EARTH-LIFE
SCIENCE
INSTITUTE

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Life beyond our planet

1
00:00:00,720 --> 00:00:11,410
[Music]

2
00:00:16,790 --> 00:00:14,120
hi well as you've seen from the talk so

3
00:00:20,060 --> 00:00:16,800
far we clearly completely understand

4
00:00:23,570 --> 00:00:20,070
life on Earth so our next question is

5
00:00:25,540 --> 00:00:23,580
where might we find life beyond our

6
00:00:28,940 --> 00:00:25,550
planets

7
00:00:31,600 --> 00:00:28,950
say this our Sun is one of a hundred

8
00:00:34,490 --> 00:00:31,610
billion stars in the Milky Way galaxy

9
00:00:38,360 --> 00:00:34,500
and when we talk about extrasolar

10
00:00:43,130 --> 00:00:38,370
planets we're saying extra as in outside

11
00:00:46,640 --> 00:00:43,140
and solar means the Sun so an extrasolar

12
00:00:51,290 --> 00:00:46,650
planets or exoplanets is a planet that

13
00:00:54,350 --> 00:00:51,300

orbits a star that is not our Sun I in

14
00:00:56,510 --> 00:00:54,360
the last 20 or 25 years we have

15
00:01:00,980 --> 00:00:56,520
discovered over three and a half

16
00:01:03,770 --> 00:01:00,990
thousand exoplanets roughly one-third of

17
00:01:07,880 --> 00:01:03,780
those have a radius that is less than

18
00:01:12,349 --> 00:01:07,890
twice the size of the earth so we have

19
00:01:14,989 --> 00:01:12,359
all these earth sized worlds but could

20
00:01:15,529 --> 00:01:14,999
any of them be inhabited and how would

21
00:01:22,370 --> 00:01:15,539
we know

22
00:01:24,230 --> 00:01:22,380
Oh 1998 96 96 percent of exoplanets have

23
00:01:27,499 --> 00:01:24,240
been discovered through one of two

24
00:01:29,599 --> 00:01:27,509
techniques the first of these is known

25
00:01:32,629 --> 00:01:29,609
as the radial velocity technique or

26
00:01:35,629 --> 00:01:32,639
Doppler bubble and here the planet's

27
00:01:38,870 --> 00:01:35,639
gravity causes the star to make a very

28
00:01:41,149 --> 00:01:38,880
small movement a tiny wobble that pushes

29
00:01:44,149 --> 00:01:41,159
it towards and away from the earth and

30
00:01:47,149 --> 00:01:44,159
as it moves towards and away from us

31
00:01:49,849 --> 00:01:47,159
it's light gets stretched and compressed

32
00:01:52,340 --> 00:01:49,859
and stretching and compressing these

33
00:01:55,340 --> 00:01:52,350
wavelengths turn it from slightly redder

34
00:01:58,039 --> 00:01:55,350
to slightly bluer and if we can measure

35
00:02:01,429 --> 00:01:58,049
that we get a sense of the mass of the

36
00:02:03,590 --> 00:02:01,439
planet that might be orbiting it the

37
00:02:06,349 --> 00:02:03,600
second technique is called the transit

38
00:02:08,960 --> 00:02:06,359

method and here the planet passes

39
00:02:11,930 --> 00:02:08,970
between the star and where we're viewing

40
00:02:14,900 --> 00:02:11,940
on earth and as it passes across the

41
00:02:17,420 --> 00:02:14,910
star surface a tiny bit of the light is

42
00:02:21,500 --> 00:02:17,430
obscured to indicate a planet might be

43
00:02:23,149 --> 00:02:21,510
there not typically this tells us

44
00:02:26,270 --> 00:02:23,159
two pieces of information about the

45
00:02:29,390 --> 00:02:26,280
planet the first is something about its

46
00:02:31,729 --> 00:02:29,400
physical size if the planet has been

47
00:02:34,640 --> 00:02:31,739
found through the transit technique the

48
00:02:38,210 --> 00:02:34,650
amount of light obscures tells us about

49
00:02:39,979 --> 00:02:38,220
the planets radius alternatively if the

50
00:02:42,649 --> 00:02:39,989
planet is found through the Doppler

51
00:02:45,229 --> 00:02:42,659
