

1
00:00:01,669 --> 00:00:07,169
good evening and welcome to the Space

2
00:00:04,500 --> 00:00:09,000
Telescope public lecture series I'm your

3
00:00:07,169 --> 00:00:11,550
host dr. Frank summers of the office of

4
00:00:09,000 --> 00:00:13,469
public outreach and is my joy and

5
00:00:11,550 --> 00:00:16,230
pleasure to be your host each and every

6
00:00:13,468 --> 00:00:18,809
month when you came in tonight we had

7
00:00:16,230 --> 00:00:19,679
lithographs tonight's lithograph is a

8
00:00:18,809 --> 00:00:22,679
new one

9
00:00:19,679 --> 00:00:25,559
it's an old image but we realized we'd

10
00:00:22,679 --> 00:00:27,480
never put out a lithograph of this image

11
00:00:25,559 --> 00:00:30,509
it's one of the classic images of the

12
00:00:27,480 --> 00:00:32,159
Orion Nebula from 2005 Hubble's it was

13
00:00:30,510 --> 00:00:35,460
released on Hubble's 15th anniversary

14
00:00:32,159 --> 00:00:37,379
and at the time it was one of the

15
00:00:35,460 --> 00:00:42,120
largest mosaics we'd ever put together

16
00:00:37,380 --> 00:00:44,730
it was some 300 million pixels when we

17
00:00:42,119 --> 00:00:47,308
released it Photoshop had a really hard

18
00:00:44,729 --> 00:00:49,439
time melding all those pixels together

19
00:00:47,308 --> 00:00:51,179
it's kind of funny we look at the things

20
00:00:49,439 --> 00:00:52,769
who all we handled all the time these

21
00:00:51,179 --> 00:00:56,488
days these hundred million pixel images

22
00:00:52,770 --> 00:00:59,190
you know in 2005 handily a 300 million

23
00:00:56,488 --> 00:01:01,948
pixel image was not an easy thing thing

24
00:00:59,189 --> 00:01:04,768
to do so if you want to learn about

25
00:01:01,948 --> 00:01:06,929
what's at the science in it turn over on

26
00:01:04,769 --> 00:01:09,600
the back and you can see it is star

27
00:01:06,930 --> 00:01:12,510
formation on a grand scale in the Orion

28
00:01:09,599 --> 00:01:14,759
Nebula and for those of you online we

29

00:01:12,510 --> 00:01:19,020
have the link amazing space Torg

30
00:01:14,760 --> 00:01:21,630
resource page 5 4 5 and you can download

31
00:01:19,019 --> 00:01:24,989
a PDF of it and look at it at your

32
00:01:21,629 --> 00:01:29,219
leisure our talk tonight your place in

33
00:01:24,989 --> 00:01:32,819
the stars from a my immoral Martyn next

34
00:01:29,219 --> 00:01:35,280
month we have an astrophysicist guide to

35
00:01:32,819 --> 00:01:37,618
the film Deep Field the impossible

36
00:01:35,280 --> 00:01:40,290
magnitude of our universe by this crazy

37
00:01:37,618 --> 00:01:41,849
guy Frank summers he'll probably just

38
00:01:40,290 --> 00:01:44,610
make it all up as he goes along because

39
00:01:41,849 --> 00:01:48,118
I know him he just says he just rambles

40
00:01:44,609 --> 00:01:50,700
on in April the art and science of

41
00:01:48,118 --> 00:01:53,849
astronomical image processing from Joe

42
00:01:50,700 --> 00:01:55,409
de Pascua a few years ago how many

43
00:01:53,849 --> 00:01:57,688

people heard Zolt Levay give a talk

44

00:01:55,409 --> 00:02:00,390

similar to this a couple years ago it

45

00:01:57,688 --> 00:02:02,908

was like four or five years ago Joe is

46

00:02:00,390 --> 00:02:05,909

our new image processor if you remember

47

00:02:02,909 --> 00:02:09,719

his old retired last summer at the end

48

00:02:05,909 --> 00:02:12,120

of last summer and Joe is our new lead

49

00:02:09,719 --> 00:02:14,318

image processor and he will give his

50

00:02:12,120 --> 00:02:17,289

take on it on how he processes

51

00:02:14,318 --> 00:02:19,539

he also has significant experience doing

52

00:02:17,289 --> 00:02:23,919

x-ray astronomy he came to us from the

53

00:02:19,539 --> 00:02:26,259

Chandra x-ray Observatory up in Boston

54

00:02:23,919 --> 00:02:30,578

so he's got a really cool take on a lot

55

00:02:26,259 --> 00:02:32,769

of things and in May we have Jolin carbo

56

00:02:30,579 --> 00:02:35,859

Berg talking she did not give me a topic

57

00:02:32,769 --> 00:02:38,259

yet but her specialty is red giant stars

58
00:02:35,859 --> 00:02:40,840
in extrasolar planets so I'm thinking

59
00:02:38,259 --> 00:02:44,709
that will be her title but we'll find

60
00:02:40,840 --> 00:02:47,438
out from her soon real soon and it will

61
00:02:44,709 --> 00:02:50,259
be posted on our website when we do have

62
00:02:47,438 --> 00:02:51,638
that this is our website if you just go

63
00:02:50,259 --> 00:02:53,649
to your favorite search engine and took

64
00:02:51,639 --> 00:02:56,799
it look for Space Telescope public

65
00:02:53,650 --> 00:02:58,329
lecture you'll find this webpage where

66
00:02:56,799 --> 00:03:00,730
we have the list of the upcoming talks

67
00:02:58,329 --> 00:03:03,150
over here on the right on the Left we

68
00:03:00,729 --> 00:03:07,568
have the links to the webcasting both

69
00:03:03,150 --> 00:03:10,389
live on STS a webcasting and YouTube as

70
00:03:07,568 --> 00:03:14,530
well as the archives where YouTube goes

71
00:03:10,389 --> 00:03:18,609
back to 2014 that's five years now and

72
00:03:14,530 --> 00:03:21,908
STS AI goes all the way back to 2005 so

73
00:03:18,609 --> 00:03:22,629
that's of almost 14 years of webcasting

74
00:03:21,908 --> 00:03:25,539
there for you

75
00:03:22,628 --> 00:03:28,560
if you would like the monthly and out

76
00:03:25,539 --> 00:03:31,959
announcements sign up for email there

77
00:03:28,560 --> 00:03:35,500
yes that emails just to say again sign

78
00:03:31,959 --> 00:03:36,938
up at the website or if you not don't

79
00:03:35,500 --> 00:03:38,169
want to do that you could just write it

80
00:03:36,938 --> 00:03:39,758
down on a piece of paper and hand it to

81
00:03:38,169 --> 00:03:42,009
me at the end of the lecture and I'll

82
00:03:39,758 --> 00:03:43,568
make sure you get on there if you have

83
00:03:42,008 --> 00:03:46,119
comments and questions you can send them

84
00:03:43,568 --> 00:03:50,530
to our email address public lecture at

85
00:03:46,120 --> 00:03:52,810
STScI dot edu finally if you are on

86

00:03:50,530 --> 00:03:55,000
looking for us on social media you will

87
00:03:52,810 --> 00:03:56,408
find Hubble of the James Webb Space

88
00:03:55,000 --> 00:03:58,688
Telescope as well as the Space Telescope

89
00:03:56,408 --> 00:04:01,870
Science Institute on Facebook Twitter

90
00:03:58,688 --> 00:04:06,728
YouTube and Instagram you'll find me on

91
00:04:01,870 --> 00:04:09,430
Facebook and Twitter sometimes now after

92
00:04:06,729 --> 00:04:11,680
the lecture we often go observing or

93
00:04:09,430 --> 00:04:14,319
sometimes go to observing hasn't been

94
00:04:11,680 --> 00:04:17,158
very often lately they tell me it is

95
00:04:14,318 --> 00:04:20,019
cloudy tonight so we will not be having

96
00:04:17,158 --> 00:04:22,269
observing if you would like to try and

97
00:04:20,019 --> 00:04:26,110
get to the observing you can go to MD

98
00:04:22,269 --> 00:04:27,909
dot space grant o RG and you'll find the

99
00:04:26,110 --> 00:04:30,069
Maryland spacecraft servitor e open

100
00:04:27,910 --> 00:04:31,990

how's Paige and they have the

101

00:04:30,069 --> 00:04:34,240
observatory status there they do

102

00:04:31,990 --> 00:04:36,370
observing every Friday nights check it

103

00:04:34,240 --> 00:04:37,600
about 5:00 p.m. on Friday and they'll

104

00:04:36,370 --> 00:04:42,550
let you know whether they're gonna open

105

00:04:37,600 --> 00:04:47,320
on a Friday night okay now our news from

106

00:04:42,550 --> 00:04:51,189
the universe for February 2019 our first

107

00:04:47,319 --> 00:04:54,399
story is new year new moon and new

108

00:04:51,189 --> 00:04:55,319
perspective now new year was last month

109

00:04:54,399 --> 00:05:02,669
right

110

00:04:55,319 --> 00:05:06,790
not quite today is Chinese New Year or

111

00:05:02,670 --> 00:05:08,590
the year of the pig so happy new year as

112

00:05:06,790 --> 00:05:10,660
an astronomer I don't like to think that

113

00:05:08,589 --> 00:05:12,879
this is Chinese New Year because the

114

00:05:10,660 --> 00:05:16,360
Chinese use the Gregorian calendar too

115
00:05:12,879 --> 00:05:19,870
it's the traditional Chinese or it's the

116
00:05:16,360 --> 00:05:21,610
lunar calendar because this was the

117
00:05:19,870 --> 00:05:25,300
beginning of the lunar calendar the

118
00:05:21,610 --> 00:05:26,770
lunar new year is today which means of

119
00:05:25,300 --> 00:05:27,250
course what is the start of a lunar

120
00:05:26,769 --> 00:05:29,979
cycle

121
00:05:27,250 --> 00:05:34,600
so what phases the moon in at the start

122
00:05:29,980 --> 00:05:37,060
of a cycle it's in New Moon and it just

123
00:05:34,600 --> 00:05:43,180
so happens that yesterday during New

124
00:05:37,060 --> 00:05:46,990
Moon the Chinese satellite longcheng -

125
00:05:43,180 --> 00:05:50,139
took a picture of the moon during new

126
00:05:46,990 --> 00:05:51,460
moon so when you take a picture can we

127
00:05:50,139 --> 00:05:54,899
get the house lights down a bit this is

128
00:05:51,459 --> 00:05:57,189
there's too much scattered light on this

129
00:05:54,899 --> 00:05:57,699
there you go now you're starting to see

130
00:05:57,189 --> 00:05:59,589
it better

131
00:05:57,699 --> 00:06:02,250
so what are you seeing when you're

132
00:05:59,589 --> 00:06:05,560
seeing the moon what is lit at New Moon

133
00:06:02,250 --> 00:06:09,389
the far side there is no dark side to

134
00:06:05,560 --> 00:06:11,709
the moon but dark side of the Moon is

135
00:06:09,389 --> 00:06:14,889
night ok uh-huh

136
00:06:11,709 --> 00:06:17,769
so when we look at the moon during New

137
00:06:14,889 --> 00:06:18,879
Moon we only see the dark side ok all

138
00:06:17,769 --> 00:06:21,310
right that's the near side of the moon

139
00:06:18,879 --> 00:06:24,550
but the far side of course is fully lit

140
00:06:21,310 --> 00:06:27,129
so this satellite is orbiting around the

141
00:06:24,550 --> 00:06:30,730
moon and is able to take a picture of

142
00:06:27,129 --> 00:06:33,279
the full full full moon but it's of the

143

00:06:30,730 --> 00:06:36,090
dark side ok on the far side really you

144
00:06:33,279 --> 00:06:36,089
guys are messing me up

145
00:06:36,668 --> 00:06:43,250
of the far side of the moon in full moon

