PUBLIC LECTURE SERIES

Our Place in the Stars

Featuring Guest Speaker:
Amaya Moro-Martin

1
00:00:07,160 --> 00:00:04,490
good evening and welcome to the Space

2
00:00:08,990 --> 00:00:07,170
Telescope public lecture series I'm your

3
00:00:11,540 --> 00:00:09,000
host dr. Frank summers of the office of

4
00:00:13,459 --> 00:00:11,550
public outreach and is my joy and

5
00:00:16,220 --> 00:00:13,469
pleasure to be your host each and every

6
00:00:18,800 --> 00:00:16,230
month when you came in tonight we had

7
00:00:19,670 --> 00:00:18,810
lithographs tonight's lithograph is a

8
00:00:22,670 --> 00:00:19,680
new one

9
00:00:25,550 --> 00:00:22,680
it's an old image but we realized we'd

10
00:00:27,470 --> 00:00:25,560
never put out a lithograph of this image

11
00:00:30,500 --> 00:00:27,480
it's one of the classic images of the

12
00:00:32,150 --> 00:00:30,510
Orion Nebula from 2005 Hubble's it was

13
00:00:35,450 --> 00:00:32,160

released on Hubble's 15th anniversary

14
00:00:37,370 --> 00:00:35,460
and at the time it was one of the

15
00:00:42,110 --> 00:00:37,380
largest mosaics we'd ever put together

16
00:00:44,720 --> 00:00:42,120
it was some 300 million pixels when we

17
00:00:47,299 --> 00:00:44,730
released it Photoshop had a really hard

18
00:00:49,430 --> 00:00:47,309
time melding all those pixels together

19
00:00:51,170 --> 00:00:49,440
it's kind of funny we look at the things

20
00:00:52,760 --> 00:00:51,180
who all we handled all the time these

21
00:00:56,479 --> 00:00:52,770
days these hundred million pixel images

22
00:00:59,180 --> 00:00:56,489
you know in 2005 handily a 300 million

23
00:01:01,939 --> 00:00:59,190
pixel image was not an easy thing thing

24
00:01:04,759 --> 00:01:01,949
to do so if you want to learn about

25
00:01:06,920 --> 00:01:04,769
what's at the science in it turn over on

26
00:01:09,590 --> 00:01:06,930
the back and you can see it is star

27
00:01:12,500 --> 00:01:09,600
formation on a grand scale in the Orion

28
00:01:14,750 --> 00:01:12,510
Nebula and for those of you online we

29
00:01:19,010 --> 00:01:14,760
have the link amazing space Torg

30
00:01:21,620 --> 00:01:19,020
resource page 5 4 5 and you can download

31
00:01:24,980 --> 00:01:21,630
a PDF of it and look at it at your

32
00:01:29,210 --> 00:01:24,990
leisure our talk tonight your place in

33
00:01:32,810 --> 00:01:29,220
the stars from a my immoral Martyn next

34
00:01:35,270 --> 00:01:32,820
month we have an astrophysicist guide to

35
00:01:37,609 --> 00:01:35,280
the film Deep Field the impossible

36
00:01:40,280 --> 00:01:37,619
magnitude of our universe by this crazy

37
00:01:41,840 --> 00:01:40,290
guy Frank summers he'll probably just

38
00:01:44,600 --> 00:01:41,850

make it all up as he goes along because

39
00:01:48,109 --> 00:01:44,610
I know him he just says he just rambles

40
00:01:50,690 --> 00:01:48,119
on in April the art and science of

41
00:01:53,840 --> 00:01:50,700
astronomical image processing from Joe

42
00:01:55,399 --> 00:01:53,850
de Pascua a few years ago how many

43
00:01:57,679 --> 00:01:55,409
people heard Zolt Levay give a talk

44
00:02:00,380 --> 00:01:57,689
similar to this a couple years ago it

45
00:02:02,899 --> 00:02:00,390
was like four or five years ago Joe is

46
00:02:05,899 --> 00:02:02,909
our new image processor if you remember

47
00:02:09,710 --> 00:02:05,909
his old retired last summer at the end

48
00:02:12,110 --> 00:02:09,720
of last summer and Joe is our new lead

49
00:02:14,309 --> 00:02:12,120
image processor and he will give his

50
00:02:17,280 --> 00:02:14,319
take on it on how he processes

51
00:02:19,530 --> 00:02:17,290
he also has significant experience doing

52
00:02:23,910 --> 00:02:19,540
x-ray astronomy he came to us from the

53
00:02:26,250 --> 00:02:23,920
Chandra x-ray Observatory up in Boston

54
00:02:30,569 --> 00:02:26,260
so he's got a really cool take on a lot

55
00:02:32,759 --> 00:02:30,579
of things and in May we have Jolin carbo

56
00:02:35,849 --> 00:02:32,769
Berg talking she did not give me a topic

57
00:02:38,250 --> 00:02:35,859
yet but her specialty is red giant stars

58
00:02:40,830 --> 00:02:38,260
in extrasolar planets so I'm thinking

59
00:02:44,699 --> 00:02:40,840
that will be her title but we'll find

60
00:02:47,429 --> 00:02:44,709
out from her soon real soon and it will

61
00:02:50,250 --> 00:02:47,439
be posted on our website when we do have

62
00:02:51,629 --> 00:02:50,260
that this is our website if you just go

63
00:02:53,640 --> 00:02:51,639

to your favorite search engine and took

64
00:02:56,789 --> 00:02:53,650
it look for Space Telescope public

65
00:02:58,319 --> 00:02:56,799
lecture you'll find this webpage where

66
00:03:00,720 --> 00:02:58,329
we have the list of the upcoming talks

67
00:03:03,140 --> 00:03:00,730
over here on the right on the Left we

68
00:03:07,559 --> 00:03:03,150
have the links to the webcasting both

69
00:03:10,379 --> 00:03:07,569
live on STS a webcasting and YouTube as

70
00:03:14,520 --> 00:03:10,389
well as the archives where YouTube goes

71