wobble technique the size of the wobble

52
00:02:47,930 --> 00:02:45,239
that is induces in the star tells us

53
00:02:50,210 --> 00:02:47,940
about the planets minimum mass the

54
00:02:53,030 --> 00:02:50,220
second thing we typically know is how

55
00:02:56,509 --> 00:02:53,040
much starlight so how much radiation is

56
00:02:59,030 --> 00:02:56,519
reaching the planet from its star now

57
00:03:01,210 --> 00:02:59,040
this is not the same as knowing the

58
00:03:04,729 --> 00:03:01,220
temperature on the planet's surface

59
00:03:06,770 --> 00:03:04,739
indeed in our own solar system Venus

60
00:03:09,530 --> 00:03:06,780
receives roughly twice the amount of

61
00:03:11,330 --> 00:03:09,540
sunlight compared to the earth and if

62
00:03:14,420 --> 00:03:11,340
you were to guess at Venus's surface

63
00:03:16,280 --> 00:03:14,430

temperature based on this number you

64
00:03:20,539 --> 00:03:16,290
might think venus had a surface

65
00:03:22,069 --> 00:03:20,549
temperature of 27 30 degrees sounds

66
00:03:25,190 --> 00:03:22,079
quite nice maybe go there for a holiday

67
00:03:29,839 --> 00:03:25,200
in fact the surface temperature of Venus

68
00:03:31,970 --> 00:03:29,849
is 460 Celsius it melts lead and the

69
00:03:34,729 --> 00:03:31,980
longest a spacecraft has ever survived

70
00:03:37,819 --> 00:03:34,739
on the Venetian surface is less than two

71
00:03:40,039 --> 00:03:37,829
hours so these two properties don't tell

72
00:03:42,559 --> 00:03:40,049
us anything about the surface conditions

73
00:03:44,629 --> 00:03:42,569
and it's the surface conditions we're

74
00:03:47,900 --> 00:03:44,639
really interested in when we want to

75
00:03:52,220 --> 00:03:47,910
think about life so what does it take to

76
00:03:54,650 --> 00:03:52,230
be an earth well size is certainly part

77
00:03:57,050 --> 00:03:54,660
of it if the planet is vastly bigger

78
00:03:59,720 --> 00:03:57,060
than the earth the chances are it would

79
00:04:02,420 --> 00:03:59,730
be like Jupiter with a colossal

80
00:04:05,330 --> 00:04:02,430
atmosphere and no real surface that

81
00:04:07,759 --> 00:04:05,340
anything could live upon however as

82
00:04:10,250 --> 00:04:07,769
we've heard from marine there's also our

83
00:04:12,710 --> 00:04:10,260
planet's magnetic fields that protects

84
00:04:15,470 --> 00:04:12,720
us from the worst of the sun's flares

85
00:04:17,689 --> 00:04:15,480
and radiation we see this as a Northern

86
00:04:20,270 --> 00:04:17,699
Lights occasionally a strong flare may

87
00:04:23,029 --> 00:04:20,280
damage our GPS systems but it doesn't

88
00:04:26,659 --> 00:04:23,039

sterilize our surface because we have

89
00:04:28,939 --> 00:04:26,669
this protective magnetic field we also

90
00:04:31,010 --> 00:04:28,949
have volcanoes which don't initially

91
00:04:33,230 --> 00:04:31,020
seem like a good thing but in fact

92
00:04:35,379 --> 00:04:33,240
helped generate our atmosphere that we

93
00:04:38,350 --> 00:04:35,389
breathe

94
00:04:41,860 --> 00:04:38,360
rock-type helps also regulate the amount

95
00:04:44,529 --> 00:04:41,870
of greenhouse gases in our air and the

96
00:04:47,619 --> 00:04:44,539
presence of water as we've heard our

97
00:04:50,170 --> 00:04:47,629
planet was probably born dry and later

98
00:04:52,839 --> 00:04:50,180
had a delivery of icy meteorites that

99
00:04:54,610 --> 00:04:52,849
gave us our oceans so you could have a

100
00:04:56,980 --> 00:04:54,620
planet that was very similar to the

101
00:04:59,320 --> 00:04:56,990
earth but without the presence of a

102