146
00:06:40,310 --> 00:06:44,959
okay whatever you and I from Earth see

147
00:06:43,250 --> 00:06:46,759
the full moon it's always the near side

148
00:06:44,959 --> 00:06:49,269
at full moon right okay

149
00:06:46,759 --> 00:06:53,270
this is a fully lit far side of the Moon

150
00:06:49,269 --> 00:06:56,930
however it's a really cooler picture

151
00:06:53,269 --> 00:07:01,038
than you might think it is because six

152
00:06:56,930 --> 00:07:03,918
billion people photobomb this image I

153
00:07:01,038 --> 00:07:12,069
covered it up and now I reveal there it

154
00:07:03,918 --> 00:07:15,560
is they got a picture of the full moon

155
00:07:12,069 --> 00:07:18,409
off showing the far side and earth in

156
00:07:15,560 --> 00:07:24,050
the background okay this is kind of cool

157
00:07:18,410 --> 00:07:26,660

so do you have a question yes this is

158

00:07:24,050 --> 00:07:28,639

the side we never see okay it's because

159

00:07:26,660 --> 00:07:32,930

the moon is tidally locked so we only

160

00:07:28,639 --> 00:07:35,720

see the same side as it orbits it always

161

00:07:32,930 --> 00:07:38,538

shows the same side to earth right okay

162

00:07:35,720 --> 00:07:40,250

so this backside of the far side is

163

00:07:38,538 --> 00:07:41,959

never is never seen when you're on earth

164

00:07:40,250 --> 00:07:44,418

you actually have to get off earth to

165

00:07:41,959 --> 00:07:47,899

see it so we never saw the far side

166

00:07:44,418 --> 00:07:51,609

until we're in it to space okay so

167

00:07:47,899 --> 00:07:51,609

that's a cool thing other question

168

00:07:54,189 --> 00:07:59,629

actually is on this side there what

169

00:07:57,139 --> 00:08:01,759

there aren't of the big moire okay in

170

00:07:59,629 --> 00:08:03,620

detail this is a rope but first of all

171

00:08:01,759 --> 00:08:06,169

this is a really really low resolution

172
00:08:03,620 --> 00:08:08,959
camera okay it's a webcam basically at

173
00:08:06,168 --> 00:08:11,329
best all right this is not a scientific

174
00:08:08,959 --> 00:08:13,098
instrument okay this is just a webcam

175
00:08:11,329 --> 00:08:16,189
and I think the whole resolution of this

176
00:08:13,098 --> 00:08:19,879
pic of this photo is 640 by 480 okay so

177
00:08:16,189 --> 00:08:22,519
it's not even a good web kick but in

178
00:08:19,879 --> 00:08:25,610
detail there's a ton more craters on the

179
00:08:22,519 --> 00:08:27,529
far side where I was on the near side we

180
00:08:25,610 --> 00:08:29,900
had the huge impact that that had the

181
00:08:27,529 --> 00:08:33,588
Mari spread out and the lava filled in

182
00:08:29,899 --> 00:08:36,078
to create the big large impact crater

183
00:08:33,589 --> 00:08:39,709
scare question over there

184
00:08:36,078 --> 00:08:42,439
same question okay yeah unfortunately if

185
00:08:39,708 --> 00:08:44,869
you see a Clementine image of the far

186
00:08:42,440 --> 00:08:47,540
side of the Moon it's got tons and tons

187
00:08:44,870 --> 00:08:49,698
of craters okay and this is actually a

188
00:08:47,539 --> 00:08:56,480
a much more detailed in the cratering

189
00:08:49,698 --> 00:08:59,120
okay last question all right so the dark

190
00:08:56,480 --> 00:09:00,949
spot up top here alright so the dark

191
00:08:59,120 --> 00:09:02,899
spot up top here that would be where

192
00:09:00,948 --> 00:09:05,149
there was a significant impact that

193
00:09:02,899 --> 00:09:07,490
smashed through the crust and then the

194
00:09:05,149 --> 00:09:09,470
lava welled up and filled it in okay

195
00:09:07,490 --> 00:09:11,568
just like you see on the near side you

196
00:09:09,470 --> 00:09:14,839
see some really big ones of the Luna

197
00:09:11,568 --> 00:09:17,179
Mari mom Aria right the C's quote quote

198
00:09:14,839 --> 00:09:20,029
of the moon these are actually places

199
00:09:17,179 --> 00:09:22,068
where the lava from the inside welled up

200

00:09:20,028 --> 00:09:23,990
and and filled in and made it smooth and

201
00:09:22,068 --> 00:09:27,799
actually erase the craters that were

202
00:09:23,990 --> 00:09:32,389
there before okay all right our second

203
00:09:27,799 --> 00:09:34,609
story a 500 megapixel view of the

204
00:09:32,389 --> 00:09:37,129
Triangulum galaxy I was speaking about

205
00:09:34,610 --> 00:09:39,860
the Orion Nebula image being 300

206
00:09:37,129 --> 00:09:41,448
megapixels Wow we have a 500 megapixel

207
00:09:39,860 --> 00:09:44,659
view okay

208
00:09:41,448 --> 00:09:48,349
so let's set this up for you this is a

209
00:09:44,659 --> 00:09:51,528
pan of the night sky for showing our

210
00:09:48,350 --> 00:09:53,810
Milky Way galaxy our Milky Way is a

211
00:09:51,528 --> 00:09:56,778
large galaxy and in the local group

212
00:09:53,809 --> 00:09:58,250
there are three respectable galaxies and

213
00:09:56,778 --> 00:10:01,068
a lot of you know flotsam and jetsam

214
00:09:58,250 --> 00:10:02,899

dwarf galaxies okay you can see two of

215

00:10:01,068 --> 00:10:04,759

the philosopher jets and Worf galaxies

216

00:10:02,899 --> 00:10:07,970

over here on the right these are the

217

00:10:04,759 --> 00:10:10,009

large and small Magellanic Clouds you

218

00:10:07,970 --> 00:10:14,360

can see the other large galaxies over

219

00:10:10,009 --> 00:10:17,120

here on the left this is the Andromeda

220

00:10:14,360 --> 00:10:19,430

galaxy so the second large galaxies in

221

00:10:17,120 --> 00:10:22,039

our local group is the Andromeda galaxy

222

00:10:19,429 --> 00:10:24,859

it's about the same size as the Milky

223

00:10:22,039 --> 00:10:29,419

Way perhaps about 10-15 percent larger

224

00:10:24,860 --> 00:10:34,850

from most estimates and about ten years

225

00:10:29,419 --> 00:10:37,370

ago we did a very large mosaic spanning

226

00:10:34,850 --> 00:10:39,649

through the Andromeda galaxy and it was

227

00:10:37,370 --> 00:10:42,828

called the pen chromatic Hubble

228

00:10:39,649 --> 00:10:45,139

Andromeda Treasury program just because

229
00:10:42,828 --> 00:10:51,169
the P I wanted to be able to spell out

230
00:10:45,139 --> 00:10:52,579
PA JT o it's fat all right um so the pan

231
00:10:51,169 --> 00:10:55,929
chromatic novel and drama treasure

232
00:10:52,578 --> 00:10:58,549
burger was the largest image we've ever

233
00:10:55,929 --> 00:11:01,429
mosaic we've ever produced okay

234
00:10:58,549 --> 00:11:02,990
it was C if I go to the next

235
00:11:01,429 --> 00:11:06,589
here you go here it is here's the phat

236
00:11:02,990 --> 00:11:09,350
image okay it was like 52,000 pixels

237
00:11:06,590 --> 00:11:11,090
this way by like twenty thousand pixels

238
00:11:09,350 --> 00:11:13,670
this way this was definitely the full

239
00:11:11,090 --> 00:11:17,240
image was like a billion pixels here

240
00:11:13,669 --> 00:11:18,949
alright and this was like 420

241
00:11:17,240 --> 00:11:21,110
observations with Hubble different

242
00:11:18,950 --> 00:11:23,000
fields in the observations are amazing

243
00:11:21,110 --> 00:11:25,340
huge and that's why it's a treasury

244
00:11:23,000 --> 00:11:27,379
program because these were special

245
00:11:25,340 --> 00:11:30,560
programs given a lot of Hubble time to

246
00:11:27,379 --> 00:11:33,439
do really big things well this was a

247
00:11:30,559 --> 00:11:35,599
huge boon for stellar astronomy because

248
00:11:33,440 --> 00:11:38,000
they could resolve hundreds of millions

249
00:11:35,600 --> 00:11:40,519
of stars in the Andromeda galaxy and

250
00:11:38,000 --> 00:11:42,259
able to study the stellar populations

251
00:11:40,519 --> 00:11:45,139
going from the core of the galaxy out to

252
00:11:42,259 --> 00:11:47,779
the edge of the galaxy so if that worked

253
00:11:45,139 --> 00:11:50,240
for the Andromeda galaxy let's apply it

254
00:11:47,779 --> 00:11:52,879
to the third largest galaxies in our

255
00:11:50,240 --> 00:11:55,580
local group which is the Triangulum

256
00:11:52,879 --> 00:11:58,220
galaxy so this is a ground-based picture

257

00:11:55,580 --> 00:12:01,340
of the Triangulum galaxy and Hubble's

258
00:11:58,220 --> 00:12:04,340
going to do that same mosaicing and a

259
00:12:01,340 --> 00:12:06,200
few field on this and we covered

260
00:12:04,340 --> 00:12:09,889
approximately that much of the

261
00:12:06,200 --> 00:12:13,670
Triangulum galaxy and this 500 million

262
00:12:09,889 --> 00:12:16,250
pixel mosaic looks like that and you say

263
00:12:13,669 --> 00:12:17,779
well that's not really cool that not

264
00:12:16,250 --> 00:12:20,509
that that well you're seeing it unlike

265
00:12:17,779 --> 00:12:22,610
one megapixel okay so the 500 megapixels

266
00:12:20,509 --> 00:12:25,789
are aren't thing but just see there's an

267
00:12:22,610 --> 00:12:28,550
incredible amount of detail and let me

268
00:12:25,789 --> 00:12:30,649
oh and so they I think they probably

269
00:12:28,549 --> 00:12:33,139
considered calling it the pan chromatic

270
00:12:30,649 --> 00:12:36,559
Hubble Triangulum Treasury program but

271
00:12:33,139 --> 00:12:39,919

that would come out it so I'm just gonna

272

00:12:36,559 --> 00:12:43,399

refer to as the humble Triangulum mosaic

273

00:12:39,919 --> 00:12:47,240

no they did not try to call it the phtt

274

00:12:43,399 --> 00:12:50,029

that's suggest by me having fun here the

275

00:12:47,240 --> 00:12:52,310

Hubble triangular mosaic of all this

276

00:12:50,029 --> 00:12:56,029

stuff and let's show you just how

277

00:12:52,309 --> 00:12:58,399

detailed it is so here is the night sky

278

00:12:56,029 --> 00:13:00,649

and if you didn't know there's

279

00:12:58,399 --> 00:13:03,319

triangular major and triangular minor

280

00:13:00,649 --> 00:13:05,269

four constellations and of course here

281

00:13:03,320 --> 00:13:08,690

is our Triangulum galaxy in the center

282

00:13:05,269 --> 00:13:12,669

and watch how far we get to zoom in to

283

00:13:08,690 --> 00:13:12,670

see the full detail of the Hubble image

284

00:13:14,419 --> 00:13:30,740

yeah we just keep going and we keep

285

00:13:18,320 --> 00:13:33,870

going yeah there you go that we get to

286
00:13:30,740 --> 00:13:36,799
the detail the Hubble image okay

287
00:13:33,870 --> 00:13:39,139
[Laughter]