00:03:18,599 --> 00:03:14,530
back to 2014 that's five years now and

72
00:03:21,899 --> 00:03:18,609
STS AI goes all the way back to 2005 so

73
00:03:22,619 --> 00:03:21,909
that's of almost 14 years of webcasting

74
00:03:25,530 --> 00:03:22,629
there for you

75
00:03:28,550 --> 00:03:25,540
if you would like the monthly and out

76
00:03:31,949 --> 00:03:28,560
announcements sign up for email there

77
00:03:35,490 --> 00:03:31,959
yes that emails just to say again sign

78
00:03:36,929 --> 00:03:35,500
up at the website or if you not don't

79
00:03:38,159 --> 00:03:36,939
want to do that you could just write it

80
00:03:39,749 --> 00:03:38,169
down on a piece of paper and hand it to

81
00:03:41,999 --> 00:03:39,759
me at the end of the lecture and I'll

82
00:03:43,559 --> 00:03:42,009
make sure you get on there if you have

83
00:03:46,110 --> 00:03:43,569
comments and questions you can send them

84
00:03:50,520 --> 00:03:46,120
to our email address public lecture at

85
00:03:52,800 --> 00:03:50,530
STScI dot edu finally if you are on

86
00:03:54,990 --> 00:03:52,810
looking for us on social media you will

87
00:03:56,399 --> 00:03:55,000
find Hubble of the James Webb Space

88
00:03:58,679 --> 00:03:56,409

Telescope as well as the Space Telescope

89
00:04:01,860 --> 00:03:58,689
Science Institute on Facebook Twitter

90
00:04:06,719 --> 00:04:01,870
YouTube and Instagram you'll find me on

91
00:04:09,420 --> 00:04:06,729
Facebook and Twitter sometimes now after

92
00:04:11,670 --> 00:04:09,430
the lecture we often go observing or

93
00:04:14,309 --> 00:04:11,680
sometimes go to observing hasn't been

94
00:04:17,149 --> 00:04:14,319
very often lately they tell me it is

95
00:04:20,009 --> 00:04:17,159
cloudy tonight so we will not be having

96
00:04:22,260 --> 00:04:20,019
observing if you would like to try and

97
00:04:26,100 --> 00:04:22,270
get to the observing you can go to MD

98
00:04:27,900 --> 00:04:26,110
dot space grant o RG and you'll find the

99
00:04:30,060 --> 00:04:27,910
Maryland spacecraft servitor e open

100
00:04:31,980 --> 00:04:30,070
how's Paige and they have the

101
00:04:34,230 --> 00:04:31,990
observatory status there they do

102
00:04:36,360 --> 00:04:34,240
observing every Friday nights check it

103
00:04:37,590 --> 00:04:36,370
about 5:00 p.m. on Friday and they'll

104
00:04:42,540 --> 00:04:37,600
let you know whether they're gonna open

105
00:04:47,310 --> 00:04:42,550
on a Friday night okay now our news from

106
00:04:51,180 --> 00:04:47,320
the universe for February 2019 our first

107
00:04:54,390 --> 00:04:51,190
story is new year new moon and new

108
00:04:55,310 --> 00:04:54,400
perspective now new year was last month

109
00:05:02,660 --> 00:04:55,320
right

110
00:05:06,780 --> 00:05:02,670
not quite today is Chinese New Year or

111
00:05:08,580 --> 00:05:06,790
the year of the pig so happy new year as

112
00:05:10,650 --> 00:05:08,590
an astronomer I don't like to think that

113
00:05:12,870 --> 00:05:10,660

this is Chinese New Year because the

114
00:05:16,350 --> 00:05:12,880
Chinese use the Gregorian calendar too

115
00:05:19,860 --> 00:05:16,360
it's the traditional Chinese or it's the

116
00:05:21,600 --> 00:05:19,870
lunar calendar because this was the

117
00:05:25,290 --> 00:05:21,610
beginning of the lunar calendar the

118
00:05:26,760 --> 00:05:25,300
lunar new year is today which means of

119
00:05:27,240 --> 00:05:26,770
course what is the start of a lunar

120
00:05:29,970 --> 00:05:27,250
cycle

121
00:05:34,590 --> 00:05:29,980
so what phases the moon in at the start

122
00:05:37,050 --> 00:05:34,600
of a cycle it's in New Moon and it just

123
00:05:43,170 --> 00:05:37,060
so happens that yesterday during New

124
00:05:46,980 --> 00:05:43,180
Moon the Chinese satellite longcheng -

125
00:05:50,130 --> 00:05:46,990
took a picture of the moon during new

126
00:05:51,450 --> 00:05:50,140
moon so when you take a picture can we

127
00:05:54,890 --> 00:05:51,460
get the house lights down a bit this is

128
00:05:57,180 --> 00:05:54,900
there's too much scattered light on this

129
00:05:57,690 --> 00:05:57,190
there you go now you're starting to see

130
00:05:59,580 --> 00:05:57,700
it better

131
00:06:02,240 --> 00:05:59,590
so what are you seeing when you're

132
00:06:05,550 --> 00:06:02,250
seeing the moon what is lit at New Moon

133
00:06:09,380 --> 00:06:05,560
the far side there is no dark side to

134
00:06:11,700 --> 00:06:09,390
the moon but dark side of the Moon is

135
00:06:14,880 --> 00:06:11,710
night ok uh-huh

136
00:06:17,760 --> 00:06:14,890
so when we look at the moon during New

137
00:06:18,870 --> 00:06:17,770
Moon we only see the dark side ok all

138
00:06:21,300 --> 00:06:18,880

right that's the near side of the moon

139
00:06:24,540 --> 00:06:21,310
but the far side of course is fully lit

140
00:06:27,120 --> 00:06:24,550
so this satellite is orbiting around the

141
00:06:30,720 --> 00:06:27,130
moon and is able to take a picture of

142
00:06:33,270 --> 00:06:30,730
the full full full moon but it's of the

143
00:06:36,659 --> 00:06:33,280