00:05:02,080 --> 00:04:59,330
giant planet like Jupiter to start

103
00:05:04,179 --> 00:05:02,090
shoveling in these icy meteorites we

104
00:05:09,159 --> 00:05:04,189
might not have ever had a water delivery

105
00:05:11,980 --> 00:05:09,169
service and plate tectonics the fact our

106
00:05:14,409 --> 00:05:11,990
crust is broken up into bite-sized

107
00:05:17,290 --> 00:05:14,419
chunks helps with cooling and helps

108
00:05:21,219 --> 00:05:17,300
generate our magnetic field so it takes

109
00:05:25,029 --> 00:05:21,229
a lot to be an earth and we don't know

110
00:05:27,730 --> 00:05:25,039
very much about exoplanets yet our

111
00:05:30,730 --> 00:05:27,740
newest missions are aimed at finding us

112
00:05:33,070 --> 00:05:30,740
a little bit more the aim is to start

113
00:05:36,219 --> 00:05:33,080

looking at light that has passed through

114
00:05:38,159 --> 00:05:36,229
the planet's atmosphere and as the light

115
00:05:41,170 --> 00:05:38,169
passes through a planet's atmosphere

116
00:05:44,019 --> 00:05:41,180
certain wavelengths are absorbed by the

117
00:05:45,869 --> 00:05:44,029
molecules in the atmosphere so if those

118
00:05:49,629 --> 00:05:45,879
are missing when we see the Starlight

119
00:05:52,329 --> 00:05:49,639
that gives a hint of what the gases are

120
00:05:54,100 --> 00:05:52,339
in the planets air and therefore what

121
00:05:58,180 --> 00:05:54,110
might be going on on the planet's

122
00:06:01,119 --> 00:05:58,190
surface so we have a fingerprint to

123
00:06:03,459 --> 00:06:01,129
identify gases in terms of missing

124
00:06:07,149 --> 00:06:03,469
wavelengths that have been absorbed by

125
00:06:09,420 --> 00:06:07,159
the planet's atmosphere so we end up

126
00:06:11,619 --> 00:06:09,430
with something like this where the dips

127
00:06:16,959 --> 00:06:11,629
correspond to certain elements in the

128
00:06:18,999 --> 00:06:16,969
air so can list identify life well one

129
00:06:22,540 --> 00:06:19,009
way to test will be to look at a planet

130
00:06:25,269 --> 00:06:22,550
we know has life and see if these gases

131
00:06:26,829 --> 00:06:25,279
can confirm that whereas only one planet

132
00:06:29,860 --> 00:06:26,839
we know that has life that's this one

133
00:06:33,429 --> 00:06:29,870
and fortunately we got the chance to

134
00:06:36,820 --> 00:06:33,439
observe it in 1989 NASA's Galileo

135
00:06:39,040 --> 00:06:36,830
spacecraft was on its way to Jupiter but

136
00:06:40,929 --> 00:06:39,050
on route it's swung by the earth and

137
00:06:44,230 --> 00:06:40,939
took a look at our planet with his

138
00:06:47,709 --> 00:06:44,240

instruments so Galileo viewed the earth

139
00:06:48,629 --> 00:06:47,719
from just a thousand kilometers away so

140
00:06:51,959 --> 00:06:48,639
if it couldn't

141
00:06:54,209 --> 00:06:51,969
find detectable life we're in trouble so

142
00:06:57,269 --> 00:06:54,219
what did Galileo see well in particular

143
00:07:00,330 --> 00:06:57,279
Galileo saw three things it saw the

144
00:07:03,119 --> 00:07:00,340
presence of water it saw the presence of

145
00:07:06,029 --> 00:07:03,129
oxygen and it saw the presence of

146
00:07:07,980 --> 00:07:06,039
methane so are these enough to

147
00:07:11,399 --> 00:07:07,990
definitely say life because they're all

148
00:07:13,080 --> 00:07:11,409
related to life on the earth well the

149
00:07:15,629 --> 00:07:13,090
paper that published this result in

150
00:07:18,659 --> 00:07:15,639
nature was led by Carl Sagan a famous

151
00:07:22,140 --> 00:07:18,669
science communicator and he concluded it

152
00:07:24,409 --> 00:07:22,150
