3257
01:57:02,550 --> 01:57:00,639
happen to those organic molecules in

3258
01:57:04,470 --> 01:57:02,560
other words what they might turn into

3259
01:57:07,430 --> 01:57:04,480
once they get to mars

3260
01:57:10,390 --> 01:57:07,440
so we have so the instrument itself

3261
01:57:12,390 --> 01:57:10,400
is is super clean it goes through every

3262
01:57:14,390 --> 01:57:12,400
single component goes through multiple

3263
01:57:15,990 --> 01:57:14,400

levels of cleaning cleaning cleaning

3264
01:57:17,910 --> 01:57:16,000
cleaning cleaning clean and clean it's a

3265
01:57:20,470 --> 01:57:17,920
long long cleaning process

3266
01:57:22,229 --> 01:57:20,480
the rest of the instrument is also have

3267
01:57:24,070 --> 01:57:22,239
certain specs that have to be met for

3268
01:57:26,229 --> 01:57:24,080
keeping it clean but the other thing

3269
01:57:28,310 --> 01:57:26,239
that we're doing is cataloging

3270
01:57:30,310 --> 01:57:28,320
all of the organic materials

3271
01:57:32,149 --> 01:57:30,320
that are actually going on there so for

3272
01:57:35,589 --> 01:57:32,159
instance

3273
01:57:37,270 --> 01:57:35,599
teflon type coatings are used often for

3274
01:57:39,030 --> 01:57:37,280
insulating wires

3275
01:57:42,070 --> 01:57:39,040
we have logged all that type of

3276
01:57:43,510 --> 01:57:42,080
information you know that there's um uh

3277
01:57:44,790 --> 01:57:43,520
different um

3278
01:57:46,390 --> 01:57:44,800
i think there's lubricants in the

3279
01:57:49,109 --> 01:57:46,400
actuators or something like that is that

3280
01:57:50,629 --> 01:57:49,119
right the dry lubricants those types of

3281
01:57:52,550 --> 01:57:50,639
things all that stuff is cataloged and

3282
01:57:55,669 --> 01:57:52,560
we have a record of it so what will

3283
01:57:57,669 --> 01:57:55,679
happen when we get to mars is there is

3284
01:57:59,510 --> 01:57:57,679
what's called the organic check material

3285
01:58:01,830 --> 01:57:59,520
they're they're basically bricks that

3286
01:58:03,910 --> 01:58:01,840
are super clean with exception of one or

3287
01:58:06,070 --> 01:58:03,920
two compounds that we put in there and

3288
01:58:07,109 --> 01:58:06,080

we will send the drill over the drill

3289
01:58:08,870 --> 01:58:07,119
actually

3290
01:58:11,510 --> 01:58:08,880
goes into the brick drills it like it's

3291
01:58:14,229 --> 01:58:11,520
a sample and then we process that sample

3292
01:58:16,390 --> 01:58:14,239
like it was any other rock on mars

3293
01:58:18,550 --> 01:58:16,400
and that is going to tell us what is the

3294
01:58:21,669 --> 01:58:18,560
background level of contaminants in the

3295
01:58:23,350 --> 01:58:21,679
system right then and there on mars

3296
01:58:25,189 --> 01:58:23,360
so we will know if there's something

3297
01:58:27,350 --> 01:58:25,199
there and if we see it in that then we

3298
01:58:29,910 --> 01:58:27,360
know that if we see it in a sample it's

3299
01:58:31,910 --> 01:58:29,920
something we brought with us

3300
01:58:38,470 --> 01:58:31,920
well listen i want to thank everybody

3301
01:58:43,750 --> 01:58:40,709
if we could have the the next slide

3302
01:58:46,070 --> 01:58:43,760
please what i want we have had the

3303
01:58:50,149 --> 01:58:46,080
privilege of having an exploration

3304
01:58:51,990 --> 01:58:50,159
program that has brought us from being

3305
01:58:54,709 --> 01:58:52,000
able to follow the water and determine

3306
01:58:57,109 --> 01:58:54,719
at least that mars has the potential

3307
01:58:59,750 --> 01:58:57,119
for having had life

3308
01:59:01,830 --> 01:58:59,760
and we're now on the on the track to

3309
01:59:03,669 --> 01:59:01,840
figure out if that has ever happened and

3310
01:59:05,189 --> 01:59:03,679
it's going to be difficult it's going to

3311
01:59:07,030 --> 01:59:05,199
be a challenge

3312
01:59:08,070 --> 01:59:07,040
but it's going to be a wonderful

3313
01:59:09,510 --> 01:59:08,080

adventure

3314
01:59:11,910 --> 01:59:09,520
and one of the things that we want to do

3315
01:59:14,390 --> 01:59:11,920
is bring you all with us as we go on

3316
01:59:16,950 --> 01:59:14,400
this exploration so please look at these

3317
01:59:18,790 --> 01:59:16,960
websites you can see curiosity being

3318
01:59:21,350 --> 01:59:18,800
built you can see what we're doing in

3319
01:59:23,270 --> 01:59:21,360
the mars program you can actually join a

3320
01:59:25,189 --> 01:59:23,280
student imaging program where in fact

3321
01:59:27,750 --> 01:59:25,199
you can recommend places that you want

3322
01:59:30,149 --> 01:59:27,760
pictures taken of mars

3323
01:59:31,669 --> 01:59:30,159
please go there and join us in this fun

3324
01:59:33,589 --> 01:59:31,679
i want to thank everybody and in

3325
01:59:36,149 --> 01:59:33,599
particular want to thank