288
00:13:36,799 --> 00:13:41,089
yours go definitely can't do it because

289
00:13:39,139 --> 00:13:43,309
you see all this blurry over here in the

290
00:13:41,090 --> 00:13:45,800
lower left corner yeah that's what we're

291
00:13:43,309 --> 00:13:47,569
taking from the DSS survey etc and this

292
00:13:45,799 --> 00:13:50,289
is the Hubble image overlaid on top of

293
00:13:47,570 --> 00:13:52,629
it and all of these stars you see here

294
00:13:50,289 --> 00:13:56,980
they're not stars in the foreground

295
00:13:52,629 --> 00:14:01,309
those are stars in the Triangulum galaxy

296
00:13:56,980 --> 00:14:04,129
okay we are resolving individual stars

297
00:14:01,309 --> 00:14:06,579
in the Triangulum galaxy they tell me

298
00:14:04,129 --> 00:14:10,639
there are more than 25 million

299
00:14:06,580 --> 00:14:13,490
individual stars in this mosaic so

300
00:14:10,639 --> 00:14:15,919
here's the mosaic this up here is NGC

301
00:14:13,490 --> 00:14:18,379
604 one of the largest star forming

302
00:14:15,919 --> 00:14:20,299
regions in the local group and you can

303
00:14:18,379 --> 00:14:22,159
see what incredible detail Hubble can

304
00:14:20,299 --> 00:14:23,899
get in that and all the individual stars

305
00:14:22,159 --> 00:14:25,789
they can see look at this globular

306
00:14:23,899 --> 00:14:26,629
cluster okay that's the green box so

307
00:14:25,789 --> 00:14:29,149
that's right here

308
00:14:26,629 --> 00:14:31,669
that's a globular cluster that we're

309
00:14:29,149 --> 00:14:32,449
seeing in a galaxy three million

310
00:14:31,669 --> 00:14:35,269
light-years away

311
00:14:32,450 --> 00:14:37,820
okay there are of course a few

312
00:14:35,269 --> 00:14:40,189
foreground stars here that's the blue

313
00:14:37,820 --> 00:14:42,620
box so right here and there are also

314

00:14:40,190 --> 00:14:46,730
background galaxies alright then this

315
00:14:42,620 --> 00:14:50,720
red box here so the the world would even

316
00:14:46,730 --> 00:14:52,670
at the Triangulum galaxy is not opaque

317
00:14:50,720 --> 00:14:54,230
it is somewhat transparent so we can see

318
00:14:52,669 --> 00:14:56,360
through it and see some of the

319
00:14:54,230 --> 00:14:59,180
background galaxies now they're going to

320
00:14:56,360 --> 00:15:01,669
do again with the Triangulum galaxy the

321
00:14:59,179 --> 00:15:03,529
same star formation and star cell our

322
00:15:01,669 --> 00:15:06,829
population studies that they did with

323
00:15:03,529 --> 00:15:11,000
the Andromeda galaxy but as evidenced by

324
00:15:06,830 --> 00:15:13,490
NGC 604 there is significantly more star

325
00:15:11,000 --> 00:15:15,860
formation per unit mass in the

326
00:15:13,490 --> 00:15:19,100
Triangulum galaxy so they're able to

327
00:15:15,860 --> 00:15:21,259
study more of these bursting star four

328
00:15:19,100 --> 00:15:23,720

regions the star formation rate in the

329

00:15:21,259 --> 00:15:25,340
Triangulum is ten times the star

330

00:15:23,720 --> 00:15:27,980
formation rate in the Andromeda galaxy

331

00:15:25,340 --> 00:15:30,980
so they're able to study in great

332

00:15:27,980 --> 00:15:32,450
Heil the stellar populations in a cell

333

00:15:30,980 --> 00:15:35,750
exceed with much more star formation

334

00:15:32,450 --> 00:15:39,770
which will give extend the study into

335

00:15:35,750 --> 00:15:41,899
new realms so we have another 500

336

00:15:39,769 --> 00:15:42,590
megapixel image Oh piece of cake right

337

00:15:41,899 --> 00:15:44,480
these days

338

00:15:42,590 --> 00:15:47,480
yeah even these are still difficult

339

00:15:44,480 --> 00:15:49,730
difficult to handle but by taking Hubble

340

00:15:47,480 --> 00:15:53,539
and spreading it over a lot of fields

341

00:15:49,730 --> 00:15:54,590
you can get a lot of images let me just

342

00:15:53,539 --> 00:15:58,759
say one thing

343
00:15:54,590 --> 00:16:03,649
okay that we have on the on the books

344
00:15:58,759 --> 00:16:06,590
for the next decade a telescope that has

345
00:16:03,649 --> 00:16:10,490
one the same resolution as Hubble but

346
00:16:06,590 --> 00:16:12,980
100 times the field of view all right

347
00:16:10,490 --> 00:16:15,139
in the next decade it's an infrared one

348
00:16:12,980 --> 00:16:17,269
okay but in the next decade we'll be

349
00:16:15,139 --> 00:16:19,669
able to take images like this routinely

350
00:16:17,269 --> 00:16:22,629
not using hundreds of individual

351
00:16:19,669 --> 00:16:24,219
pointings but using you know five ten

352
00:16:22,629 --> 00:16:26,990
individual pointings

353
00:16:24,220 --> 00:16:29,330
so we're looking towards in the next

354
00:16:26,990 --> 00:16:31,370
decade a great revolution in astronomy

355
00:16:29,330 --> 00:16:33,560
in terms of this the amount of data that

356
00:16:31,370 --> 00:16:37,179
we're gonna be able to handle with these

357
00:16:33,559 --> 00:16:40,789
hundred megapixel cameras on these very

358
00:16:37,179 --> 00:16:43,219
variety of telescopes so this is really

359
00:16:40,789 --> 00:16:44,990
cool it's really great but just reminds

360
00:16:43,220 --> 00:16:46,790
me that in the future this is gonna be

361
00:16:44,990 --> 00:16:48,549
commonplace and we're gonna be able to

362
00:16:46,789 --> 00:16:51,860
get this kind of type of stuff every day

363
00:16:48,549 --> 00:16:54,709
so let's enjoy it and always look

364
00:16:51,860 --> 00:16:57,039
forward to the future all right that's

365
00:16:54,710 --> 00:17:00,320
our news for the universe for tonight

366
00:16:57,039 --> 00:17:02,809
our featured speaker tonight is a Maya

367
00:17:00,320 --> 00:17:04,220
Mauro Martin she has been here at the

368
00:17:02,809 --> 00:17:06,230
Space Telescope Science Institute for

369
00:17:04,220 --> 00:17:13,160
five years and she works on what's

370
00:17:06,230 --> 00:17:15,170
called the science missions office and

371

00:17:13,160 --> 00:17:18,560
where she specializes it working on the

372
00:17:15,170 --> 00:17:24,200
James Webb Space Telescope our science

373
00:17:18,559 --> 00:17:26,299
studies focus on debris disks or yes

374
00:17:24,200 --> 00:17:27,740
their debris disks around stars of

375
00:17:26,299 --> 00:17:29,299
course there is a little bit of debris

376
00:17:27,740 --> 00:17:30,589
in our own solar system but most of

377
00:17:29,299 --> 00:17:32,720
place where you would find debris disc

378
00:17:30,589 --> 00:17:34,369
is around newly formed stars where there

379
00:17:32,720 --> 00:17:37,100
are planets forming out where planets

380
00:17:34,369 --> 00:17:39,469
have formed around other stars looking

381
00:17:37,099 --> 00:17:40,529
for these DS de su materials inside of

382
00:17:39,470 --> 00:17:42,870
those stars but

383
00:17:40,529 --> 00:17:44,879
she's going to talk about our place in

384
00:17:42,869 --> 00:17:58,859
the stars so ladies and gentlemen mi

385
00:17:44,880 --> 00:18:25,550

amor Oh Martin thank you thank you too

386

00:17:58,859 --> 00:18:36,959
much the pressure there you go

387

00:18:25,549 --> 00:18:39,000
all right so okay so to start with I'm

388

00:18:36,960 --> 00:18:40,140
going to show you a short movie by Eric

389

00:18:39,000 --> 00:18:42,359
we're in quiz

390

00:18:40,140 --> 00:18:45,540
narrated by Carl Sagan where you will

391

00:18:42,359 --> 00:18:48,149
see images of real sites on of our solar

392

00:18:45,539 --> 00:18:50,879
system that I've recreated from real

393

00:18:48,150 --> 00:18:53,340
photographs and real data obtained by

394

00:18:50,880 --> 00:18:55,640
NASA this short movie begins with an

395

00:18:53,339 --> 00:18:58,559
image of some nomads that are walking on

396

00:18:55,640 --> 00:18:59,880
a ballet on earth probably around the

397

00:18:58,559 --> 00:19:04,859
Neolithic around the time that

398

00:18:59,880 --> 00:19:09,140
agriculture was invented and M let's see

399

00:19:04,859 --> 00:19:09,139
if it plays there you go Oh

400
00:19:14,390 --> 00:19:21,440
what do you mean I think it went to the

401
00:19:18,750 --> 00:19:24,210
last piece of it there you go

402
00:19:21,440 --> 00:19:24,830
there so they are working on a ballet on

403
00:19:24,210 --> 00:19:28,079
earth

404
00:19:24,829 --> 00:19:31,679
just after sunset and in the horizon

405
00:19:28,079 --> 00:19:36,210
they can see Mercury Venus Mars and up

406
00:19:31,680 --> 00:19:38,160
there Jupiter and Saturn and the title

407
00:19:36,210 --> 00:19:40,950
of the movie is Wanderers which is the

408
00:19:38,160 --> 00:19:43,910
same name that the ancient Greeks gave

409
00:19:40,950 --> 00:19:46,799
to the to the planets to these nomads

410
00:19:43,910 --> 00:19:48,720
these planets were indistinguishable

411
00:19:46,799 --> 00:19:51,839
from the stars except that they were

412
00:19:48,720 --> 00:19:54,269
brighter and this how one stopped to

413
00:19:51,839 --> 00:19:56,628
observe them carefully record

414
00:19:54,269 --> 00:19:59,219
in their positions every night and

415
00:19:56,628 --> 00:20:01,949
realized that they move very different

416
00:19:59,219 --> 00:20:03,599
from the stars they start moving in one

417
00:20:01,950 --> 00:20:05,219
direction and then they start going in a

418
00:20:03,598 --> 00:20:07,439
retrograde direction and then they keep

419
00:20:05,219 --> 00:20:09,269
going in the same direction and this

420
00:20:07,440 --> 00:20:11,909
observation was done more than 2,000

421
00:20:09,269 --> 00:20:14,249
years ago by the ancient Greeks or maybe

422
00:20:11,909 --> 00:20:15,989
even earlier by the ancient Egyptians

423
00:20:14,249 --> 00:20:19,319
and this is why the ancient Greeks

424
00:20:15,989 --> 00:20:21,389
called these stars they call them

425
00:20:19,319 --> 00:20:23,308
wandering stars because they seem to

426
00:20:21,388 --> 00:20:25,228
wander in the sky and and the word

427
00:20:23,308 --> 00:20:27,868
planet comes from the Greek planet s

428

00:20:25,229 --> 00:20:30,389
that means wanderer the data of of the

429
00:20:27,868 --> 00:20:33,569
movie does not refer to the planets and

430
00:20:30,388 --> 00:20:36,088
it refers to our quest as humans to

431
00:20:33,569 --> 00:20:38,368
understand to discover to explore the

432
00:20:36,088 --> 00:20:41,519
unknown and in doing so many times we

433
00:20:38,368 --> 00:20:43,319
challenge a widely accepted ideas they

434
00:20:41,519 --> 00:20:45,959
make planets wander do movement as an

435
00:20:43,319 --> 00:20:48,118
example that movement drove many people

436
00:20:45,959 --> 00:20:49,979
crazy because they just couldn't figure

437
00:20:48,118 --> 00:20:52,319
out why the planets would do that and

438
00:20:49,979 --> 00:20:54,028
they could not understand it because the

439
00:20:52,319 --> 00:20:56,249
widely accepted view was that the earth

440
00:20:54,028 --> 00:20:58,709
was at the center of the universe but if

441
00:20:56,249 --> 00:21:00,538