was strongly suggestive of life but he

153
00:07:28,559 --> 00:07:24,419
wasn't prepared to say it was definite

154
00:07:32,279 --> 00:07:28,569
so why not well what we're hunting for

155
00:07:35,459 --> 00:07:32,289
is a bio signature a signature of

156
00:07:39,529 --> 00:07:35,469
biological activity let's take a look at

157
00:07:43,200 --> 00:07:39,539
each of the things Galileo saw water on

158
00:07:46,350 --> 00:07:43,210
earth life is found wherever there is

159
00:07:50,519 --> 00:07:46,360
water and this includes some deeply

160
00:07:53,219 --> 00:07:50,529
unlikely places for example in deep sea

161
00:07:56,519 --> 00:07:53,229
hydrothermal vents that exist on the

162
00:07:59,129 --> 00:07:56,529
ocean floor there is no light that

163
00:08:01,860 --> 00:07:59,139

reaches this place sunlight cannot

164
00:08:04,589 --> 00:08:01,870
penetrate that deep the temperature

165
00:08:07,499 --> 00:08:04,599
around these vents can be 400 Celsius

166
00:08:11,189 --> 00:08:07,509
and there is crushing pressures from the

167
00:08:13,219 --> 00:08:11,199
ocean and yet we can find a thriving

168
00:08:16,320 --> 00:08:13,229
ecosystem here

169
00:08:19,409 --> 00:08:16,330
the same is true at the opposite end of

170
00:08:22,769 --> 00:08:19,419
the extreme with glaciers of frozen

171
00:08:25,139 --> 00:08:22,779
water and even places like the acidic

172
00:08:28,010 --> 00:08:25,149
lakes found in Yellowstone National Park

173
00:08:31,139 --> 00:08:28,020
all of these are found to contain life

174
00:08:33,659 --> 00:08:31,149
so regardless of the other conditions it

175
00:08:38,130 --> 00:08:33,669
seems that water gives you life on Earth

176
00:08:41,699 --> 00:08:38,140
and the reason for this is that water is

177
00:08:44,880 --> 00:08:41,709
a great solvent so if we look at the

178
00:08:48,090 --> 00:08:44,890
cells for life we can see that water can

179
00:08:51,540 --> 00:08:48,100
deliver nutrients and it can flush away

180
00:08:54,720 --> 00:08:51,550
toxic wastes that might kill a cell it's

181
00:08:57,540 --> 00:08:54,730
also great at chemistry for biological

182
00:09:01,980 --> 00:08:57,550
systems allowing us to build large

183
00:09:04,199 --> 00:09:01,990
complex molecules that life needs but

184
00:09:06,960 --> 00:09:04,209
what you're alone does not prove life

185
00:09:09,780 --> 00:09:06,970
it's great for life but it's not proof

186
00:09:12,870 --> 00:09:09,790
life is there for example in our own

187
00:09:15,180 --> 00:09:12,880
solar system the Jovian moon of Ganymede

188
00:09:18,180 --> 00:09:15,190

is thought to have deep oceans

189
00:09:21,570 --> 00:09:18,190
underneath its icy crust but it's not

190
00:09:24,840 --> 00:09:21,580
thought to be habitable okay so how

191
00:09:27,180 --> 00:09:24,850
about oxygen well on earth oxygen is

192
00:09:30,210 --> 00:09:27,190
primarily produced by photosynthesis

193
00:09:32,490 --> 00:09:30,220
that is plants are using sunlight for

194
00:09:36,120 --> 00:09:32,500
energy and they're producing oxygen as a

195
00:09:39,240 --> 00:09:36,130
by-product now star light is going to be

196
00:09:41,730 --> 00:09:39,250
a major energy source for most planets

197
00:09:45,660 --> 00:09:41,740
that we know of so it's not unreasonable

198
00:09:48,480 --> 00:09:45,670
to assume that life on other planets may

199
00:09:53,670 --> 00:09:48,490
also use photosynthesis and generate

200
00:09:56,639 --> 00:09:53,680
oxygen as the same byproducts but it's

201
00:09:59,670 --> 00:09:56,649
not the only way oxygen can be produced

202