dark side ok on the far side really you

144
00:06:43,240 --> 00:06:40,300
of the far side of the moon in full moon

145
00:06:44,950 --> 00:06:43,250
okay whatever you and I from Earth see

146
00:06:46,749 --> 00:06:44,960
the full moon it's always the near side

147
00:06:49,260 --> 00:06:46,759
at full moon right okay

148
00:06:53,260 --> 00:06:49,270
this is a fully lit far side of the Moon

149
00:06:56,920 --> 00:06:53,270
however it's a really cooler picture

150
00:07:01,029 --> 00:06:56,930
than you might think it is because six

151
00:07:03,909 --> 00:07:01,039
billion people photobomb this image I

152
00:07:12,060 --> 00:07:03,919
covered it up and now I reveal there it

153
00:07:15,550 --> 00:07:12,070
is they got a picture of the full moon

154
00:07:18,400 --> 00:07:15,560
off showing the far side and earth in

155
00:07:24,040 --> 00:07:18,410
the background okay this is kind of cool

156
00:07:26,650 --> 00:07:24,050
so do you have a question yes this is

157
00:07:28,629 --> 00:07:26,660
the side we never see okay it's because

158
00:07:32,920 --> 00:07:28,639
the moon is tidally locked so we only

159
00:07:35,710 --> 00:07:32,930
see the same side as it orbits it always

160
00:07:38,529 --> 00:07:35,720
shows the same side to earth right okay

161
00:07:40,240 --> 00:07:38,539
so this backside of the far side is

162
00:07:41,950 --> 00:07:40,250
never is never seen when you're on earth

163
00:07:44,409 --> 00:07:41,960

you actually have to get off earth to

164
00:07:47,890 --> 00:07:44,419
see it so we never saw the far side

165
00:07:54,180 --> 00:07:47,900
until we're in it to space okay so

166
00:07:59,620 --> 00:07:57,129
actually is on this side there what

167
00:08:01,749 --> 00:07:59,630
there aren't of the big moire okay in

168
00:08:03,610 --> 00:08:01,759
detail this is a rope but first of all

169
00:08:06,159 --> 00:08:03,620
this is a really really low resolution

170
00:08:08,950 --> 00:08:06,169
camera okay it's a webcam basically at

171
00:08:11,320 --> 00:08:08,960
best all right this is not a scientific

172
00:08:13,089 --> 00:08:11,330
instrument okay this is just a webcam

173
00:08:16,180 --> 00:08:13,099
and I think the whole resolution of this

174
00:08:19,870 --> 00:08:16,190
pic of this photo is 640 by 480 okay so

175
00:08:22,510 --> 00:08:19,880
it's not even a good web kick but in

176
00:08:25,600 --> 00:08:22,520
detail there's a ton more craters on the

177
00:08:27,520 --> 00:08:25,610
far side where I was on the near side we

178
00:08:29,890 --> 00:08:27,530
had the huge impact that that had the

179
00:08:33,579 --> 00:08:29,900
Mari spread out and the lava filled in

180
00:08:36,069 --> 00:08:33,589
to create the big large impact crater

181
00:08:39,699 --> 00:08:36,079
scare question over there

182
00:08:42,430 --> 00:08:39,709
same question okay yeah unfortunately if

183
00:08:44,860 --> 00:08:42,440
you see a Clementine image of the far

184
00:08:47,530 --> 00:08:44,870
side of the Moon it's got tons and tons

185
00:08:49,689 --> 00:08:47,540
of craters okay and this is actually a

186
00:08:56,470 --> 00:08:49,699
a much more detailed in the cratering

187
00:08:59,110 --> 00:08:56,480
okay last question all right so the dark

188
00:09:00,939 --> 00:08:59,120

spot up top here alright so the dark

189
00:09:02,889 --> 00:09:00,949
spot up top here that would be where

190
00:09:05,139 --> 00:09:02,899
there was a significant impact that

191
00:09:07,480 --> 00:09:05,149
smashed through the crust and then the

192
00:09:09,460 --> 00:09:07,490
lava welled up and filled it in okay

193
00:09:11,559 --> 00:09:09,470
just like you see on the near side you

194
00:09:14,829 --> 00:09:11,569
see some really big ones of the Luna

195
00:09:17,170 --> 00:09:14,839
Mari mom Aria right the C's quote quote

196
00:09:20,019 --> 00:09:17,180
of the moon these are actually places

197
00:09:22,059 --> 00:09:20,029
where the lava from the inside welled up

198
00:09:23,980 --> 00:09:22,069
and and filled in and made it smooth and

199
00:09:27,790 --> 00:09:23,990
actually erase the craters that were

200
00:09:32,379 --> 00:09:27,800
there before okay all right our second

201
00:09:34,600 --> 00:09:32,389
story a 500 megapixel view of the

202
00:09:37,120 --> 00:09:34,610
Triangulum galaxy I was speaking about

203
00:09:39,850 --> 00:09:37,130
the Orion Nebula image being 300

204
00:09:41,439 --> 00:09:39,860
megapixels Wow we have a 500 megapixel

205
00:09:44,650 --> 00:09:41,449
view okay

206
00:09:48,340 --> 00:09:44,660
so let's set this up for you this is a

207
00:09:51,519 --> 00:09:48,350
pan of the night sky for showing our

208
00:09:53,800 --> 00:09:51,529
Milky Way galaxy our Milky Way is a

209
00:09:56,769 --> 00:09:53,810
large galaxy and in the local group

210
00:09:58,240 --> 00:09:56,779
there are three respectable galaxies and

211
00:10:01,059 --> 00:09:58,250
a lot of you know flotsam and jetsam

212
00:10:02,889 --> 00:10:01,069
dwarf galaxies okay you can see two of

213
00:10:04,750 --> 00:10:02,899

the philosopher jets and Worf galaxies