you change that view that mindset that

442
00:20:58,709 --> 00:21:02,399

everybody believed in and you accept

443

00:21:00,538 --> 00:21:04,769

that the earth is not at the center of

444

00:21:02,398 --> 00:21:07,199

the universe but that moves around the

445

00:21:04,769 --> 00:21:09,569

Sun as Copernicus suggested more than

446

00:21:07,200 --> 00:21:12,028

400 years ago then the movement of the

447

00:21:09,569 --> 00:21:14,999

planets could be understood but

448

00:21:12,028 --> 00:21:15,569

challenging widely accepted ideas is not

449

00:21:14,999 --> 00:21:18,538

easy

450

00:21:15,569 --> 00:21:20,729

this is Galileo Galilei you all know him

451

00:21:18,538 --> 00:21:22,440

this is the Italian astronomer that ran

452

00:21:20,729 --> 00:21:25,619

into a lot of trouble for defending that

453

00:21:22,440 --> 00:21:27,179

the earth was moving around the Sun and

454

00:21:25,618 --> 00:21:29,999

he was convinced this was the case

455

00:21:27,179 --> 00:21:32,399

because he had made careful observations

456

00:21:29,999 --> 00:21:34,858

using a telescope he was the first

457
00:21:32,398 --> 00:21:36,718
astronomer to do so and he had also

458
00:21:34,858 --> 00:21:38,398
discovered that they were fainter

459
00:21:36,719 --> 00:21:40,769
planets that were orbiting around

460
00:21:38,398 --> 00:21:42,598
Jupiter so if they were finding planets

461
00:21:40,769 --> 00:21:43,979
orbiting idea around you better why

462
00:21:42,598 --> 00:21:46,558
couldn't a bright the planets orbit

463
00:21:43,979 --> 00:21:48,778
around the Sun on Galileo got into a lot

464
00:21:46,558 --> 00:21:51,388
of trouble as I said for for defending

465
00:21:48,778 --> 00:21:52,858
this idea and for claiming the earth was

466
00:21:51,388 --> 00:21:55,019
not fixed at the center of the universe

467
00:21:52,858 --> 00:21:58,138
and he ended under house arrest because

468
00:21:55,019 --> 00:22:00,239
the Inquisition gives him and the story

469
00:21:58,138 --> 00:22:02,338
goes that when he was released he looked

470
00:22:00,239 --> 00:22:04,588
to the sky he looked down and he is

471
00:22:02,338 --> 00:22:06,928
stumped his food and he said and yet it

472
00:22:04,588 --> 00:22:07,589
moves because he wasn't surrender he

473
00:22:06,929 --> 00:22:11,460
said yeah

474
00:22:07,589 --> 00:22:14,759
it was based on evidence this is your

475
00:22:11,460 --> 00:22:16,200
Lana Bruno another astronomer scientist

476
00:22:14,759 --> 00:22:18,990
and philosopher that lived before

477
00:22:16,200 --> 00:22:21,150
Galileo that also got into a lot of

478
00:22:18,990 --> 00:22:23,308
trouble for arguing that in an infinite

479
00:22:21,150 --> 00:22:24,778
universe in which all if stars are

480
00:22:23,308 --> 00:22:26,639
surrounded by their own planetary

481
00:22:24,778 --> 00:22:28,409
systems the most logical thing will be

482
00:22:26,640 --> 00:22:32,669
for other worlds like the earth to exist

483
00:22:28,409 --> 00:22:34,528
and if so they would Harbor life think

484
00:22:32,669 --> 00:22:36,860
that this was this was an assignment

485

00:22:34,528 --> 00:22:40,500
made more than 400 years ago this is

486
00:22:36,859 --> 00:22:42,148
mind-blowing and his views of course

487
00:22:40,500 --> 00:22:44,460
were considered heretical at the time

488
00:22:42,148 --> 00:22:46,829
because and he was on trial and he was

489
00:22:44,460 --> 00:22:48,509
born to it to death but he stayed true

490
00:22:46,829 --> 00:22:50,158
to his arguments and one of the quotes

491
00:22:48,509 --> 00:22:52,829
that people attribute to him is that

492
00:22:50,159 --> 00:22:54,840
truth that does not change because it is

493
00:22:52,829 --> 00:22:57,658
or it is not believed by a majority of

494
00:22:54,839 --> 00:22:59,668
the people and guess what the other day

495
00:22:57,659 --> 00:23:01,620
while I was preparing this as lights

496
00:22:59,669 --> 00:23:03,750
I took a break to press one of the

497
00:23:01,619 --> 00:23:06,479
issues from nature the nature magazine

498
00:23:03,750 --> 00:23:09,509
that I get on the mail every week and I

499
00:23:06,480 --> 00:23:12,649

found this letter and this is a letter

500

00:23:09,509 --> 00:23:15,509
written by Galileo in 1613 and

501

00:23:12,648 --> 00:23:17,038
historians knew it existed but it was

502

00:23:15,509 --> 00:23:20,158
thought to be lost and it was discovered

503

00:23:17,038 --> 00:23:22,528
by chance this last August in London in

504

00:23:20,159 --> 00:23:25,950
the in the archives of the Royal Society

505

00:23:22,528 --> 00:23:28,079
and according to nature this is the

506

00:23:25,950 --> 00:23:30,390
letter where Galileo first defends that

507

00:23:28,079 --> 00:23:33,808
scientific research should be free from

508

00:23:30,390 --> 00:23:35,669
the theological doctrine and this letter

509

00:23:33,808 --> 00:23:38,009
that launched one of science history's

510

00:23:35,669 --> 00:23:40,080
most famous battles is one of the first

511

00:23:38,009 --> 00:23:42,179
secular manifestos about the freedom of

512

00:23:40,079 --> 00:23:46,769
science so this is a very powerful

513

00:23:42,179 --> 00:23:49,679
letter that fortunately now you know we

514
00:23:46,769 --> 00:23:52,230
know it's we have it now if it was it

515
00:23:49,679 --> 00:23:55,500
was thought it was lost and when I saw

516
00:23:52,230 --> 00:23:58,169
this him I felt that history was sending

517
00:23:55,500 --> 00:24:00,169
us a message from a time long past to

518
00:23:58,169 --> 00:24:02,850
remind us what is fantastic today

519
00:24:00,169 --> 00:24:04,980
because we live in a paradoxical time in

520
00:24:02,849 --> 00:24:07,469
which even though science and technology

521
00:24:04,980 --> 00:24:09,360
are omnipresent in our everyday life and

522
00:24:07,470 --> 00:24:11,069
thanks to them many of us enjoy a

523
00:24:09,359 --> 00:24:13,019
standard of living that has never been

524
00:24:11,069 --> 00:24:15,808
so high there is a growing gap between

525
00:24:13,019 --> 00:24:17,190
science and society as it can be seen

526
00:24:15,808 --> 00:24:19,200
for example in the questioning of

527
00:24:17,190 --> 00:24:20,789
vaccines and climate change the rise of

528
00:24:19,200 --> 00:24:23,009
alternative medicine

529
00:24:20,789 --> 00:24:25,980
and even the questioning of evolution

530
00:24:23,009 --> 00:24:28,349
and this is so because also things to

531
00:24:25,980 --> 00:24:29,579
science and technology never before we

532
00:24:28,349 --> 00:24:32,480
have had access to so much information

533
00:24:29,579 --> 00:24:34,889
but also to so much misinformation and

534
00:24:32,480 --> 00:24:36,750
we live in a Bosch truth world

535
00:24:34,890 --> 00:24:38,490
unfortunately we're ideological

536
00:24:36,750 --> 00:24:40,319
affirmations are commonly presented as

537
00:24:38,490 --> 00:24:43,049
equivalent to those based on evidence

538
00:24:40,319 --> 00:24:45,480
and this letter I thought was a reminder

539
00:24:43,049 --> 00:24:47,460
of the extraordinary importance of

540
00:24:45,480 --> 00:24:49,559
science to help citizens to develop the

541
00:24:47,460 --> 00:24:51,420
ability to think critically based on

542

00:24:49,559 --> 00:24:53,669
evidence which is the key of all

543
00:24:51,420 --> 00:24:55,289
scientific activity of course and which

544
00:24:53,670 --> 00:24:57,480
is an ability that can be applied to all

545
00:24:55,289 --> 00:24:59,399
aspects of her life and help us become

546
00:24:57,480 --> 00:25:01,740
better inform less manipulable and

547
00:24:59,400 --> 00:25:04,650
demand evidence nice policy and this is

548
00:25:01,740 --> 00:25:06,539
so important nowadays but let's get back

549
00:25:04,650 --> 00:25:08,250
to the source field I promise to show

550
00:25:06,539 --> 00:25:10,519
you this film talks about the need of

551
00:25:08,250 --> 00:25:13,230
the human being to explore the unknown

552
00:25:10,519 --> 00:25:15,150
because that curiosity is precisely one

553
00:25:13,230 --> 00:25:17,099
of the human beings most characteristic

554
00:25:15,150 --> 00:25:19,350
traits that curiosity is what centuries

555
00:25:17,099 --> 00:25:21,269
ago made us climb to the top of the

556
00:25:19,349 --> 00:25:24,899

highest mountains to see her essence

557

00:25:21,269 --> 00:25:26,460

that nobody has ever seen or make us

558

00:25:24,900 --> 00:25:28,290

dive into the deepest trenches of the

559

00:25:26,460 --> 00:25:31,710

ocean to witness the dark alien of the

560

00:25:28,289 --> 00:25:33,659

abbeys and it is the same quest that

561

00:25:31,710 --> 00:25:35,460

made us search for answers for what we

562

00:25:33,660 --> 00:25:36,960

don't understand like the movement of

563

00:25:35,460 --> 00:25:39,269

the planets in the sky it is the same

564

00:25:36,960 --> 00:25:41,309

curiosity that allow us to little by

565

00:25:39,269 --> 00:25:43,980

little make sense of the world we live

566

00:25:41,309 --> 00:25:45,869

in even if the findings challenge our

567

00:25:43,980 --> 00:25:48,750

previous beliefs like a story of Galileo

568

00:25:45,869 --> 00:25:50,609

and as I said that sort of movie begins

569

00:25:48,750 --> 00:25:52,589

with nomads that are looking at the

570

00:25:50,609 --> 00:25:54,990

planets and then a movie makes a big

571
00:25:52,589 --> 00:25:56,279
leap in time to show us a snapshot of

572
00:25:54,990 --> 00:25:58,079
the future where you can see a

573
00:25:56,279 --> 00:26:00,599
spacecraft moving away from the earth

574
00:25:58,079 --> 00:26:02,789
and on board this is crazy a spacecraft

575
00:26:00,599 --> 00:26:05,069
may be the first explorers of the solar

576
00:26:02,789 --> 00:26:07,680
system and what the short film does is

577
00:26:05,069 --> 00:26:11,519
to narrow it with images recreate it on

578
00:26:07,680 --> 00:26:13,710
real data and the story of these nomads

579
00:26:11,519 --> 00:26:15,839
these wonders of the future this

580
00:26:13,710 --> 00:26:20,940
pioneers Explorer II not me continents

581
00:26:15,839 --> 00:26:23,389
or new oceans but new worlds and now we

582
00:26:20,940 --> 00:26:23,390
see the movie

583
00:26:33,359 --> 00:26:35,839
the

584
00:26:46,250 --> 00:26:49,328
[Music]

585
00:26:59,740 --> 00:27:11,799
[Music]

586
00:27:11,259 --> 00:27:19,598
[Applause]

587
00:27:11,799 --> 00:27:19,598
[Music]

588
00:27:30,420 --> 00:27:43,109
[Music]

589
00:27:46,559 --> 00:27:49,710
[Music]

590
00:28:09,240 --> 00:28:12,480
[Music]

591
00:28:15,319 --> 00:28:35,399
[Music]

592
00:28:40,230 --> 00:28:43,358
[Music]

593
00:28:55,109 --> 00:28:59,269
[Music]

594
00:28:56,039 --> 00:28:59,990
[Applause]

595
00:28:59,269 --> 00:29:07,108
[Music]

596
00:28:59,990 --> 00:29:07,108
[Applause]

597
00:29:09,369 --> 00:29:19,788
[Music]

598
00:29:23,789 --> 00:29:26,858
[Music]

599

00:29:38,869 --> 00:29:41,969

[Music]