00:10:02,630 --> 00:09:59,680
in particular ultraviolet light from the

203
00:10:06,690 --> 00:10:02,640
star can break apart water molecules

204
00:10:09,389 --> 00:10:06,700
into oxygen and hydrogen now a planet

205
00:10:12,060 --> 00:10:09,399
with the mass of roughly the earth can't

206
00:10:14,880 --> 00:10:12,070
hold on to a gas that is as light as

207
00:10:18,090 --> 00:10:14,890
hydrogen so in this case the hydrogen

208
00:10:22,440 --> 00:10:18,100
escapes and you get left with an oxygen

209
00:10:24,470 --> 00:10:22,450
atmosphere without life and again we

210
00:10:27,930 --> 00:10:24,480
have an example in our own solar system

211
00:10:30,780 --> 00:10:27,940
the Jovian moons have tenuous oxygen

212
00:10:33,420 --> 00:10:30,790
atmospheres and that's because the UV is

213
00:10:36,000 --> 00:10:33,430

breaking apart the ice with water water

214
00:10:38,400 --> 00:10:36,010
molecules on the surface the hydrogen is

215
00:10:42,780 --> 00:10:38,410
escaping and you're left with the oxygen

216
00:10:45,840 --> 00:10:42,790
but definitely no trees so what about

217
00:10:48,569 --> 00:10:45,850
methane well on earth methane is

218
00:10:51,030 --> 00:10:48,579
typically found due to microbes in the

219
00:10:55,590 --> 00:10:51,040
guts of animals and it's also produced

220
00:10:57,930 --> 00:10:55,600
by decomposing plants but again in our

221
00:11:01,230 --> 00:10:57,940
solar system we have a counter example

222
00:11:04,170 --> 00:11:01,240
so Saturn's moon Titan has a methane

223
00:11:07,079 --> 00:11:04,180
atmosphere it's roughly 5% methane and

224
00:11:09,420 --> 00:11:07,089
that's produced because underneath Titan

225
00:11:12,630 --> 00:11:09,430
surface there's thought to be a methane

226
00:11:13,890 --> 00:11:12,640
sea which it gets ejected to the surface

227
00:11:17,269 --> 00:11:13,900
through volcanoes

228
00:11:23,430 --> 00:11:17,279
so we have a methane atmosphere but uh

229
00:11:27,360 --> 00:11:23,440
no cows becomes so our best bet may be a

230
00:11:31,710 --> 00:11:27,370
combination of these markers for example

231
00:11:35,700 --> 00:11:31,720
if we had oxygen and methane maybe that

232
00:11:39,360 --> 00:11:35,710
would be indication of life so if left

233
00:11:42,720 --> 00:11:39,370
alone and not replenished oxygen plus

234
00:11:45,750 --> 00:11:42,730
methane forms carbon dioxide so

235
00:11:48,900 --> 00:11:45,760
therefore if we see methane and oxygen

236
00:11:51,810 --> 00:11:48,910
and it hasn't formed it has an oil and

237
00:11:56,850 --> 00:11:51,820
carbon dioxide that suggests something

238
00:11:59,040 --> 00:11:56,860

is continuously producing it but you

239
00:12:01,230 --> 00:11:59,050
could imagine a system where you might

240
00:12:04,140 --> 00:12:01,240
have say a planet with this tenuous

241
00:12:07,050 --> 00:12:04,150
oxygen atmosphere produced by light and

242
00:12:10,500 --> 00:12:07,060
maybe a moon with a methane atmosphere

243
00:12:13,079 --> 00:12:10,510
and the signatures might overlap so we

244
00:12:15,390 --> 00:12:13,089
would think we were seeing one body with

245
00:12:17,250 --> 00:12:15,400
both oxygen and methane but actually

246
00:12:20,610 --> 00:12:17,260
there were two that were very close

247
00:12:22,890 --> 00:12:20,620
together so the bottom line is when we

248
00:12:25,980 --> 00:12:22,900
start looking for alien life we're going

249
00:12:28,920 --> 00:12:25,990
to have to be very cautious and as Carl

250
00:12:32,250 --> 00:12:28,930
Sagan said extraordinary claims require

251
00:12:35,430 --> 00:12:32,260