214
00:10:07,960 --> 00:10:04,760
over here on the right these are the

215
00:10:10,000 --> 00:10:07,970
large and small Magellanic Clouds you

216
00:10:14,350 --> 00:10:10,010
can see the other large galaxies over

217
00:10:17,110 --> 00:10:14,360
here on the left this is the Andromeda

218
00:10:19,420 --> 00:10:17,120
galaxy so the second large galaxies in

219
00:10:22,030 --> 00:10:19,430
our local group is the Andromeda galaxy

220
00:10:24,850 --> 00:10:22,040
it's about the same size as the Milky

221
00:10:29,410 --> 00:10:24,860
Way perhaps about 10-15 percent larger

222
00:10:34,840 --> 00:10:29,420
from most estimates and about ten years

223
00:10:37,360 --> 00:10:34,850
ago we did a very large mosaic spanning

224
00:10:39,639 --> 00:10:37,370
through the Andromeda galaxy and it was

225
00:10:42,819 --> 00:10:39,649
called the pen chromatic Hubble

226
00:10:45,129 --> 00:10:42,829
Andromeda Treasury program just because

227
00:10:51,160 --> 00:10:45,139
the P I wanted to be able to spell out

228
00:10:52,569 --> 00:10:51,170
PA JT o it's fat all right um so the pan

229
00:10:55,920 --> 00:10:52,579
chromatic novel and drama treasure

230
00:10:58,540 --> 00:10:55,930
burger was the largest image we've ever

231
00:11:01,420 --> 00:10:58,550
mosaic we've ever produced okay

232
00:11:02,980 --> 00:11:01,430
it was C if I go to the next

233
00:11:06,580 --> 00:11:02,990
here you go here it is here's the phat

234
00:11:09,340 --> 00:11:06,590
image okay it was like 52,000 pixels

235
00:11:11,080 --> 00:11:09,350
this way by like twenty thousand pixels

236
00:11:13,660 --> 00:11:11,090
this way this was definitely the full

237
00:11:17,230 --> 00:11:13,670
image was like a billion pixels here

238
00:11:18,940 --> 00:11:17,240

alright and this was like 420

239
00:11:21,100 --> 00:11:18,950
observations with Hubble different

240
00:11:22,990 --> 00:11:21,110
fields in the observations are amazing

241
00:11:25,330 --> 00:11:23,000
huge and that's why it's a treasury

242
00:11:27,370 --> 00:11:25,340
program because these were special

243
00:11:30,550 --> 00:11:27,380
programs given a lot of Hubble time to

244
00:11:33,430 --> 00:11:30,560
do really big things well this was a

245
00:11:35,590 --> 00:11:33,440
huge boon for stellar astronomy because

246
00:11:37,990 --> 00:11:35,600
they could resolve hundreds of millions

247
00:11:40,510 --> 00:11:38,000
of stars in the Andromeda galaxy and

248
00:11:42,250 --> 00:11:40,520
able to study the stellar populations

249
00:11:45,130 --> 00:11:42,260
going from the core of the galaxy out to

250
00:11:47,770 --> 00:11:45,140
the edge of the galaxy so if that worked

251
00:11:50,230 --> 00:11:47,780
for the Andromeda galaxy let's apply it

252
00:11:52,870 --> 00:11:50,240
to the third largest galaxies in our

253
00:11:55,570 --> 00:11:52,880
local group which is the Triangulum

254
00:11:58,210 --> 00:11:55,580
galaxy so this is a ground-based picture

255
00:12:01,330 --> 00:11:58,220
of the Triangulum galaxy and Hubble's

256
00:12:04,330 --> 00:12:01,340
going to do that same mosaicing and a

257
00:12:06,190 --> 00:12:04,340
few field on this and we covered

258
00:12:09,880 --> 00:12:06,200
approximately that much of the

259
00:12:13,660 --> 00:12:09,890
Triangulum galaxy and this 500 million

260
00:12:16,240 --> 00:12:13,670
pixel mosaic looks like that and you say

261
00:12:17,770 --> 00:12:16,250
well that's not really cool that not

262
00:12:20,500 --> 00:12:17,780
that that well you're seeing it unlike

263
00:12:22,600 --> 00:12:20,510

one megapixel okay so the 500 megapixels

264
00:12:25,780 --> 00:12:22,610
are aren't thing but just see there's an

265
00:12:28,540 --> 00:12:25,790
incredible amount of detail and let me

266
00:12:30,640 --> 00:12:28,550
oh and so they I think they probably

267
00:12:33,130 --> 00:12:30,650
considered calling it the pan chromatic

268
00:12:36,550 --> 00:12:33,140
Hubble Triangulum Treasury program but

269
00:12:39,910 --> 00:12:36,560
that would come out it so I'm just gonna

270
00:12:43,390 --> 00:12:39,920
refer to as the humble Triangulum mosaic

271
00:12:47,230 --> 00:12:43,400
no they did not try to call it the phtt

272
00:12:50,020 --> 00:12:47,240
that's suggest by me having fun here the

273
00:12:52,300 --> 00:12:50,030
Hubble triangular mosaic of all this

274
00:12:56,020 --> 00:12:52,310
stuff and let's show you just how

275
00:12:58,390 --> 00:12:56,030
detailed it is so here is the night sky

276
00:13:00,640 --> 00:12:58,400
and if you didn't know there's

277
00:13:03,310 --> 00:13:00,650
triangular major and triangular minor

278
00:13:05,260 --> 00:13:03,320
four constellations and of course here

279
00:13:08,680 --> 00:13:05,270
is our Triangulum galaxy in the center

280
00:13:14,410 --> 00:13:08,690
and watch how far we get to zoom in to

281
00:13:30,730 --> 00:13:18,310
yeah we just keep going and we keep

282
00:13:33,860 --> 00:13:30,740
going yeah there you go that we get to

283
00:13:36,790 --> 00:13:33,870
the detail the Hubble image okay

284
00:13:39,130 --> 00:13:36,800
[Laughter]