600

00:30:04,880 --> 00:30:10,440

breathtaking so why are we fascinated by

601

00:30:08,670 --> 00:30:12,210

these worlds because we have found

602

00:30:10,440 --> 00:30:14,100

through careful observation that they

603

00:30:12,210 --> 00:30:14,870

might Harbor the conditions to sustain

604

00:30:14,099 --> 00:30:17,549

life

605

00:30:14,869 --> 00:30:19,199

we haven't found life yet but knowing

606

00:30:17,549 --> 00:30:20,990

that the conditions for life may exist

607

00:30:19,200 --> 00:30:25,049

in these worlds is extraordinarily

608

00:30:20,990 --> 00:30:26,579

exciting so this is an image of Europa

609

00:30:25,049 --> 00:30:31,349

that you saw in the film

610

00:30:26,579 --> 00:30:34,919

it shows M explorers you see the

611

00:30:31,349 --> 00:30:36,809

Explorers here and they're walking on

612

00:30:34,920 --> 00:30:39,269

it's icy surface Europa is one of the

613

00:30:36,809 --> 00:30:44,159

great moons of Jupiter so here in the

614

00:30:39,269 --> 00:30:45,779

horizon this is Jupiter right and Europa

615

00:30:44,160 --> 00:30:47,730

is a little smaller than the moon and

616

00:30:45,779 --> 00:30:49,980

it's made of silicates with a core made

617

00:30:47,730 --> 00:30:52,650

of iron and nickel just like the earth

618

00:30:49,980 --> 00:30:54,660

but Europa has a thick frozen crust that

619

00:30:52,650 --> 00:30:57,420

is several several kilometers in thick

620

00:30:54,660 --> 00:30:59,310

that is full of cracks and there is

621

00:30:57,420 --> 00:31:01,440

evidence that under this ice there is a

622

00:30:59,309 --> 00:31:03,269

liquid ocean that is estimated to harbor

623

00:31:01,440 --> 00:31:04,680

twice as much water as the oceans of the

624

00:31:03,269 --> 00:31:06,960

earth and it is also believed that

625

00:31:04,680 --> 00:31:11,640

Europa has a tenuous atmosphere of

626

00:31:06,960 --> 00:31:13,950

oxygen how can there be liquid water

627

00:31:11,640 --> 00:31:16,380

inside Europa is it so far from the Sun

628
00:31:13,950 --> 00:31:18,720
right this is what we call the habitable

629
00:31:16,380 --> 00:31:20,940
zone is the area in the solar system

630
00:31:18,720 --> 00:31:23,640
where liquid water can exist on the

631
00:31:20,940 --> 00:31:27,000
surface only two planets are in this

632
00:31:23,640 --> 00:31:30,120
habitable zone in solar system Mars and

633
00:31:27,000 --> 00:31:32,190
and the earth and if you go to a to

634
00:31:30,119 --> 00:31:34,379
close scene is too hot and the water

635
00:31:32,190 --> 00:31:38,220
will evaporate and if you go too far out

636
00:31:34,380 --> 00:31:40,260
is to call and the water will be ice but

637
00:31:38,220 --> 00:31:41,880
liquid water can exist in Europa because

638
00:31:40,259 --> 00:31:44,250
it is very close to Jupiter and its

639
00:31:41,880 --> 00:31:46,050
enormous gravity produces tidal forces

640
00:31:44,250 --> 00:31:48,450
inside Europa data resource of energy

641
00:31:46,049 --> 00:31:50,970
these tidal forces are similar to those

642
00:31:48,450 --> 00:31:52,799
created by the moon on Earth's ocean

643
00:31:50,970 --> 00:31:55,799
that are responsible for the ocean tides

644
00:31:52,799 --> 00:31:57,779
so this tides in Europa are much

645
00:31:55,799 --> 00:31:59,519
stronger because Jupiter is very massive

646
00:31:57,779 --> 00:32:02,339
and they're so strong that they can

647
00:31:59,519 --> 00:32:04,049
cause geological activity similar to

648
00:32:02,339 --> 00:32:06,569
that of the tectonic plates on earth and

649
00:32:04,049 --> 00:32:09,149
this creates these cracks in the in the

650
00:32:06,569 --> 00:32:09,879
icy surface of Europa and through this

651
00:32:09,150 --> 00:32:12,190
crack

652
00:32:09,880 --> 00:32:14,530
seems that there is material from the

653
00:32:12,190 --> 00:32:16,779
frozen surface that sinks to the liquid

654
00:32:14,529 --> 00:32:18,399
ocean underneath and the other way

655
00:32:16,779 --> 00:32:20,910
around material from the liquid ocean

656

00:32:18,400 --> 00:32:24,160
underneath that rises to the surface and

657
00:32:20,910 --> 00:32:25,540
the reason why we know this is happening

658
00:32:24,160 --> 00:32:29,200
even though we haven't actually seen any

659
00:32:25,539 --> 00:32:31,059
robotic explorers project is any any any

660
00:32:29,200 --> 00:32:33,400
Explorer is there or any robotic

661
00:32:31,059 --> 00:32:35,289
explorers there is because we think that

662
00:32:33,400 --> 00:32:38,320
this brownish material that you see in

663
00:32:35,289 --> 00:32:40,119
the cracks is the salt that is coming

664
00:32:38,319 --> 00:32:43,149
from the liquid ocean underneath and we

665
00:32:40,119 --> 00:32:46,989
know this because when you put this type

666
00:32:43,150 --> 00:32:49,509
of salt in in a chamber and you put it

667
00:32:46,990 --> 00:32:51,579
under the temperature and the pressure

668
00:32:49,509 --> 00:32:53,799
that is in Europe I it comes out of a

669
00:32:51,579 --> 00:32:57,369
similar color as the one that we see in

670
00:32:53,799 --> 00:32:59,409

the cracks of Europa both the existence

671

00:32:57,369 --> 00:33:01,599

of liquid water in Europe and of that

672

00:32:59,410 --> 00:33:04,360

flow of material between the icy surface

673

00:33:01,599 --> 00:33:05,919

and the liquid or water underneath are

674

00:33:04,359 --> 00:33:07,719

very interested in the costal in the

675

00:33:05,920 --> 00:33:09,970

context of weather Europa could Harbor

676

00:33:07,720 --> 00:33:13,299

life and it has been speculated that

677

00:33:09,970 --> 00:33:15,279

there may be hydrothermal vents in that

678

00:33:13,299 --> 00:33:18,460

ocean of Europa as similar to the ones

679

00:33:15,279 --> 00:33:20,279

we have on earth and in on earth these

680

00:33:18,460 --> 00:33:23,860

vents are teeming with life

681

00:33:20,279 --> 00:33:27,309

sank to the heat exchange and the

682

00:33:23,859 --> 00:33:29,349

exchange of chemical compounds so Europa

683

00:33:27,309 --> 00:33:31,299

is also very interesting because it is

684

00:33:29,349 --> 00:33:33,369

very likely that it has the yetze of

685
00:33:31,299 --> 00:33:37,079
material that are will lunch into a

686
00:33:33,369 --> 00:33:38,859
space hundreds of kilometers high and

687
00:33:37,079 --> 00:33:41,319
similar to those that have been

688
00:33:38,859 --> 00:33:43,149
observing in another morning Enceladus

689
00:33:41,319 --> 00:33:45,549
one of Saturn's moon and this is an

690
00:33:43,150 --> 00:33:47,470
image of those jets of material taking

691
00:33:45,549 --> 00:33:51,730
with the Hubble Space Telescope by one

692
00:33:47,470 --> 00:33:53,920
of her researchers and this is an fel

693
00:33:51,730 --> 00:33:56,470
Enceladus so these are the jet thin

694
00:33:53,920 --> 00:33:57,789
Enceladus this is not a recreated image

695
00:33:56,470 --> 00:34:00,430
this is a real image

696
00:33:57,789 --> 00:34:02,259
Enceladus also have an icy surface and

697
00:34:00,430 --> 00:34:04,360
the jets are produced by geysers that

698
00:34:02,259 --> 00:34:07,180
form in the cracks that throw jets of

699

00:34:04,359 --> 00:34:09,369

water vapor into space and this water

700

00:34:07,180 --> 00:34:11,409

vapor then falls in the form of his snow

701

00:34:09,369 --> 00:34:14,109

to the surface a fraction of that

702

00:34:11,409 --> 00:34:16,389

material escapes into escape and becomes

703

00:34:14,110 --> 00:34:18,280

Saturn's ring and these geysers are one

704

00:34:16,389 --> 00:34:20,139

of the indications that like Europa that

705

00:34:18,280 --> 00:34:24,169

is liquid or ocean that there is a

706

00:34:20,139 --> 00:34:26,088

liquid water ocean under the surface

707

00:34:24,168 --> 00:34:27,529

of Enceladus also making it a very

708

00:34:26,088 --> 00:34:30,619

interesting target for the search of

709

00:34:27,530 --> 00:34:32,359

life and existence of these debts in

710

00:34:30,619 --> 00:34:34,639

salado's and in europe is particularly

711

00:34:32,358 --> 00:34:36,199

interesting because imagine trying to

712

00:34:34,639 --> 00:34:38,929

design experiments that actually look

713

00:34:36,199 --> 00:34:40,068
for that life in europa for example it

714
00:34:38,929 --> 00:34:42,200
will have to drill through ten

715
00:34:40,068 --> 00:34:43,308
kilometers of ice and this is very

716
00:34:42,199 --> 00:34:44,989
difficult to do on earth

717
00:34:43,309 --> 00:34:47,929
so imagine bringing all that equipment

718
00:34:44,989 --> 00:34:51,618
to do that drilling in Europe is very

719
00:34:47,929 --> 00:34:53,659
difficult right but if there are jets

720
00:34:51,619 --> 00:34:56,119
there is much easier to design a special

721
00:34:53,659 --> 00:34:59,510
mission like the one you see here that

722
00:34:56,119 --> 00:35:01,010
flies through that those debts and in

723
00:34:59,510 --> 00:35:02,839
this is a scrub you could have

724
00:35:01,010 --> 00:35:05,630
instruments able to analyze the material

725
00:35:02,838 --> 00:35:07,219
coming out of this yet and which is a

726
00:35:05,630 --> 00:35:08,838
sample of the material that exists in

727
00:35:07,219 --> 00:35:11,480

the ocean and you can look for signs of

728

00:35:08,838 --> 00:35:14,269

life there so no need to drill and in

729

00:35:11,480 --> 00:35:16,940

fact scientists realize a few months ago

730

00:35:14,269 --> 00:35:20,030

that the spacecraft 20 years ago

731

00:35:16,940 --> 00:35:21,980

spacecraft named Galileo is thought to

732

00:35:20,030 --> 00:35:23,809

accidentally have flown over one of the

733

00:35:21,980 --> 00:35:26,329

Jets in Europa at the time we didn't

734

00:35:23,809 --> 00:35:28,640

know this yet existed now we do and

735

00:35:26,329 --> 00:35:30,950

Galileo shows an anomalies that now can

736

00:35:28,639 --> 00:35:33,379

be explained by the presence of these

737

00:35:30,949 --> 00:35:35,298

jets and there is indeed a mission

738

00:35:33,380 --> 00:35:37,818

called Europa clipper that NASA is

739

00:35:35,298 --> 00:35:40,250

planning to launch around 2023 that will

740

00:35:37,818 --> 00:35:43,009

be designed to do exactly that to fly

741

00:35:40,250 --> 00:35:44,480

through through the Jets in Europe and

742
00:35:43,010 --> 00:35:48,430
to analyze the material that is coming

743
00:35:44,480 --> 00:35:51,798
from those yet searching for life Titan

744
00:35:48,429 --> 00:35:53,960
and here's another image that we saw in

745
00:35:51,798 --> 00:35:57,889
the short film it's all explorers that

746
00:35:53,960 --> 00:36:00,500
are flying over the lakes of Titan Titan

747
00:35:57,889 --> 00:36:02,389
is a giant moon of Saturn that is larger

748
00:36:00,500 --> 00:36:04,940
than the planet Mercury about half the

749
00:36:02,389 --> 00:36:06,858
size of the earth is mainly composed of

750
00:36:04,940 --> 00:36:08,559
silicates and water and is their only

751
00:36:06,858 --> 00:36:11,000
Moon known to have a dense atmosphere

752
00:36:08,559 --> 00:36:12,349
composed mainly of nitrogen like the

753
00:36:11,000 --> 00:36:15,588
atmosphere of the earth and a bit of

754
00:36:12,349 --> 00:36:18,890
methane and other hydrocarbons Titan has

755
00:36:15,588 --> 00:36:22,429
an average temperature of minus 290

756
00:36:18,889 --> 00:36:24,889
Fahrenheit minus 180 degrees and at that

757
00:36:22,429 --> 00:36:28,279
temperature the methane can be in solid

758
00:36:24,889 --> 00:36:30,710
liquid or gaseous state just like the

759
00:36:28,280 --> 00:36:33,140
water on earth so instead of having a

760
00:36:30,710 --> 00:36:35,780
water cycle like in the earth we have a

761
00:36:33,139 --> 00:36:37,299
methane cycle and where the methane

762
00:36:35,780 --> 00:36:39,390
evaporates right

763
00:36:37,300 --> 00:36:44,280
into the atmosphere forms the clouds

764
00:36:39,389 --> 00:36:47,049
rains down and forms rivers and lakes

765
00:36:44,280 --> 00:36:48,790
here you have some of here you have the

766
00:36:47,050 --> 00:36:51,519
reflection in one of those lakes and

767
00:36:48,789 --> 00:36:54,460
here you have a one of those lakes where

768
00:36:51,519 --> 00:36:58,750
you see the coast you can see the coast

769
00:36:54,460 --> 00:37:02,590
how it changes as the liquid level rises

770

00:36:58,750 --> 00:37:05,920
and falls and it's actually one of the

771
00:37:02,590 --> 00:37:08,230
is it's actually the only place up in

772
00:37:05,920 --> 00:37:11,019
addition to the earth where in the solar

773
00:37:08,230 --> 00:37:12,429
system world you can have lakes and you

774
00:37:11,019 --> 00:37:16,119
can have far cheaper elegance and you

775
00:37:12,429 --> 00:37:18,819
can have Iceland's and the results of

776
00:37:16,119 --> 00:37:21,099
winning titan that forms dunes but the

777
00:37:18,820 --> 00:37:22,510
grains in the dunes are not made of

778
00:37:21,099 --> 00:37:23,980
silicates like in the earth they're

779
00:37:22,510 --> 00:37:27,040
probably made of complex organic

780
00:37:23,980 --> 00:37:28,990
compounds so unknown Titan it is

781
00:37:27,039 --> 00:37:30,969
possible that there are also volcanoes

782
00:37:28,989 --> 00:37:32,799
but the lava would would be made of

783
00:37:30,969 --> 00:37:34,989
water and ammonia instead of silicates

784
00:37:32,800 --> 00:37:37,420

like in the earth and the energy source

785

00:37:34,989 --> 00:37:39,429

that will drive the volcanoes will be

786

00:37:37,420 --> 00:37:41,170

not only the radioactive elements like

787

00:37:39,429 --> 00:37:44,379

in the earth but also the tidal forces

788

00:37:41,170 --> 00:37:46,329

caused by Mars by sorry by Saturn that

789

00:37:44,380 --> 00:37:49,570

deforms the planet producing producing

790

00:37:46,329 --> 00:37:52,719

heat and it has also been a speculated

791

00:37:49,570 --> 00:37:56,140

that there is liquid or water under the

792

00:37:52,719 --> 00:37:58,689

the icy surface so the presence of all

793

00:37:56,139 --> 00:38:01,059

these complex organic compounds of lakes

794

00:37:58,690 --> 00:38:03,730

of an ocean under the surface of

795

00:38:01,059 --> 00:38:05,440

cryovolcanism of an exchange of chemical

796

00:38:03,730 --> 00:38:07,929

compounds between the atmosphere the

797

00:38:05,440 --> 00:38:09,610

surface the lake all this makes Titan an

798

00:38:07,929 --> 00:38:11,529

extraordinarily interesting place to

799

00:38:09,610 --> 00:38:13,840
search for life and people have done

800

00:38:11,530 --> 00:38:15,820
experiments in the lab or in the chamber

801

00:38:13,840 --> 00:38:17,410
they put the gases that they think are

802

00:38:15,820 --> 00:38:19,510
in the atmosphere on Titan and we put it

803

00:38:17,409 --> 00:38:21,250
at the temperature and the pressure that

804

00:38:19,510 --> 00:38:22,660
they think are on Titan and then they

805

00:38:21,250 --> 00:38:24,550
hit everything and what they find is

806

00:38:22,659 --> 00:38:28,179
very interesting they find that

807

00:38:24,550 --> 00:38:30,610