extraordinary evidence so I think our

252
00:12:37,740 --> 00:12:35,440
next generation of telescopes will find

253
00:12:39,540 --> 00:12:37,750
evidence that could be life but we

254
00:12:43,290 --> 00:12:39,550
should expect to spend many decades

255
00:12:45,540 --> 00:12:43,300
arguing over whether actually is but

256
00:12:48,540 --> 00:12:45,550
assuming we find this bio signature

257
00:12:52,320 --> 00:12:48,550
where might we find life that wasn't

258
00:12:56,040 --> 00:12:52,330
earth well according to earth the life

259
00:12:59,910 --> 00:12:56,050
recipe requires three things it requires

260
00:13:01,769 --> 00:12:59,920
water for our bio car biological

261
00:13:05,850 --> 00:13:01,779
reactions to build up our complex

262
00:13:09,000 --> 00:13:05,860
molecules it requires biogenic elements

263
00:13:13,230 --> 00:13:09,010

so the elements of life carbon hydrogen

264
00:13:16,019 --> 00:13:13,240
oxygen for living systems and it

265
00:13:20,519 --> 00:13:16,029
requires an energy source something to

266
00:13:22,350 --> 00:13:20,529
power life's metabolisms so where might

267
00:13:23,190 --> 00:13:22,360
we find environments that are different

268
00:13:25,230 --> 00:13:23,200
from ours

269
00:13:27,570 --> 00:13:25,240
but might still have these key

270
00:13:32,329 --> 00:13:30,150
one exciting possibility is actually

271
00:13:35,790 --> 00:13:32,339
Europa one of the moons of Jupiter and

272
00:13:39,690 --> 00:13:35,800
this does have we suspect we know a

273
00:13:43,590 --> 00:13:39,700
strong sir a large subsurface ocean now

274
00:13:46,670 --> 00:13:43,600
by definition big ocean water check no

275
00:13:47,880 --> 00:13:46,680
problem what about our biological

276
00:13:50,850 --> 00:13:47,890
elements

277
00:13:54,329 --> 00:13:50,860
well we think Europa probably could have

278
00:13:57,090 --> 00:13:54,339
them meteorites which come from comets

279
00:13:59,970 --> 00:13:57,100
and asteroids can definitely form the

280
00:14:02,009 --> 00:13:59,980
beginnings of organic molecules and we

281
00:14:04,710 --> 00:14:02,019
think these arrived on earth we know

282
00:14:07,620 --> 00:14:04,720
Europa is pockmarked from collisions

283
00:14:10,350 --> 00:14:07,630
with these bodies so if they could go

284
00:14:13,079 --> 00:14:10,360
through the ice we would expect the

285
00:14:16,370 --> 00:14:13,089
ocean to be infused with these organic

286
00:14:20,639 --> 00:14:16,380
ingredients so okay let's give it a tick

287
00:14:22,410 --> 00:14:20,649
how about energy well Jupiter's an

288
00:14:24,690 --> 00:14:22,420

awfully a long way away from the Sun

289
00:14:28,530 --> 00:14:24,700
it's not going to be receiving much

290
00:14:30,740 --> 00:14:28,540
sunlight however it turns out to have an

291
00:14:33,530 --> 00:14:30,750
alternative energy source

292
00:14:36,569 --> 00:14:33,540
Europa's orbit is slightly elliptical

293
00:14:40,019 --> 00:14:36,579
due to the pull from neighbouring moons

294
00:14:42,269 --> 00:14:40,029
IO and Ganymede and this means that it

295
00:14:44,850 --> 00:14:42,279
comes closer to Jupiter and then it

296
00:14:47,130 --> 00:14:44,860
moves a bit further away and as it does

297
00:14:50,639 --> 00:14:47,140
Jupiter's gravity strengthens and

298
00:14:53,160 --> 00:14:50,649
weakens and this means the moon is

299
00:14:56,910 --> 00:14:53,170
actually flexed like squeezing a flake

300
00:15:00,240 --> 00:14:56,920
stress ball and as this flexing occurs

301
00:15:05,430 --> 00:15:00,250
the moon is heated and we call this

302
00:15:09,480 --> 00:15:05,440