285
00:13:41,080 --> 00:13:39,140
yours go definitely can't do it because

286
00:13:43,300 --> 00:13:41,090
you see all this blurry over here in the

287
00:13:45,790 --> 00:13:43,310
lower left corner yeah that's what we're

288
00:13:47,560 --> 00:13:45,800

taking from the DSS survey etc and this

289
00:13:50,280 --> 00:13:47,570
is the Hubble image overlaid on top of

290
00:13:52,620 --> 00:13:50,290
it and all of these stars you see here

291
00:13:56,970 --> 00:13:52,630
they're not stars in the foreground

292
00:14:01,300 --> 00:13:56,980
those are stars in the Triangulum galaxy

293
00:14:04,120 --> 00:14:01,310
okay we are resolving individual stars

294
00:14:06,570 --> 00:14:04,130
in the Triangulum galaxy they tell me

295
00:14:10,630 --> 00:14:06,580
there are more than 25 million

296
00:14:13,480 --> 00:14:10,640
individual stars in this mosaic so

297
00:14:15,910 --> 00:14:13,490
here's the mosaic this up here is NGC

298
00:14:18,370 --> 00:14:15,920
604 one of the largest star forming

299
00:14:20,290 --> 00:14:18,380
regions in the local group and you can

300
00:14:22,150 --> 00:14:20,300
see what incredible detail Hubble can

301
00:14:23,890 --> 00:14:22,160
get in that and all the individual stars

302
00:14:25,780 --> 00:14:23,900
they can see look at this globular

303
00:14:26,620 --> 00:14:25,790
cluster okay that's the green box so

304
00:14:29,140 --> 00:14:26,630
that's right here

305
00:14:31,660 --> 00:14:29,150
that's a globular cluster that we're

306
00:14:32,440 --> 00:14:31,670
seeing in a galaxy three million

307
00:14:35,260 --> 00:14:32,450
light-years away

308
00:14:37,810 --> 00:14:35,270
okay there are of course a few

309
00:14:40,180 --> 00:14:37,820
foreground stars here that's the blue

310
00:14:42,610 --> 00:14:40,190
box so right here and there are also

311
00:14:46,720 --> 00:14:42,620
background galaxies alright then this

312
00:14:50,710 --> 00:14:46,730
red box here so the the world would even

313
00:14:52,660 --> 00:14:50,720

at the Triangulum galaxy is not opaque

314
00:14:54,220 --> 00:14:52,670
it is somewhat transparent so we can see

315
00:14:56,350 --> 00:14:54,230
through it and see some of the

316
00:14:59,170 --> 00:14:56,360
background galaxies now they're going to

317
00:15:01,660 --> 00:14:59,180
do again with the Triangulum galaxy the

318
00:15:03,520 --> 00:15:01,670
same star formation and star cell our

319
00:15:06,820 --> 00:15:03,530
population studies that they did with

320
00:15:10,990 --> 00:15:06,830
the Andromeda galaxy but as evidenced by

321
00:15:13,480 --> 00:15:11,000
NGC 604 there is significantly more star

322
00:15:15,850 --> 00:15:13,490
formation per unit mass in the

323
00:15:19,090 --> 00:15:15,860
Triangulum galaxy so they're able to

324
00:15:21,250 --> 00:15:19,100
study more of these bursting star four

325
00:15:23,710 --> 00:15:21,260
regions the star formation rate in the

326
00:15:25,330 --> 00:15:23,720
Triangulum is ten times the star

327
00:15:27,970 --> 00:15:25,340
formation rate in the Andromeda galaxy

328
00:15:30,970 --> 00:15:27,980
so they're able to study in great

329
00:15:32,440 --> 00:15:30,980
Heil the stellar populations in a cell

330
00:15:35,740 --> 00:15:32,450
exceed with much more star formation

331
00:15:39,760 --> 00:15:35,750
which will give extend the study into

332
00:15:41,890 --> 00:15:39,770
new realms so we have another 500

333
00:15:42,580 --> 00:15:41,900
megapixel image Oh piece of cake right

334
00:15:44,470 --> 00:15:42,590
these days

335
00:15:47,470 --> 00:15:44,480
yeah even these are still difficult

336
00:15:49,720 --> 00:15:47,480
difficult to handle but by taking Hubble

337
00:15:53,530 --> 00:15:49,730
and spreading it over a lot of fields

338
00:15:54,580 --> 00:15:53,540

you can get a lot of images let me just

339
00:15:58,750 --> 00:15:54,590
say one thing

340
00:16:03,640 --> 00:15:58,760
okay that we have on the on the books

341
00:16:06,580 --> 00:16:03,650
for the next decade a telescope that has

342
00:16:10,480 --> 00:16:06,590
one the same resolution as Hubble but

343
00:16:12,970 --> 00:16:10,490
100 times the field of view all right

344
00:16:15,130 --> 00:16:12,980
in the next decade it's an infrared one

345
00:16:17,260 --> 00:16:15,140
okay but in the next decade we'll be

346
00:16:19,660 --> 00:16:17,270
able to take images like this routinely

347
00:16:22,620 --> 00:16:19,670
not using hundreds of individual

348
00:16:24,210 --> 00:16:22,630
pointings but using you know five ten

349
00:16:26,980 --> 00:16:24,220
individual pointings

350
00:16:29,320 --> 00:16:26,990
so we're looking towards in the next

351
00:16:31,360 --> 00:16:29,330
decade a great revolution in astronomy

352
00:16:33,550 --> 00:16:31,370
in terms of this the amount of data that

353
00:16:37,170 --> 00:16:33,560
we're gonna be able to handle with these

354
00:16:40,780 --> 00:16:37,180
hundred megapixel cameras on these very

355
00:16:43,210 --> 00:16:40,790
variety of telescopes so this is really

356
00:16:44,980 --> 00:16:43,220
cool it's really great but just reminds

357
00:16:46,780 --> 00:16:44,990
me that in the future this is gonna be

358
00:16:48,540 --> 00:16:46,790
commonplace and we're gonna be able to

359
00:16:51,850 --> 00:16:48,550
get this kind of type of stuff every day

360
00:16:54,700 --> 00:16:51,860
so let's enjoy it and always look

361
00:16:57,030 --> 00:16:54,710
forward to the future all right that's

362
00:17:00,310 --> 00:16:57,040
our news for the universe for tonight

363
00:17:02,800 --> 00:17:00,320