nucleotide bases form which are part of

808

00:38:28,179 --> 00:38:32,829
our DNA and RNA the building blocks of

809

00:38:30,610 --> 00:38:34,690
life they also find that amino acids

810

00:38:32,829 --> 00:38:37,000
form that are essential ingredients for

811

00:38:34,690 --> 00:38:38,740
of proteins and this is really

812

00:38:37,000 --> 00:38:40,380
extraordinary because it means that even

813
00:38:38,739 --> 00:38:45,309
in the absence of water

814
00:38:40,380 --> 00:38:48,099
m-disc these elements that are so

815
00:38:45,309 --> 00:38:51,159
important for for life can can emerge

816
00:38:48,099 --> 00:38:54,299
from simple simple organic

817
00:38:51,159 --> 00:38:57,099
molecules in fact it is possible that

818
00:38:54,300 --> 00:38:58,510
the atmosphere of Titan is very similar

819
00:38:57,099 --> 00:39:01,469
to the atmosphere that we think the

820
00:38:58,510 --> 00:39:04,930
primitive earth earth had when first

821
00:39:01,469 --> 00:39:06,609
when life first arose on our planet and

822
00:39:04,929 --> 00:39:08,829
this is why Titan is such an

823
00:39:06,610 --> 00:39:10,539
extraordinary laboratory to study the

824
00:39:08,829 --> 00:39:13,119
conditions that could have given rise to

825
00:39:10,539 --> 00:39:15,369
life on Earth and if there is an ocean

826
00:39:13,119 --> 00:39:17,619
beneath the surface of Titan is possible

827

00:39:15,369 --> 00:39:19,299
that it could Harbor life today that

828
00:39:17,619 --> 00:39:21,549
could survive thanks to the transfer of

829
00:39:19,300 --> 00:39:25,860
chemical compounds and heat between the

830
00:39:21,550 --> 00:39:28,780
ocean and the surface so if life were to

831
00:39:25,860 --> 00:39:31,840
exhibit exist in Titan or Enceladus or

832
00:39:28,780 --> 00:39:34,600
in Europa it will be under very extreme

833
00:39:31,840 --> 00:39:36,640
conditions but the truth is that life on

834
00:39:34,599 --> 00:39:40,210
Earth can survive under very extreme

835
00:39:36,639 --> 00:39:42,989
conditions for example in this water

836
00:39:40,210 --> 00:39:47,760
lakes in these geysers in Yellowstone

837
00:39:42,989 --> 00:39:50,589
life can survive and in extreme heap in

838
00:39:47,760 --> 00:39:52,810
extremely extremely cold environments

839
00:39:50,590 --> 00:39:55,990
and also in various heat environments

840
00:39:52,809 --> 00:39:58,449
like those inside the battery and if

841
00:39:55,989 --> 00:40:00,009

life were to exist in titan gyro power

842

00:39:58,449 --> 00:40:01,539

and salado's or somewhere else it would

843

00:40:00,010 --> 00:40:03,820

be probably very different from that on

844

00:40:01,539 --> 00:40:06,880

earth for example it has been speculated

845

00:40:03,820 --> 00:40:08,500

that life in the shallow mess and lakes

846

00:40:06,880 --> 00:40:11,530

of Titan instead of breathing oxygen

847

00:40:08,500 --> 00:40:14,139

will breathe hydrogen and it's death of

848

00:40:11,530 --> 00:40:16,150

exhaling co2 it will exhale methane and

849

00:40:14,139 --> 00:40:18,429

instead of using water as a solvent it

850

00:40:16,150 --> 00:40:20,619

will use methane liquid methane the

851

00:40:18,429 --> 00:40:22,269

bottom line is that we need to open up

852

00:40:20,619 --> 00:40:24,069

our mind regarding the search for life

853

00:40:22,269 --> 00:40:26,530

because what is out there is probably

854

00:40:24,070 --> 00:40:28,090

very different from what we know and we

855

00:40:26,530 --> 00:40:30,130

might not discover it if we are not

856
00:40:28,090 --> 00:40:33,460
ready for those surprises so the search

857
00:40:30,130 --> 00:40:35,559
for life needs a mindset change like the

858
00:40:33,460 --> 00:40:37,599
one that was required to under start the

859
00:40:35,559 --> 00:40:41,710
movement of the planets or the theory of

860
00:40:37,599 --> 00:40:44,500
evolution so well where do we come from

861
00:40:41,710 --> 00:40:46,510
how did life on Earth originate our

862
00:40:44,500 --> 00:40:48,039
species is a very curious one and this

863
00:40:46,510 --> 00:40:50,410
very question has followed us for

864
00:40:48,039 --> 00:40:52,179
thousands of years at first we have

865
00:40:50,409 --> 00:40:54,819
tried to address it through stories and

866
00:40:52,179 --> 00:40:56,829
myths because that was our the best way

867
00:40:54,820 --> 00:40:59,050
we had to make sense of what we did not

868
00:40:56,829 --> 00:41:00,130
understand and later who have been able

869
00:40:59,050 --> 00:41:01,870
to address it through careful

870
00:41:00,130 --> 00:41:04,000
observation of nature by carefully

871
00:41:01,869 --> 00:41:04,569
collecting the evidence left in many

872
00:41:04,000 --> 00:41:06,250
hypotheses

873
00:41:04,570 --> 00:41:09,280
checking what it works what it doesn't

874
00:41:06,250 --> 00:41:11,170
work and this very question regarding

875
00:41:09,280 --> 00:41:12,850
the origin of life has also sent women

876
00:41:11,170 --> 00:41:15,159
and men to seek for our origins in the

877
00:41:12,849 --> 00:41:17,710
remotest corners of our planet and even

878
00:41:15,159 --> 00:41:19,659
beyond so what do we come from did life

879
00:41:17,710 --> 00:41:22,360
on Earth originate in our planet or did

880
00:41:19,659 --> 00:41:24,819
originate somewhere else

881
00:41:22,360 --> 00:41:26,920
good if there is life on Earth another

882
00:41:24,820 --> 00:41:30,400
planet or other moon in our solar system

883
00:41:26,920 --> 00:41:32,829
or in other planets in nearby stars

884

00:41:30,400 --> 00:41:34,809
could it have a common origin to ours or

885
00:41:32,829 --> 00:41:36,489
did it emerge independently cool life on

886
00:41:34,809 --> 00:41:38,949
Earth or the building blocks of life has

887
00:41:36,489 --> 00:41:44,229
spread to other planets and other moons

888
00:41:38,949 --> 00:41:46,539
or vice versa so look at this rock this

889
00:41:44,230 --> 00:41:48,429
is a meteorite meteorites are extremely

890
00:41:46,539 --> 00:41:49,509
valuable because they can teach us a lot

891
00:41:48,429 --> 00:41:52,449
about our origins

892
00:41:49,510 --> 00:41:54,520
if you years ago in 2011 after analyzing

893
00:41:52,449 --> 00:41:56,319
rocks like this in the lab people found

894
00:41:54,519 --> 00:41:59,710
that they contain some of the components

895
00:41:56,320 --> 00:42:01,570
of DNA and RNA and as you know these are

896
00:41:59,710 --> 00:42:03,429
the building blocks of life or of life

897
00:42:01,570 --> 00:42:04,840
they're like life's ligo's and people

898
00:42:03,429 --> 00:42:07,839

discover that these complex organic

899

00:42:04,840 --> 00:42:11,140

molecules adenine guanine confirm in a

900

00:42:07,840 --> 00:42:13,600

space it was also recently discovered

901

00:42:11,139 --> 00:42:16,329

that the does that exist in a space

902

00:42:13,599 --> 00:42:18,849

contains complex organic molecules like

903

00:42:16,329 --> 00:42:21,190

sugar that are also necessary for the

904

00:42:18,849 --> 00:42:22,539

formation of our name and of course the

905

00:42:21,190 --> 00:42:23,889

yolk when this was discovered is that

906

00:42:22,539 --> 00:42:27,099

the next thing astronomers will be

907

00:42:23,889 --> 00:42:29,379

seeking is caffeine and and this was

908

00:42:27,099 --> 00:42:31,659

found by analyzing the light that the

909

00:42:29,380 --> 00:42:34,450

dust emit and what people realize is

910

00:42:31,659 --> 00:42:36,609

that these sugars can form very rapidly

911

00:42:34,449 --> 00:42:38,529

around a stars even before the planets

912

00:42:36,610 --> 00:42:40,980

form and this is very exciting because

913
00:42:38,530 --> 00:42:43,870
it means that once the planets form

914
00:42:40,980 --> 00:42:46,840
these molecules can fall on the planets

915
00:42:43,869 --> 00:42:50,829
and facilitate the emergence of life so

916
00:42:46,840 --> 00:42:54,700
how do stars and planets form so stars

917
00:42:50,829 --> 00:42:57,219
are born in clouds of gas and dust one

918
00:42:54,699 --> 00:42:59,619
region of the cloud it gets very dense

919
00:42:57,219 --> 00:43:04,509
and very hot and collapses under its own

920
00:42:59,619 --> 00:43:06,460
gravity and at some point the star

921
00:43:04,510 --> 00:43:08,920
ignites and and and this is when the

922
00:43:06,460 --> 00:43:11,289
star is born around these protostars

923
00:43:08,920 --> 00:43:13,420
there is an envelope of gas and dust and

924
00:43:11,289 --> 00:43:15,159
because everything is rotating because

925
00:43:13,420 --> 00:43:17,470
of conservation of angular momentum you

926
00:43:15,159 --> 00:43:19,989
form a disk

927
00:43:17,469 --> 00:43:23,259
so this is what we call a protoplanetary

928
00:43:19,989 --> 00:43:25,179
disk so some of the gas in the dust

929
00:43:23,260 --> 00:43:28,750
some of the gas on the disk in the star

930
00:43:25,179 --> 00:43:30,279
is secreted to the star and on some of

931
00:43:28,750 --> 00:43:32,800
the guys on the dust in the disk is

932
00:43:30,280 --> 00:43:34,660
secreted to the star and some other part

933
00:43:32,800 --> 00:43:37,539
of the material is ejected in this yes

934
00:43:34,659 --> 00:43:39,399
but let's see what happens to the gas

935
00:43:37,539 --> 00:43:41,050
and dust that the stays in the disk that

936
00:43:39,400 --> 00:43:43,090
the remains entities the disk is very

937
00:43:41,050 --> 00:43:45,970
dense and the dust particles are

938
00:43:43,090 --> 00:43:47,829
colliding with each other and frequently

939
00:43:45,969 --> 00:43:49,929
this collision makes the particle spring

940
00:43:47,829 --> 00:43:51,639
into a smaller pieces but they or they

941

00:43:49,929 --> 00:43:53,529
bounce but in many times they stick

942
00:43:51,639 --> 00:43:55,569
together and when I stick to whether you

943
00:43:53,530 --> 00:43:58,210
start they start forming larger and

944
00:43:55,570 --> 00:44:00,160
larger aggregates they first form like

945
00:43:58,210 --> 00:44:02,530
people styles then it's like you know

946
00:44:00,159 --> 00:44:05,319
Boulder size then it's like asteroid

947
00:44:02,530 --> 00:44:08,349
type size until they form the planets

948
00:44:05,320 --> 00:44:09,910
and also they form planets much more

949
00:44:08,349 --> 00:44:11,859
massive than the than the earth like

950
00:44:09,909 --> 00:44:13,750
around ten times the mass of the Earth

951
00:44:11,858 --> 00:44:15,400
and at that point these planets are

952
00:44:13,750 --> 00:44:17,710
sufficiently massive that they start

953
00:44:15,400 --> 00:44:18,940
attracting the gas ended in the disk to

954
00:44:17,710 --> 00:44:21,670
form

955
00:44:18,940 --> 00:44:24,369

jaian atmospheres like the planet

956

00:44:21,670 --> 00:44:28,000

Jupiter or the planet Saturn and later

957

00:44:24,369 --> 00:44:32,650

when the star dies a part of that

958

00:44:28,000 --> 00:44:34,750

material is returned to a space and to

959

00:44:32,650 --> 00:44:37,750

become part of the new clouds of dust

960

00:44:34,750 --> 00:44:39,670

and gas that from where from where

961

00:44:37,750 --> 00:44:42,159

new stars will be born so all this

962

00:44:39,670 --> 00:44:43,780

material is recycled and that is how

963

00:44:42,159 --> 00:44:46,179

some of those complex organic molecules

964

00:44:43,780 --> 00:44:48,150

that are so interesting for life that

965

00:44:46,179 --> 00:44:52,750

come forth in a space or around other

966

00:44:48,150 --> 00:44:57,639

dynastars can get to the jungle to the

967

00:44:52,750 --> 00:44:59,349

young forming planets so and here you

968

00:44:57,639 --> 00:45:01,509

have real images that capture how it

969

00:44:59,349 --> 00:45:03,460

starts on planet form this is an image

970
00:45:01,510 --> 00:45:07,230
of the clouds of gas and dust where the

971
00:45:03,460 --> 00:45:10,630
planets and the stars are born this is

972
00:45:07,230 --> 00:45:12,789
of course taking with Hubble this is

973
00:45:10,630 --> 00:45:14,829
another image taking with Hubble of the

974
00:45:12,789 --> 00:45:15,849
protis stars and their discs where the

975
00:45:14,829 --> 00:45:18,279
planets will be born

976
00:45:15,849 --> 00:45:21,369
seen here in silhouette so here you have

977
00:45:18,280 --> 00:45:23,980
a disk and here you have the the newborn

978
00:45:21,369 --> 00:45:27,820
star and here you see it more face on

979
00:45:23,980 --> 00:45:30,039
here you see in h on and this is a disc

980
00:45:27,820 --> 00:45:33,070
where the large planets have

981
00:45:30,039 --> 00:45:36,730
formerly had begun to accrete the gas in

982
00:45:33,070 --> 00:45:39,519
the disc so these dark areas is all the

983
00:45:36,730 --> 00:45:41,289
the gas depleted regions in the disk

984
00:45:39,519 --> 00:45:43,719
that has already accreted into the

985
00:45:41,289 --> 00:45:46,300
atmosphere of the forming planets and

986
00:45:43,719 --> 00:45:49,769
here is a family photo of baby planetary

987
00:45:46,300 --> 00:45:52,750
systems being born so here you like

988
00:45:49,769 --> 00:45:55,090
their babies some of them are face-on

989
00:45:52,750 --> 00:45:56,949
some of them are its own and some of

990
00:45:55,090 --> 00:45:58,930
them have this cometary along with its

991
00:45:56,949 --> 00:46:00,879
shape because they happened to be very

992
00:45:58,929 --> 00:46:03,009
close to a very massive star that is

993
00:46:00,880 --> 00:46:05,380
blowing away with its strong wind some

994
00:46:03,010 --> 00:46:07,690
of the material in the disc and this is

995
00:46:05,380 --> 00:46:09,970
a family picture picture of the elderly

996
00:46:07,690 --> 00:46:12,099
showing the spectacular wasting with

997
00:46:09,969 --> 00:46:14,529
some stars when they become very all

998

00:46:12,099 --> 00:46:17,489
returned material to a space for its

999
00:46:14,530 --> 00:46:20,380
reciting another beautiful Hubble image

1000
00:46:17,489 --> 00:46:22,389
so I have told you that they are very

1001
00:46:20,380 --> 00:46:24,460
interesting molecules that form in a

1002
00:46:22,389 --> 00:46:26,829
space around this type of stars that can

1003
00:46:24,460 --> 00:46:29,740
get to the young planets and maybe help

1004
00:46:26,829 --> 00:46:31,179
life to emerge and another molecule that

1005
00:46:29,739 --> 00:46:35,559
got here from a space that is very

1006
00:46:31,179 --> 00:46:38,079
important for life is water after and

1007
00:46:35,559 --> 00:46:41,799
when the earth was formed it was very

1008
00:46:38,079 --> 00:46:44,860
dry I'm very hot it was more than a

1009
00:46:41,800 --> 00:46:46,930
thousand Celsius so around 2000

1010
00:46:44,860 --> 00:46:49,840
Fahrenheit now he's nice and cool and

1011
00:46:46,929 --> 00:46:52,029
about 3/4 of the surface are covered by

1012
00:46:49,840 --> 00:46:53,800

liquid water but the still if you

1013

00:46:52,030 --> 00:46:56,650
considered the bulk of the

1014

00:46:53,800 --> 00:46:58,750
planet the earth is very dry but what

1015

00:46:56,650 --> 00:46:59,260
did all this water in the surface come