tidal heating so tick Europa may indeed

303
00:15:11,370 --> 00:15:09,490
have all three key ingredients so how do

304
00:15:14,460 --> 00:15:11,380
we find out well

305
00:15:17,220 --> 00:15:14,470
Europa's in our solar system so let's go

306
00:15:19,740 --> 00:15:17,230
and there's two future missions that are

307
00:15:22,620 --> 00:15:19,750
going to be exploring this the first is

308
00:15:25,410 --> 00:15:22,630
deuce Jupiter icy moon Explorer mission

309
00:15:27,930 --> 00:15:25,420
this is a mission led by the European

310
00:15:30,329 --> 00:15:27,940
Space Agency but has a strong

311
00:15:33,750 --> 00:15:30,339
association with Japan's JAXA as well

312
00:15:36,540 --> 00:15:33,760
and juice will launch in 2022 and arrive

313
00:15:38,670 --> 00:15:36,550

in 2030 and is going to be exploring a

314
00:15:39,639 --> 00:15:38,680
number of the moons principally Ganymede

315
00:15:42,129 --> 00:15:39,649
but also

316
00:15:44,470 --> 00:15:42,139
Europa following that is going to be

317
00:15:46,660 --> 00:15:44,480
NASA's you rope a clipper which is

318
00:15:48,609 --> 00:15:46,670
hoping to launch sometime in the 2020s

319
00:15:51,189 --> 00:15:48,619
if the mission is finally approved and

320
00:15:54,160 --> 00:15:51,199
this would be a mission focused on

321
00:15:58,449 --> 00:15:54,170
Europa with plans to see if there's any

322
00:16:00,759 --> 00:15:58,459
detectable signs of life however this is

323
00:16:02,859 --> 00:16:00,769
all very well when we can go to the

324
00:16:06,309 --> 00:16:02,869
place but if we're going to start

325
00:16:09,790 --> 00:16:06,319
looking at exoplanets subsurface life is

326
00:16:11,829 --> 00:16:09,800
going to be really hard to spot we need

327
00:16:15,579 --> 00:16:11,839
life that can interact with the planet's

328
00:16:17,040 --> 00:16:15,589
atmosphere so what about detectable life

329
00:16:21,249 --> 00:16:17,050
on exoplanets

330
00:16:24,340 --> 00:16:21,259
well Gliese a 1214 B is interesting

331
00:16:26,980 --> 00:16:24,350
because its density is weird it has a

332
00:16:29,619 --> 00:16:26,990
density that's too low to be a rocky

333
00:16:34,119 --> 00:16:29,629
planet like the earth but too high for

334
00:16:37,329 --> 00:16:34,129
gas so what is it well we think it may

335
00:16:40,449 --> 00:16:37,339
be a water world with a global ocean

336
00:16:44,230 --> 00:16:40,459
covering the whole planet could that be

337
00:16:47,530 --> 00:16:44,240
habitable it got water but for a surface

338
00:16:50,650 --> 00:16:47,540

ocean we have some problems namely our

339
00:16:54,309 --> 00:16:50,660
atmosphere so on earth carbon dioxide

340
00:16:56,110 --> 00:16:54,319
keeps our earth warm and the quantity is

341
00:16:59,470 --> 00:16:56,120
controlled by something called the

342
00:17:02,650 --> 00:16:59,480
carbon cycle so here the carbon dioxide

343
00:17:05,289 --> 00:17:02,660
in the air comes down as rain it reacts

344
00:17:08,049 --> 00:17:05,299
with the rocks and forms a solid the

345
00:17:09,460 --> 00:17:08,059
solid get washed into the ocean and then

346
00:17:12,730 --> 00:17:09,470
eventually it's returned to the

347
00:17:15,909 --> 00:17:12,740
atmosphere through volcanoes now during

348
00:17:18,610 --> 00:17:15,919
the early stages of our Earth's life the

349
00:17:21,669 --> 00:17:18,620
Sun was cooler and dimmer and this

350
00:17:24,159 --> 00:17:21,679
actually would have reduced the reaction

351
00:17:26,799 --> 00:17:24,169
with the rock and so we would have ended

352
00:17:29,769 --> 00:17:26,809
up pumping more carbon dioxide into the

353