our featured speaker tonight is a Maya

364
00:17:04,210 --> 00:17:02,810
Mauro Martin she has been here at the

365
00:17:06,220 --> 00:17:04,220
Space Telescope Science Institute for

366
00:17:13,150 --> 00:17:06,230
five years and she works on what's

367
00:17:15,160 --> 00:17:13,160
called the science missions office and

368
00:17:18,550 --> 00:17:15,170
where she specializes it working on the

369
00:17:24,190 --> 00:17:18,560
James Webb Space Telescope our science

370
00:17:26,290 --> 00:17:24,200
studies focus on debris disks or yes

371
00:17:27,730 --> 00:17:26,300
their debris disks around stars of

372
00:17:29,290 --> 00:17:27,740
course there is a little bit of debris

373
00:17:30,580 --> 00:17:29,300
in our own solar system but most of

374
00:17:32,710 --> 00:17:30,590
place where you would find debris disc

375
00:17:34,360 --> 00:17:32,720
is around newly formed stars where there

376
00:17:37,090 --> 00:17:34,370
are planets forming out where plants

377
00:17:39,460 --> 00:17:37,100
have formed around other stars looking

378
00:17:40,520 --> 00:17:39,470
for these DS de su materials inside of

379
00:17:42,860 --> 00:17:40,530
those stars but

380
00:17:44,870 --> 00:17:42,870
she's going to talk about our place in

381
00:17:58,850 --> 00:17:44,880
the stars so ladies and gentlemen mi

382
00:18:25,540 --> 00:17:58,860
amor Oh Martin thank you thank you too

383
00:18:36,950 --> 00:18:25,550
much the pressure there you go

384
00:18:38,990 --> 00:18:36,960
all right so okay so to start with I'm

385
00:18:40,130 --> 00:18:39,000
going to show you a short movie by Eric

386
00:18:42,350 --> 00:18:40,140
we're in quiz

387
00:18:45,530 --> 00:18:42,360
narrated by Carl Sagan where you will

388
00:18:48,140 --> 00:18:45,540

see images of real sites on of our solar

389
00:18:50,870 --> 00:18:48,150
system that I've recreated from real

390
00:18:53,330 --> 00:18:50,880
photographs and real data obtained by

391
00:18:55,630 --> 00:18:53,340
NASA this short movie begins with an

392
00:18:58,550 --> 00:18:55,640
image of some nomads that are walking on

393
00:18:59,870 --> 00:18:58,560
a ballet on earth probably around the

394
00:19:04,850 --> 00:18:59,880
Neolithic around the time that

395
00:19:14,380 --> 00:19:04,860
agriculture was invented and M let's see

396
00:19:21,430 --> 00:19:18,740
what do you mean I think it went to the

397
00:19:24,200 --> 00:19:21,440
last piece of it there you go

398
00:19:24,820 --> 00:19:24,210
there so they are working on a ballet on

399
00:19:28,070 --> 00:19:24,830
earth

400
00:19:31,670 --> 00:19:28,080
just after sunset and in the horizon

401
00:19:36,200 --> 00:19:31,680
they can see Mercury Venus Mars and up

402
00:19:38,150 --> 00:19:36,210
there Jupiter and Saturn and the title

403
00:19:40,940 --> 00:19:38,160
of the movie is Wanderers which is the

404
00:19:43,900 --> 00:19:40,950
same name that the ancient Greeks gave

405
00:19:46,790 --> 00:19:43,910
to the to the planets to these nomads

406
00:19:48,710 --> 00:19:46,800
these planets were indistinguishable

407
00:19:51,830 --> 00:19:48,720
from the stars except that they were

408
00:19:54,259 --> 00:19:51,840
brighter and this how one stopped to

409
00:19:56,619 --> 00:19:54,269
observe them carefully record

410
00:19:59,209 --> 00:19:56,629
in their positions every night and

411
00:20:01,940 --> 00:19:59,219
realized that they move very different

412
00:20:03,589 --> 00:20:01,950
from the stars they start moving in one

413
00:20:05,209 --> 00:20:03,599

direction and then they start going in a

414
00:20:07,430 --> 00:20:05,219
retrograde direction and then they keep

415
00:20:09,259 --> 00:20:07,440
going in the same direction and this

416
00:20:11,899 --> 00:20:09,269
observation was done more than 2,000

417
00:20:14,239 --> 00:20:11,909
years ago by the ancient Greeks or maybe

418
00:20:15,979 --> 00:20:14,249
even earlier by the ancient Egyptians

419
00:20:19,310 --> 00:20:15,989
and this is why the ancient Greeks

420
00:20:21,379 --> 00:20:19,320
called these stars they call them

421
00:20:23,299 --> 00:20:21,389
wandering stars because they seem to

422
00:20:25,219 --> 00:20:23,309
wander in the sky and and the word

423
00:20:27,859 --> 00:20:25,229
planet comes from the Greek planet s

424
00:20:30,379 --> 00:20:27,869
that means wanderer the data of of the

425
00:20:33,560 --> 00:20:30,389
movie does not refer to the planets and

426
00:20:36,079 --> 00:20:33,570
it refers to our quest as humans to

427
00:20:38,359 --> 00:20:36,089
understand to discover to explore the

428
00:20:41,509 --> 00:20:38,369
unknown and in doing so many times we

429
00:20:43,310 --> 00:20:41,519
challenge a widely accepted ideas they

430
00:20:45,949 --> 00:20:43,320
make planets wander do movement as an

431
00:20:48,109 --> 00:20:45,959
example that movement drove many people

432
00:20:49,969 --> 00:20:48,119
crazy because they just couldn't figure

433
00:20:52,310 --> 00:20:49,979
out why the planets would do that and

434
00:20:54,019 --> 00:20:52,320
they could not understand it because the

435
00:20:56,239 --> 00:20:54,029
widely accepted view was that the earth

436
00:20:58,699 --> 00:20:56,249
was at the center of the universe but if

437
00:21:00,529 --> 00:20:58,709
you change that view that mindset that

438
00:21:02,389 --> 00:21:00,539

everybody believed in and you accept

439
00:21:04,759 --> 00:21:02,399
that the earth is not at the center of

440
00:21:07,190 --> 00:21:04,769
the universe but that moves around the

441
00:21:09,560 --> 00:21:07,200