1016

00:46:58,750 --> 00:47:01,269
from

1017

00:46:59,260 --> 00:47:03,430
after analyzing different types of

1018

00:47:01,269 --> 00:47:05,469
comets and asteroids in our solar system

1019

00:47:03,429 --> 00:47:07,839
people realized that they may come from

1020

00:47:05,469 --> 00:47:09,609
these objects that fell on the earth

1021

00:47:07,840 --> 00:47:11,410
when the earth was very young and we

1022

00:47:09,610 --> 00:47:14,079
know this by analyzing the type of water

1023

00:47:11,409 --> 00:47:16,779
that is detected in asteroids and comets

1024

00:47:14,079 --> 00:47:19,509
and and comparing it to the water that

1025

00:47:16,780 --> 00:47:22,060
is on earth because water as you know is

1026

00:47:19,510 --> 00:47:25,000
made of 2 atoms of hydrogen and one

1027
00:47:22,059 --> 00:47:28,420
atom of oxygen but sometimes you have a

1028
00:47:25,000 --> 00:47:30,820
an extra Neutron in the hydrogen instead

1029
00:47:28,420 --> 00:47:33,670
of dehydrate the standard Hydra you have

1030
00:47:30,820 --> 00:47:35,650
the Tyrion at that ratio of how many

1031
00:47:33,670 --> 00:47:38,559
water molecules percent that extra

1032
00:47:35,650 --> 00:47:40,780
Neutron compared to what the so you

1033
00:47:38,559 --> 00:47:43,179
compare that that ratio of the water

1034
00:47:40,780 --> 00:47:43,440
with we have on earth to that fire found

1035
00:47:43,179 --> 00:47:46,139
in

1036
00:47:43,440 --> 00:47:47,970
and comets that ratio is very similar to

1037
00:47:46,139 --> 00:47:49,500
what we find in in this type of solar

1038
00:47:47,969 --> 00:47:52,078
system obvious so it is very possible

1039
00:47:49,500 --> 00:47:54,358
that the water in our planet comes from

1040
00:47:52,079 --> 00:47:56,160
from them so the next time you are on

1041
00:47:54,358 --> 00:47:57,630
the beach think that that water have not

1042
00:47:56,159 --> 00:47:59,699
always been there that it came from

1043
00:47:57,630 --> 00:48:02,760
outer space that it connects you to the

1044
00:47:59,699 --> 00:48:04,289
universe and yes as it rain on earth it

1045
00:48:02,760 --> 00:48:07,470
also did it on other planets around

1046
00:48:04,289 --> 00:48:09,809
other stars where it may have created a

1047
00:48:07,469 --> 00:48:13,889
fantastic landscape enjoy by other

1048
00:48:09,809 --> 00:48:17,338
wonderful creators like you so let's

1049
00:48:13,889 --> 00:48:19,049
look at some numbers so when did the

1050
00:48:17,338 --> 00:48:20,759
earth form and when did it meet the

1051
00:48:19,050 --> 00:48:23,670
necessary conditions for life to emerge

1052
00:48:20,760 --> 00:48:28,050
so this is for perspective this is how

1053
00:48:23,670 --> 00:48:31,500
all the Sun the solar system is this is

1054
00:48:28,050 --> 00:48:35,068
how all the earth is this is how all we

1055

00:48:31,500 --> 00:48:37,858
think life is how all our animals how

1056
00:48:35,068 --> 00:48:40,619
all our mammals how all our humans and

1057
00:48:37,858 --> 00:48:42,239
to be honest I have to make this thicker

1058
00:48:40,619 --> 00:48:44,430
than I should because otherwise you

1059
00:48:42,239 --> 00:48:46,679
wouldn't see it it's really mind-blowing

1060
00:48:44,429 --> 00:48:53,399
so let's talk a bit about how do we know

1061
00:48:46,679 --> 00:48:55,259
this part the top part so so how do we

1062
00:48:53,400 --> 00:48:57,630
know for example how is the solar system

1063
00:48:55,260 --> 00:49:00,359
we can measure it in the lab how all are

1064
00:48:57,630 --> 00:49:03,568
they all these meteorites this is a type

1065
00:49:00,358 --> 00:49:06,210
of meteorite called secon roots and they

1066
00:49:03,568 --> 00:49:08,309
have these white inclusions here these

1067
00:49:06,210 --> 00:49:09,929
are called calcium aluminum inclusions

1068
00:49:08,309 --> 00:49:12,539
because they are made out of calcium and

1069
00:49:09,929 --> 00:49:16,230

aluminum these these white specks here

1070

00:49:12,539 --> 00:49:17,969

and if you analyze them they are four

1071

00:49:16,230 --> 00:49:19,800

thousand five hundred and seventy

1072

00:49:17,969 --> 00:49:22,699

million years old and it is thought that

1073

00:49:19,800 --> 00:49:24,480

they form and when the gas in that

1074

00:49:22,699 --> 00:49:26,699

protoplanetary disk that I showed you

1075

00:49:24,480 --> 00:49:28,679

before that surrounded the jounce and

1076

00:49:26,699 --> 00:49:30,509

condensed like when water vapor

1077

00:49:28,679 --> 00:49:33,769

condenses into clouds form in the

1078

00:49:30,510 --> 00:49:35,730

raindrops and we think this is how these

1079

00:49:33,769 --> 00:49:37,289

solids form and it is thought that these

1080

00:49:35,730 --> 00:49:39,780

are they all the solids in the solar

1081

00:49:37,289 --> 00:49:42,420

system so we think they the Sun is that

1082

00:49:39,780 --> 00:49:46,170

all around four thousand five hundred

1083

00:49:42,420 --> 00:49:49,349

and seventy million years so we think

1084
00:49:46,170 --> 00:49:52,829
that 43 million years after the the

1085
00:49:49,349 --> 00:49:54,960
solar system form the young earth

1086
00:49:52,829 --> 00:49:56,880
collided with a planet the size of Mars

1087
00:49:54,960 --> 00:50:00,509
and out of the debris of that

1088
00:49:56,880 --> 00:50:02,579
collision the moon form and we we can

1089
00:50:00,509 --> 00:50:06,929
date that because we can date the rocks

1090
00:50:02,579 --> 00:50:10,048
in the in the moon and if you if you

1091
00:50:06,929 --> 00:50:12,538
date them you seen a Half Moon tungsten

1092
00:50:10,048 --> 00:50:14,670
a chronometry of the lunar magma it

1093
00:50:12,539 --> 00:50:17,220
tells you that they are very old they

1094
00:50:14,670 --> 00:50:19,889
only form they form only 43 million

1095
00:50:17,219 --> 00:50:21,989
years after the sand form but the young

1096
00:50:19,889 --> 00:50:24,088
earth was not a habitable planet because

1097
00:50:21,989 --> 00:50:27,538
he was hole covered by lava so when did

1098
00:50:24,088 --> 00:50:29,250
the surface of the earth cool down so it

1099
00:50:27,539 --> 00:50:31,259
is thought that this happened 70 million

1100
00:50:29,250 --> 00:50:32,670
years after the solar system form and we

1101
00:50:31,259 --> 00:50:35,219
know this because we can measure the

1102
00:50:32,670 --> 00:50:38,579
ages of microscopic minerals called

1103
00:50:35,219 --> 00:50:41,759
circles and this quartzite conglomerate

1104
00:50:38,579 --> 00:50:44,068
how Nina in Australia and has these

1105
00:50:41,759 --> 00:50:46,318
circles and people think the circles

1106
00:50:44,068 --> 00:50:48,389
firm from the crystallization of magma

1107
00:50:46,318 --> 00:50:50,308
that contained molten earth crust that

1108
00:50:48,389 --> 00:50:52,798
was billion recycle and that had been in

1109
00:50:50,309 --> 00:50:54,420
contact with water near the surface so

1110
00:50:52,798 --> 00:50:56,730
that's the critical part that circles

1111
00:50:54,420 --> 00:51:00,088
are evidence evidence of water near the

1112

00:50:56,730 --> 00:51:01,528
surface and other circles they the

1113
00:51:00,088 --> 00:51:08,219
presence of liquid water on earth

1114
00:51:01,528 --> 00:51:10,108
between 600 165 million years and 280

1115
00:51:08,219 --> 00:51:13,459
million years after the solar system

1116
00:51:10,108 --> 00:51:16,318
forms so pretty far pretty fast

1117
00:51:13,460 --> 00:51:19,139
so once the earth cooled down and there

1118
00:51:16,318 --> 00:51:20,759
was liquid water on the surface how long

1119
00:51:19,139 --> 00:51:23,009
would like to emerge where we don't

1120
00:51:20,759 --> 00:51:24,929
really know but studies show that it

1121
00:51:23,009 --> 00:51:27,630
could have happened very quickly between

1122
00:51:24,929 --> 00:51:31,199
0.3 and 3 million years it could have

1123
00:51:27,630 --> 00:51:33,028
happen if life arose in shallow pools

1124
00:51:31,199 --> 00:51:35,639
like this one where you see this has

1125
00:51:33,028 --> 00:51:38,940
Rommel to light a microbial carpets in

1126
00:51:35,639 --> 00:51:41,670

fact the oldest indisputable evidence of

1127

00:51:38,940 --> 00:51:43,380
life on Earth come precisely from

1128

00:51:41,670 --> 00:51:45,240
fossils that this is like a

1129

00:51:43,380 --> 00:51:49,858
cross-section that look exactly like

1130

00:51:45,239 --> 00:51:51,358
this and they are this all there are a

1131

00:51:49,858 --> 00:51:55,048
thousand five hundred and seventy

1132

00:51:51,358 --> 00:51:56,759
million years all so not meteor no not

1133

00:51:55,048 --> 00:52:01,679
million years old but million years

1134

00:51:56,759 --> 00:52:04,259
after the solar system form so or it

1135

00:52:01,679 --> 00:52:06,929
could be that life arose even faster in

1136

00:52:04,259 --> 00:52:09,130
hydrothermal vents like this ones found

1137

00:52:06,929 --> 00:52:11,529
at the bottom of the ocean

1138

00:52:09,130 --> 00:52:15,340
actually they're always evidence of life

1139

00:52:11,530 --> 00:52:19,300
this is more disputed and maybe these

1140

00:52:15,340 --> 00:52:20,710
fossils in this microorganisms here that

1141
00:52:19,300 --> 00:52:22,960
are much older than the stromatolites

1142
00:52:20,710 --> 00:52:26,769
that I showed you earlier and that are

1143
00:52:22,960 --> 00:52:29,139
found in rocks that form between 290 and

1144
00:52:26,769 --> 00:52:34,750
800 million years after the solar system

1145
00:52:29,139 --> 00:52:37,480
form so very quick so as you can see we

1146
00:52:34,750 --> 00:52:39,880
are not certain when life arose on this

1147
00:52:37,480 --> 00:52:41,530
planet and if I mean what type of

1148
00:52:39,880 --> 00:52:43,480
environment and we don't know either

1149
00:52:41,530 --> 00:52:45,850
what was the role of extraterrestrial

1150
00:52:43,480 --> 00:52:47,500
material falling on earth if it provided

1151
00:52:45,849 --> 00:52:51,009
the building blocks of life in addition

1152
00:52:47,500 --> 00:52:53,230
to water but the next time your child or

1153
00:52:51,010 --> 00:52:55,030
your grandchild bends down to pick up

1154
00:52:53,230 --> 00:52:57,099
some pebbles and you hear yourself

1155
00:52:55,030 --> 00:52:58,720
saying don't bring that home like I

1156
00:52:57,099 --> 00:53:00,690
sometimes say with my six and my two

1157
00:52:58,719 --> 00:53:03,219
year old daughter's Luna and Estella and

1158
00:53:00,690 --> 00:53:04,840
fill up their pockets with rocks gather

1159
00:53:03,219 --> 00:53:06,369
even from the parking lot and then I

1160
00:53:04,840 --> 00:53:11,680
hear those pills in the washing machine

1161
00:53:06,369 --> 00:53:14,829
so remember that those rocks are a real

1162
00:53:11,679 --> 00:53:17,409
treat for the intriguing mind of the

1163
00:53:14,829 --> 00:53:19,719
inquiring mind of a child that they are

1164
00:53:17,409 --> 00:53:22,149
collecting and inspecting the evidence

1165
00:53:19,719 --> 00:53:23,799
and that they answer to those existence

1166
00:53:22,150 --> 00:53:25,599
of questions regarding an origin

1167
00:53:23,800 --> 00:53:27,519
probably is lock in a handful of rocks

1168
00:53:25,599 --> 00:53:32,159
that is waiting to be discovered by them

1169

00:53:27,519 --> 00:53:34,389
and the source film the source film show

1170
00:53:32,159 --> 00:53:36,489
people have long dream about the

1171
00:53:34,389 --> 00:53:38,829
possibility of visiting other planets

1172
00:53:36,489 --> 00:53:41,859
even setting up colonies there here are

1173
00:53:38,829 --> 00:53:44,259
some advertisements from NASA's

1174
00:53:41,860 --> 00:53:46,870
exoplanet forum a fictional travel

1175
00:53:44,260 --> 00:53:49,540
agency for travellers to visit recently

1176
00:53:46,869 --> 00:53:52,960
discovered exoplanets these of course

1177
00:53:49,539 --> 00:53:56,889
are fictional you see Enceladus it says

1178
00:53:52,960 --> 00:54:00,190
you know visit beautiful southern axilla

1179
00:53:56,889 --> 00:54:04,089
doors you know more than 100

1180
00:54:00,190 --> 00:54:07,050
breathtaking geysers you have Titan it

1181
00:54:04,090 --> 00:54:11,700
says right the tight throughout the

1182
00:54:07,050 --> 00:54:14,530
throat of Kraken here's the kepler 16b

1183
00:54:11,699 --> 00:54:16,389

where your shadow always have a company

1184

00:54:14,530 --> 00:54:18,030

because it's a double star right here

1185

00:54:16,389 --> 00:54:20,170

you have trapeze

1186

00:54:18,030 --> 00:54:22,060

planet-hopping trapeze because you have

1187

00:54:20,170 --> 00:54:25,119

all these you know planets

1188

00:54:22,059 --> 00:54:28,389

so here you have a super jump right in

1189

00:54:25,119 --> 00:54:35,230

an atmosphere experience the gravity of

1190

00:54:28,389 --> 00:54:38,349

HD forty 370 GS uber so this these

1191

00:54:35,230 --> 00:54:40,510

posters are of course made to make you

1192

00:54:38,349 --> 00:54:41,829

laugh and to make you dream but also to

1193

00:54:40,510 --> 00:54:44,380

make you reflect on the extraordinary

1194

00:54:41,829 --> 00:54:46,090

diversity literacy how it starting early

1195

00:54:44,380 --> 00:54:48,640

diverse clientele systems are and

1196

00:54:46,090 --> 00:54:50,950

extraordinary lives life forms that

1197

00:54:48,639 --> 00:54:52,779

they could Harbor but I would like to

1198
00:54:50,949 --> 00:54:54,789
finish this top with some wise words

1199
00:54:52,780 --> 00:54:57,280
from Carl Sagan because this human

1200
00:54:54,789 --> 00:54:59,259
curiosity of ours that has allow us to

1201
00:54:57,280 --> 00:55:00,880
better understand our planets our place

1202
00:54:59,260 --> 00:55:03,280
in the universe to learn how it stars

1203
00:55:00,880 --> 00:55:05,349
and planets form and how the worst

1204
00:55:03,280 --> 00:55:07,000
voluntary systems and life can be this

1205
00:55:05,349 --> 00:55:09,159
human curiosity that has allowed us to

1206
00:55:07,000 --> 00:55:11,050
adapt to the world around us so we can

1207
00:55:09,159 --> 00:55:13,059
live in it more comfortably this

1208
00:55:11,050 --> 00:55:15,490
curiosity of us has also allow us to

1209
00:55:13,059 --> 00:55:17,679
adapt the world to an hour our own needs

1210
00:55:15,489 --> 00:55:19,689
and this comes with a responsibility a

1211
00:55:17,679 --> 00:55:22,480
responsibility to protect the earth and

1212
00:55:19,690 --> 00:55:25,090
also the species that inhabit it to live

1213
00:55:22,480 --> 00:55:27,039
a sustainable life that doesn't exhaust

1214
00:55:25,090 --> 00:55:29,170
the earth resources and to protect the

1215
00:55:27,039 --> 00:55:31,059
environment and this is what Carl Sagan

1216
00:55:29,170 --> 00:55:33,670
talks about in this short movie because

1217
00:55:31,059 --> 00:55:35,529
so far no matter what our dreams are the

1218
00:55:33,670 --> 00:55:40,210
earth is the only planet we can live in

1219
00:55:35,530 --> 00:55:43,380
all right do we have any questions for

1220
00:55:40,210 --> 00:55:43,380
our speaker Peter

1221
00:56:00,079 --> 00:56:03,170
[Music]