00:17:31,930 --> 00:17:29,779
air than we were taking out and this

354
00:17:34,510 --> 00:17:31,940
would allow our planet to stay warm

355
00:17:37,149 --> 00:17:34,520
during these early cooler years when

356
00:17:40,480 --> 00:17:37,159
life was beginning to start if we don't

357
00:17:44,350 --> 00:17:40,490
have a carbon cycle because carbon

358
00:17:46,930 --> 00:17:44,360
cycles need land you have to get exactly

359
00:17:49,240 --> 00:17:46,940
the right amount of radiation hitting

360
00:17:51,639 --> 00:17:49,250
the planets which becomes a lot less

361
00:17:52,890 --> 00:17:51,649
likely and means the planet is not

362
00:17:54,630 --> 00:17:52,900
resilient

363
00:17:57,930 --> 00:17:54,640

to slight changes in the amount of

364
00:17:59,940 --> 00:17:57,940
radiation is receiving so we're unsure

365
00:18:03,150 --> 00:17:59,950
whether a Waterworld could indeed be

366
00:18:05,790 --> 00:18:03,160
habitable another planets that's hit the

367
00:18:08,250 --> 00:18:05,800
news a lot are the Trappist system these

368
00:18:11,970 --> 00:18:08,260
came to light in February this year and

369
00:18:14,700 --> 00:18:11,980
everyone got very excited so Trappist 1e

370
00:18:18,600 --> 00:18:14,710
is a planet that orbits its star in just

371
00:18:21,690 --> 00:18:18,610
six days but its star is very very dim

372
00:18:24,390 --> 00:18:21,700
so Trappist 1e actually receives a very

373
00:18:28,680 --> 00:18:24,400
similar amount of radiation as the earth

374
00:18:31,620 --> 00:18:28,690
does from the Sun however it is so close

375
00:18:33,870 --> 00:18:31,630
to the star that we expect one side of

376
00:18:37,500 --> 00:18:33,880
the planet to be facing the star at all

377
00:18:39,960 --> 00:18:37,510
times in the same way the moon always is

378
00:18:43,020 --> 00:18:39,970
pointing to the earth and the reason for

379
00:18:46,080 --> 00:18:43,030
this is that at such close proximity a

380
00:18:49,500 --> 00:18:46,090
bulge is raised due to the gravity of

381
00:18:52,710 --> 00:18:49,510
the star on the planet and as the planet

382
00:18:56,400 --> 00:18:52,720
tries to rotate the star's gravity drags

383
00:18:59,460 --> 00:18:56,410
on this bulge and causes the planet to

384
00:19:03,800 --> 00:18:59,470
turn so that one side is always facing

385
00:19:06,510 --> 00:19:03,810
the star and we call this tidal locking

386
00:19:09,990 --> 00:19:06,520
and what this means is the planet is a

387
00:19:13,740 --> 00:19:10,000
split world one side of Perpetual day

388
00:19:15,960 --> 00:19:13,750

that can get very hot on one side of icy

389
00:19:18,840 --> 00:19:15,970
night that is always facing away from

390
00:19:21,750 --> 00:19:18,850
the star now if the planet's atmosphere

391
00:19:25,080 --> 00:19:21,760
is thick enough you could have winds

392
00:19:27,390 --> 00:19:25,090
that redistributed that heat and in

393
00:19:30,780 --> 00:19:27,400
which case it might be possible to have

394
00:19:33,450 --> 00:19:30,790
this twilight zone between the cold side

395
00:19:36,240 --> 00:19:33,460
and the hot side when liquid for water

396
00:19:39,750 --> 00:19:36,250
could form and the star was always on

397
00:19:41,610 --> 00:19:39,760
the horizon so the bottom line is yet we

398
00:19:44,010 --> 00:19:41,620
don't quite know what it takes to be a

399
00:19:46,890 --> 00:19:44,020
habitable planet because we only have

400
00:19:49,560 --> 00:19:46,900
one example but with future missions and

401
00:19:55,120 --> 00:19:49,570
our new telescopes we're on the brink of

402
00:20:28,630 --> 00:19:57,130
[Applause]