Sun as Copernicus suggested more than

442
00:21:12,019 --> 00:21:09,570
400 years ago then the movement of the

443
00:21:14,989 --> 00:21:12,029
planets could be understood but

444
00:21:15,560 --> 00:21:14,999
challenging widely accepted ideas is not

445
00:21:18,529 --> 00:21:15,570
easy

446
00:21:20,719 --> 00:21:18,539
this is Galileo Galilei you all know him

447
00:21:22,430 --> 00:21:20,729
this is the Italian astronomer that ran

448
00:21:25,609 --> 00:21:22,440
into a lot of trouble for defending that

449
00:21:27,169 --> 00:21:25,619
the earth was moving around the Sun and

450
00:21:29,989 --> 00:21:27,179
he was convinced this was the case

451
00:21:32,389 --> 00:21:29,999
because he had made careful observations

452
00:21:34,849 --> 00:21:32,399
using a telescope he was the first

453
00:21:36,709 --> 00:21:34,859
astronomer to do so and he had also

454
00:21:38,389 --> 00:21:36,719
discovered that they were fainter

455
00:21:40,759 --> 00:21:38,399
planets that were orbiting around

456
00:21:42,589 --> 00:21:40,769
Jupiter so if they were finding planets

457
00:21:43,969 --> 00:21:42,599
orbiting idea around you better why

458
00:21:46,549 --> 00:21:43,979
couldn't a bright the planets orbit

459
00:21:48,769 --> 00:21:46,559
around the Sun on Galileo got into a lot

460
00:21:51,379 --> 00:21:48,779
of trouble as I said for for defending

461
00:21:52,849 --> 00:21:51,389
this idea and for claiming the earth was

462
00:21:55,009 --> 00:21:52,859
not fixed at the center of the universe

463
00:21:58,129 --> 00:21:55,019

and he ended under house arrest because

464
00:22:00,229 --> 00:21:58,139
the Inquisition gives him and the story

465
00:22:02,329 --> 00:22:00,239
goes that when he was released he looked

466
00:22:04,579 --> 00:22:02,339
to the sky he looked down and he is

467
00:22:06,919 --> 00:22:04,589
stumped his food and he said and yet it

468
00:22:07,580 --> 00:22:06,929
moves because he wasn't surrender he

469
00:22:11,450 --> 00:22:07,590
said yeah

470
00:22:14,750 --> 00:22:11,460
it was based on evidence this is your

471
00:22:16,190 --> 00:22:14,760
Lana Bruno another astronomer scientist

472
00:22:18,980 --> 00:22:16,200
and philosopher that lived before

473
00:22:21,140 --> 00:22:18,990
Galileo that also got into a lot of

474
00:22:23,299 --> 00:22:21,150
trouble for arguing that in an infinite

475
00:22:24,769 --> 00:22:23,309
universe in which all if stars are

476
00:22:26,630 --> 00:22:24,779
surrounded by their own planetary

477
00:22:28,399 --> 00:22:26,640
systems the most logical thing will be

478
00:22:32,659 --> 00:22:28,409
for other worlds like the earth to exist

479
00:22:34,519 --> 00:22:32,669
and if so they would Harbor life think

480
00:22:36,850 --> 00:22:34,529
that this was this was an assignment

481
00:22:40,490 --> 00:22:36,860
made more than 400 years ago this is

482
00:22:42,139 --> 00:22:40,500
mind-blowing and his views of course

483
00:22:44,450 --> 00:22:42,149
were considered heretical at the time

484
00:22:46,820 --> 00:22:44,460
because and he was on trial and he was

485
00:22:48,500 --> 00:22:46,830
born to it to death but he stayed true

486
00:22:50,149 --> 00:22:48,510
to his arguments and one of the quotes

487
00:22:52,820 --> 00:22:50,159
that people attribute to him is that

488
00:22:54,830 --> 00:22:52,830

truth that does not change because it is

489
00:22:57,649 --> 00:22:54,840
or it is not believed by a majority of

490
00:22:59,659 --> 00:22:57,659
the people and guess what the other day

491
00:23:01,610 --> 00:22:59,669
while I was preparing this as lights

492
00:23:03,740 --> 00:23:01,620
I took a break to press one of the

493
00:23:06,470 --> 00:23:03,750
issues from nature the nature magazine

494
00:23:09,500 --> 00:23:06,480
that I get on the mail every week and I

495
00:23:12,639 --> 00:23:09,510
found this letter and this is a letter

496
00:23:15,500 --> 00:23:12,649
written by Galileo in 1613 and

497
00:23:17,029 --> 00:23:15,510
historians knew it existed but it was

498
00:23:20,149 --> 00:23:17,039
thought to be lost and it was discovered

499
00:23:22,519 --> 00:23:20,159
by chance this last August in London in

500
00:23:25,940 --> 00:23:22,529
the in the archives of the Royal Society

501
00:23:28,070 --> 00:23:25,950
and according to nature this is the

502
00:23:30,380 --> 00:23:28,080
letter where Galileo first defends that

503
00:23:33,799 --> 00:23:30,390
scientific research should be free from

504
00:23:35,659 --> 00:23:33,809
the theological doctrine and this letter

505
00:23:38,000 --> 00:23:35,669
that launched one of science history's

506
00:23:40,070 --> 00:23:38,010
most famous battles is one of the first

507
00:23:42,169 --> 00:23:40,080
secular manifestos about the freedom of

508
00:23:46,760 --> 00:23:42,179
science so this is a very powerful

509
00:23:49,669 --> 00:23:46,770
letter that fortunately now you know we

510
00:23:52,220 --> 00:23:49,679
know it's we have it now if it was it

511
00:23:55,490 --> 00:23:52,230
was thought it was lost and when I saw

512
00:23:58,159 --> 00:23:55,500
this him I felt that history was sending

513
00:24:00,159 --> 00:23:58,169

us a message from a time long past to

514
00:24:02,840 --> 00:24:00,169
remind us what is fantastic today

515
00:24:04,970 --> 00:24:02,850
because we live in a paradoxical time in

516
00:24:07,460 --> 00:24:04,980
which even though science and technology

517
00:24:09,350 --> 00:24:07,470
are omnipresent in our everyday life and

518
00:24:11,060 --> 00:24:09,360
thanks to them many of us enjoy a