1222
00:56:04,380 --> 00:56:14,400
some say that microbial life could found

1223
00:56:08,769 --> 00:56:14,400
on Mars perhaps deep underground before

1224
00:56:18,750 --> 00:56:26,139
yes I don't have any comments that

1225
00:56:23,619 --> 00:56:29,440
absolutely and I think they you know

1226

00:56:26,139 --> 00:56:32,289
they are actively searching for science

1227
00:56:29,440 --> 00:56:34,150
that that to see if that is still the

1228
00:56:32,289 --> 00:56:37,389
case if we take stills you know

1229
00:56:34,150 --> 00:56:41,260
could survive there but and it's so

1230
00:56:37,389 --> 00:56:44,049
close right we it's just mind-blowing

1231
00:56:41,260 --> 00:56:47,710
that it's actually a real possibility

1232
00:56:44,050 --> 00:56:51,010
but this could happen yes and also

1233
00:56:47,710 --> 00:56:52,599
another thing there is M there is a lot

1234
00:56:51,010 --> 00:56:55,480
of material that is exchanged between

1235
00:56:52,599 --> 00:56:57,670
the planets in the solar system a lot of

1236
00:56:55,480 --> 00:57:00,309
solid material so you know if that was a

1237
00:56:57,670 --> 00:57:03,990
case they are meteorites that come from

1238
00:57:00,309 --> 00:57:10,630
Mars that would have Harbor you know

1239
00:57:03,989 --> 00:57:14,019
this type of microorganisms so yes I

1240
00:57:10,630 --> 00:57:16,450

noticed in the and in the pictures that

1241
00:57:14,019 --> 00:57:18,130
you have of Europa and Titan how

1242
00:57:16,449 --> 00:57:20,259
pristine and clear was you could

1243
00:57:18,130 --> 00:57:24,180
actually see right down there and then

1244
00:57:20,260 --> 00:57:27,670
when you had a picture of on the earth

1245
00:57:24,179 --> 00:57:30,789
that there were clouds on the earth that

1246
00:57:27,670 --> 00:57:33,639
makes me think is do these other planets

1247
00:57:30,789 --> 00:57:36,550
or moons have any kind of atmospheres

1248
00:57:33,639 --> 00:57:43,900
yes and is the atmosphere is necessary

1249
00:57:36,550 --> 00:57:47,050
for life to develop M well as I said you

1250
00:57:43,900 --> 00:57:48,880
need a mindset change right so I would

1251
00:57:47,050 --> 00:57:51,789
say yes that you would you need an

1252
00:57:48,880 --> 00:57:53,769
atmosphere if you have an ocean you have

1253
00:57:51,789 --> 00:57:55,509
an atmosphere and you need you need

1254
00:57:53,769 --> 00:57:57,429
liquid water so probably yes you need an

1255
00:57:55,510 --> 00:58:00,070
atmosphere in there so yes I would say

1256
00:57:57,429 --> 00:58:02,349
yes you need an atmosphere and it will

1257
00:58:00,070 --> 00:58:05,080
Titan has an atmosphere Mars has an

1258
00:58:02,349 --> 00:58:08,259
atmosphere Enceladus has a thin

1259
00:58:05,079 --> 00:58:11,079
atmosphere as well so um so yeah they

1260
00:58:08,260 --> 00:58:14,380
all have had much fears and but like

1261
00:58:11,079 --> 00:58:16,059
like you so Titan has has beautiful

1262
00:58:14,380 --> 00:58:19,180
clouds so the image of the clouds in

1263
00:58:16,059 --> 00:58:20,650
Titan that it really dissymmetry maybe

1264
00:58:19,179 --> 00:58:23,739
you thought that it was an image of the

1265
00:58:20,650 --> 00:58:26,800
earth but this is actually an image of

1266
00:58:23,739 --> 00:58:28,899
Titan is a real image of Titan this is a

1267
00:58:26,800 --> 00:58:31,560
real image of Titan and that's an image

1268
00:58:28,900 --> 00:58:34,990
of this type of clouds in the earth so

1269
00:58:31,559 --> 00:58:39,519
and these are real images these are real

1270
00:58:34,989 --> 00:58:40,959
photographs so of course the composition

1271
00:58:39,519 --> 00:58:42,519
the atmosphere makes it's very different

1272
00:58:40,960 --> 00:58:45,429
oh yes the composition is very different

1273
00:58:42,519 --> 00:58:46,980
right you know 97% carbon dioxide on

1274
00:58:45,429 --> 00:58:50,399
Venus

1275
00:58:46,980 --> 00:58:53,070
this is yes all nitrogen s methane and

1276
00:58:50,400 --> 00:58:55,619
if I remember from my courses course

1277
00:58:53,070 --> 00:58:57,510
work oxygen in the early earth

1278
00:58:55,619 --> 00:58:59,730
atmosphere would have been bad for the

1279
00:58:57,510 --> 00:59:01,980
development right this oxygen didn't up

1280
00:58:59,730 --> 00:59:10,260
until about two billion years ago thanks

1281
00:59:01,980 --> 00:59:21,329
through life right so yeah all right

1282
00:59:10,260 --> 00:59:24,240
microphone over to hear this say our

1283

00:59:21,329 --> 00:59:26,369
moon is tidally locked but these other

1284
00:59:24,239 --> 00:59:31,009
bodies aren't necessarily and that's

1285
00:59:26,369 --> 00:59:33,180
providing the heating anything about I

1286
00:59:31,010 --> 00:59:35,910
know they're covered with ice

1287
00:59:33,179 --> 00:59:37,949
is there anything like higher low tides

1288
00:59:35,909 --> 00:59:40,769
with the ice and is that visible in any

1289
00:59:37,949 --> 00:59:43,078
photographs and I think that you cannot

1290
00:59:40,769 --> 00:59:45,000
see the tight Sunday on the ice but you

1291
00:59:43,079 --> 00:59:48,300
can see evidence that that is these

1292
00:59:45,000 --> 00:59:51,000
diverse stresses that are producing that

1293
00:59:48,300 --> 00:59:53,550
are a source of heat and this is what is

1294
00:59:51,000 --> 00:59:55,530
producing the cryovolcanism that we

1295
00:59:53,550 --> 00:59:57,839
think it is taking place in some of

1296
00:59:55,530 --> 01:00:00,660
these objects this is what is producing

1297
00:59:57,838 --> 01:00:02,670

the the balkan is him on lo you see you

1298

01:00:00,659 --> 01:00:05,279

know volcanoes erupting of an iron and

1299

01:00:02,670 --> 01:00:08,789

it is because of the this title forces

1300

01:00:05,280 --> 01:00:10,560

created by you Peter and so yeah so

1301

01:00:08,789 --> 01:00:13,259

that's that's a very significant source

1302

01:00:10,559 --> 01:00:14,338

of energy for this month and just to

1303

01:00:13,260 --> 01:00:16,440

clarify some things for the online

1304

01:00:14,338 --> 01:00:18,150

audience there was a chat about

1305

01:00:16,440 --> 01:00:19,800

volcanism and they were assuming it was

1306

01:00:18,150 --> 01:00:22,289

volcanism like here on earth but you

1307

01:00:19,800 --> 01:00:24,900

said specifically just to repeat

1308

01:00:22,289 --> 01:00:28,550

cryovolcano which occurs at extremely

1309

01:00:24,900 --> 01:00:31,940

cold temperatures right right right

1310

01:00:28,550 --> 01:00:31,940

other questions

1311

01:00:33,230 --> 01:00:35,358

Herman's got a question in the back

1312
01:00:34,949 --> 01:00:37,259
there

1313
01:00:35,358 --> 01:00:42,598
hold on Herman we got to get the

1314
01:00:37,260 --> 01:00:46,570
microphone up to you sometimes the

1315
01:00:42,599 --> 01:00:51,190
online audience likes no - well he very

1316
01:00:46,570 --> 01:00:54,700
my father's based on DNA and RNA the

1317
01:00:51,190 --> 01:01:00,789
very earliest life on Earth sorry it

1318
01:00:54,699 --> 01:01:05,289
wasn't based on DNA and RNA you got me

1319
01:01:00,789 --> 01:01:08,679
there you know I work on I think it was

1320
01:01:05,289 --> 01:01:10,389
it was based on DNA right did you get

1321
01:01:08,679 --> 01:01:21,219
that I can't imagine it wouldn't be

1322
01:01:10,389 --> 01:01:23,409
right yeah yeah yeah sorry I work

1323
01:01:21,219 --> 01:01:25,389
at the other side my expertise is at the

1324
01:01:23,409 --> 01:01:29,079
other side of the spectrum is in forming

1325
01:01:25,389 --> 01:01:31,089
the planets destroying them I have a

1326
01:01:29,079 --> 01:01:33,960
question excellent presentation but a

1327
01:01:31,090 --> 01:01:37,690
lot of exciting work worlds out there

1328
01:01:33,960 --> 01:01:41,099
and I don't want to wait is it a funding

1329
01:01:37,690 --> 01:01:43,750
thing from NASA or is it a lack of

1330
01:01:41,099 --> 01:01:46,839
technology or why we have to wait to

1331
01:01:43,750 --> 01:01:50,110
2023 and do you envision continued

1332
01:01:46,840 --> 01:01:52,269
collaboration with other countries space

1333
01:01:50,110 --> 01:01:53,410
agencies and private investment I mean

1334
01:01:52,269 --> 01:01:55,900
it sounds really exciting I don't want

1335
01:01:53,409 --> 01:01:58,719
to wait about 2023 yeah but it's a

1336
01:01:55,900 --> 01:02:00,610
balance right because it's a lot of

1337
01:01:58,719 --> 01:02:02,529
money right it's a question of funding

1338
01:02:00,610 --> 01:02:04,030
of course is limited by funding we have

1339
01:02:02,530 --> 01:02:06,190
a lot of ideas that in some cases this

1340

01:02:04,030 --> 01:02:08,980
technology development right I mean we

1341
01:02:06,190 --> 01:02:10,690
would love to send explorers to Mars but

1342
01:02:08,980 --> 01:02:12,449
there are actual limit is not only

1343
01:02:10,690 --> 01:02:15,760
expensive at their actual limitations

1344
01:02:12,449 --> 01:02:18,879
sending sending human you know human

1345
01:02:15,760 --> 01:02:21,400
exploration has actual imitations so we

1346
01:02:18,880 --> 01:02:24,369
you know here at this Institute we are

1347
01:02:21,400 --> 01:02:26,710
working on a wonderful space telescope

1348
01:02:24,369 --> 01:02:28,569
that will be come in that will be

1349
01:02:26,710 --> 01:02:30,849
overlapping with with Hubble the James

1350
01:02:28,570 --> 01:02:33,340
Webb Space Telescope but this is

1351
01:02:30,849 --> 01:02:35,860
technologically very challenging so so

1352
01:02:33,340 --> 01:02:37,809
it's both you are limited by technology

1353
01:02:35,860 --> 01:02:40,990
they need to technology of technology

1354
01:02:37,809 --> 01:02:42,820

development but also they need to to

1355

01:02:40,989 --> 01:02:48,929
have a sustainable budget right

1356

01:02:42,820 --> 01:02:48,930
so but waiting to 2023 is not that long

1357

01:02:49,048 --> 01:03:05,608
but or no Neymar's right yeah yeah yeah

1358

01:03:02,518 --> 01:03:09,088
but the Viking program in the 80s for

1359

01:03:05,608 --> 01:03:11,068
the online audience yes okay

1360

01:03:09,088 --> 01:03:13,168
so the online audience was spurred by

1361

01:03:11,068 --> 01:03:15,630
the mention of cryovolcanism and they

1362

01:03:13,168 --> 01:03:17,429
wanted to know how prevalent is

1363

01:03:15,630 --> 01:03:20,278
cryovolcanism in the solar system so

1364

01:03:17,429 --> 01:03:22,409
we've got I oh we've seen it we've seen

1365

01:03:20,278 --> 01:03:26,068
evidence of it on Pluto right on Pluto

1366

01:03:22,409 --> 01:03:28,588
on Europa on on Enceladus I'll show this

1367

01:03:26,068 --> 01:03:30,509
all at least those first at least

1368

01:03:28,588 --> 01:03:32,429
several places were there how well do we

1369
01:03:30,509 --> 01:03:33,929
understand cryovolcanoes because when I

1370
01:03:32,429 --> 01:03:36,318
went to graduate school there was no

1371
01:03:33,929 --> 01:03:39,929
there was no section on cryovolcanism

1372
01:03:36,318 --> 01:03:43,108
that I remember - yes I yeah I don't

1373
01:03:39,929 --> 01:03:46,499
know I don't know and it's it's yeah

1374
01:03:43,108 --> 01:03:49,558
it's here I mean I know that the the

1375
01:03:46,498 --> 01:03:55,259
prevalence of it on Pluto was rather

1376
01:03:49,559 --> 01:03:57,149
surprising right right yeah yes yes so I

1377
01:03:55,259 --> 01:03:57,809
guess there's still plenty to learn this

1378
01:03:57,148 --> 01:04:00,838
solar system

1379
01:03:57,809 --> 01:04:03,689
yes absolutely the new horizon really

1380
01:04:00,838 --> 01:04:06,708
opening a new world to us yes okay we

1381
01:04:03,688 --> 01:04:10,379
got a question up that up there I saw

1382
01:04:06,708 --> 01:04:13,108
you mentioned the space the James Webb

1383
01:04:10,380 --> 01:04:16,528
telescope and you work and that project

1384
01:04:13,108 --> 01:04:19,380
could you give an update on what is the

1385
01:04:16,528 --> 01:04:23,608
next year's or for that project - oh

1386
01:04:19,380 --> 01:04:27,389
yeah we are we are launching in you know

1387
01:04:23,608 --> 01:04:30,598
probably official launch date is March

1388
01:04:27,389 --> 01:04:34,229
twenty twenty one so it will it's coming

1389
01:04:30,599 --> 01:04:36,630
up and we are getting ready yeah it's

1390
01:04:34,228 --> 01:04:38,848
it's coming up we are there is already

1391
01:04:36,630 --> 01:04:41,489
approved proposals approve observing

1392
01:04:38,849 --> 01:04:43,949
proposals there is already grant money

1393
01:04:41,489 --> 01:04:46,318
flowing into the proposers and they're

1394
01:04:43,949 --> 01:04:49,798
getting ready for it so yeah

1395
01:04:46,318 --> 01:04:53,130
this building is boiling with ideas of

1396
01:04:49,798 --> 01:04:55,978
how to make it work and and it will be

1397

01:04:53,130 --> 01:04:58,798
wonderful yeah so it's coming up we only

1398
01:04:55,978 --> 01:04:59,338
get one shot at this one get it right

1399
01:04:58,798 --> 01:05:02,769
the first time

1400
01:04:59,338 --> 01:05:05,769
yes I'm sorry good

1401
01:05:02,769 --> 01:05:10,360
please refresh my memory as to what

1402
01:05:05,769 --> 01:05:13,300
Cairo volcanism is cryovolcanism cryo

1403
01:05:10,360 --> 01:05:15,369
cryolan's whatever volcanic activity at

1404
01:05:13,300 --> 01:05:18,640
extremely low temperatures cryogenic

1405
01:05:15,369 --> 01:05:21,460
temperatures right and generally the

1406
01:05:18,639 --> 01:05:42,789
heat source will be title hitting right

1407
01:05:21,460 --> 01:05:44,650
I have news as well yes yes sorry there

1408
01:05:42,789 --> 01:05:46,059
was a yes there was a good area I

1409
01:05:44,650 --> 01:05:47,579
thought I thought you wanted to comment

1410
01:05:46,059 --> 01:05:49,630
on that yes

1411
01:05:47,579 --> 01:05:52,179

what's the future of the Hubble

1412

01:05:49,630 --> 01:05:55,990

telescope when when James Webb is flying

1413

01:05:52,179 --> 01:05:57,969

Oh have a voice keep operating Hubble

1414

01:05:55,989 --> 01:05:59,379

can operate for many years from now so

1415

01:05:57,969 --> 01:06:01,569

we have it

1416

01:05:59,380 --> 01:06:03,809

we are planning a long future for Hubble

1417

01:06:01,570 --> 01:06:06,190

and it will be wonderful to have both

1418

01:06:03,809 --> 01:06:07,779

that we will work hard telescope

1419

01:06:06,190 --> 01:06:10,000

operated simultaneous because because

1420

01:06:07,780 --> 01:06:12,760

they can complement each other in a

1421

01:06:10,000 --> 01:06:16,119

wonderful way so I will say more about

1422

01:06:12,760 --> 01:06:18,400

the cryovolcanism on Io or Nile so on Io

1423

01:06:16,119 --> 01:06:21,160

is it cryovolcanism I think it's it's

1424

01:06:18,400 --> 01:06:22,780

sulfur dioxide I know that I don't know

1425

01:06:21,159 --> 01:06:23,349

what temperature that would yeah I don't

1426
01:06:22,780 --> 01:06:27,790
know either

1427
01:06:23,349 --> 01:06:31,089
I don't know either if it's I will taste

1428
01:06:27,789 --> 01:06:32,619
not it's but I don't know I don't know

1429
01:06:31,090 --> 01:06:35,800
the surface of Io is completely ice

1430
01:06:32,619 --> 01:06:39,900
correct this ice right so so it's yeah

1431
01:06:35,800 --> 01:06:43,300
so I don't know I don't know all right

1432
01:06:39,900 --> 01:06:45,579
question over here keeping the evidence

1433
01:06:43,300 --> 01:06:48,940
and everything though that we know right

1434
01:06:45,579 --> 01:06:51,549
now what which do you feel personally

1435
01:06:48,940 --> 01:06:56,019
which do you feel three candidates is

1436
01:06:51,550 --> 01:06:58,230
the best has the best chance for some

1437
01:06:56,019 --> 01:07:01,659
kind of life

1438
01:06:58,230 --> 01:07:08,800
Enceladus Titan Europa which do you

1439
01:07:01,659 --> 01:07:12,460
think well I would say Titan but maybe

1440
01:07:08,800 --> 01:07:14,289
I'm biased because I spent you know many

1441
01:07:12,460 --> 01:07:16,510
years at the University of Arizona and

1442
01:07:14,289 --> 01:07:18,099
that's you know I speak Titan X

1443
01:07:16,510 --> 01:07:22,330
in there so we had all these wonderful

1444
01:07:18,099 --> 01:07:25,059
things about Titan but I think we will

1445
01:07:22,329 --> 01:07:27,460
have much more to say about this when

1446
01:07:25,059 --> 01:07:30,849
Europa clipper gets to Europe right the

1447
01:07:27,460 --> 01:07:33,250
first body the first of these planets

1448
01:07:30,849 --> 01:07:33,880
many planets that we will explore is

1449
01:07:33,250 --> 01:07:36,730
Europa

1450
01:07:33,880 --> 01:07:40,090
so there are no plans to explore Titan

1451
01:07:36,730 --> 01:07:44,349
in the near future so so we'll cross our

1452
01:07:40,090 --> 01:07:48,820
fingers for Europa yeah alright any last

1453
01:07:44,349 --> 01:07:52,539
questions here alright if not next month

1454

01:07:48,820 --> 01:07:54,670
we will have my talk on the film and do

1455
01:07:52,539 --> 01:07:57,429
you feel the impossible magnitude of our

1456
01:07:54,670 --> 01:08:00,369
universe will include a talk as well as

1457
01:07:57,429 --> 01:08:04,469
a showing of the film but until then

1458
01:08:00,369 --> 01:08:04,469
let's give Amaya a big round of applause

1459
01:08:10,650 --> 01:08:13,010
[Applause]