519
00:24:13,010 --> 00:24:11,070
standard of living that has never been

520
00:24:15,799 --> 00:24:13,020
so high there is a growing gap between

521
00:24:17,180 --> 00:24:15,809
science and society as it can be seen

522
00:24:19,190 --> 00:24:17,190
for example in the questioning of

523
00:24:20,780 --> 00:24:19,200
vaccines and climate change the rise of

524
00:24:23,000 --> 00:24:20,790
alternative medicine

525
00:24:25,970 --> 00:24:23,010
and even the questioning of evolution

526
00:24:28,340 --> 00:24:25,980
and this is so because also things to

527
00:24:29,570 --> 00:24:28,350
science and technology never before we

528
00:24:32,470 --> 00:24:29,580
have had access to so much information

529
00:24:34,880 --> 00:24:32,480
but also to so much misinformation and

530
00:24:36,740 --> 00:24:34,890
we live in a Bosch truth world

531
00:24:38,480 --> 00:24:36,750
unfortunately we're ideological

532
00:24:40,310 --> 00:24:38,490
affirmations are commonly presented as

533
00:24:43,040 --> 00:24:40,320
equivalent to those based on evidence

534
00:24:45,470 --> 00:24:43,050
and this letter I thought was a reminder

535
00:24:47,450 --> 00:24:45,480
of the extraordinary importance of

536
00:24:49,550 --> 00:24:47,460
science to help citizens to develop the

537
00:24:51,410 --> 00:24:49,560
ability to think critically based on

538
00:24:53,660 --> 00:24:51,420

evidence which is the key of all

539
00:24:55,280 --> 00:24:53,670
scientific activity of course and which

540
00:24:57,470 --> 00:24:55,290
is an ability that can be applied to all

541
00:24:59,390 --> 00:24:57,480
aspects of her life and help us become

542
00:25:01,730 --> 00:24:59,400
better inform less manipulable and

543
00:25:04,640 --> 00:25:01,740
demand evidence nice policy and this is

544
00:25:06,530 --> 00:25:04,650
so important nowadays but let's get back

545
00:25:08,240 --> 00:25:06,540
to the source field I promise to show

546
00:25:10,510 --> 00:25:08,250
you this film talks about the need of

547
00:25:13,220 --> 00:25:10,520
the human being to explore the unknown

548
00:25:15,140 --> 00:25:13,230
because that curiosity is precisely one

549
00:25:17,090 --> 00:25:15,150
of the human beings most characteristic

550
00:25:19,340 --> 00:25:17,100
traits that curiosity is what centuries

551
00:25:21,260 --> 00:25:19,350
ago made us climb to the top of the

552
00:25:24,890 --> 00:25:21,270
highest mountains to see her essence

553
00:25:26,450 --> 00:25:24,900
that nobody has ever seen or make us

554
00:25:28,280 --> 00:25:26,460
dive into the deepest trenches of the

555
00:25:31,700 --> 00:25:28,290
ocean to witness the dark alien of the

556
00:25:33,650 --> 00:25:31,710
abbeys and it is the same quest that

557
00:25:35,450 --> 00:25:33,660
made us search for answers for what we

558
00:25:36,950 --> 00:25:35,460
don't understand like the movement of

559
00:25:39,260 --> 00:25:36,960
the planets in the sky it is the same

560
00:25:41,300 --> 00:25:39,270
curiosity that allow us to little by

561
00:25:43,970 --> 00:25:41,310
little make sense of the world we live

562
00:25:45,860 --> 00:25:43,980
in even if the findings challenge our

563
00:25:48,740 --> 00:25:45,870

previous beliefs like a story of Galileo

564
00:25:50,600 --> 00:25:48,750
and as I said that sort of movie begins

565
00:25:52,580 --> 00:25:50,610
with nomads that are looking at the

566
00:25:54,980 --> 00:25:52,590
planets and then a movie makes a big

567
00:25:56,270 --> 00:25:54,990
leap in time to show us a snapshot of

568
00:25:58,070 --> 00:25:56,280
the future where you can see a

569
00:26:00,590 --> 00:25:58,080
spacecraft moving away from the earth

570
00:26:02,780 --> 00:26:00,600
and on board this is crazy a spacecraft

571
00:26:05,060 --> 00:26:02,790
may be the first explorers of the solar

572
00:26:07,670 --> 00:26:05,070
system and what the short film does is

573
00:26:11,510 --> 00:26:07,680
to narrow it with images recreate it on

574
00:26:13,700 --> 00:26:11,520
real data and the story of these nomads

575
00:26:15,830 --> 00:26:13,710
these wonders of the future this

576
00:26:20,930 --> 00:26:15,840
pioneers Explorer II not me continents

577
00:26:33,350 --> 00:26:20,940
or new oceans but new worlds and now we

578
00:26:33,360 --> 00:26:46,240
the

579
00:27:11,790 --> 00:26:59,730
[Music]

580
00:27:30,410 --> 00:27:11,800
[Applause]

581
00:28:59,260 --> 00:27:46,550
[Music]

582
00:28:59,980 --> 00:28:59,270
[Applause]

583
00:30:04,870 --> 00:28:59,990
[Music]

584
00:30:10,430 --> 00:30:08,660
breathtaking so why are we fascinated by

585
00:30:12,200 --> 00:30:10,440
these worlds because we have found

586
00:30:14,090 --> 00:30:12,210
through careful observation that they

587
00:30:14,860 --> 00:30:14,100
might Harbor the conditions to sustain

588
00:30:20,980 --> 00:30:14,870

life

589
00:30:25,040 --> 00:30:20,990
in these worlds is extraordinarily

590
00:30:26,570 --> 00:30:25,050
exciting so this is an image of Europa

591
00:30:31,340 --> 00:30:26,580
that you saw in the film

592
00:30:34,910 --> 00:30:31,350
it shows M explorers you see the

593
00:30:36,800 --> 00:30:34,920
Explorers here and they're walking on

594
00:30:39,260 --> 00:30:36,810
it's icy surface Europa is one of the

595
00:30:44,150 --> 00:30:39,270
great moons of Jupiter so here in the

596
00:30:45,770 --> 00:30:44,160
horizon this is Jupiter right and Europe

597
00:30:47,720 --> 00:30:45,780
is a little smaller than the moon and

598
00:30:49,970 --> 00:30:47,730
it's made of silicates with a core made

599
00:30:52,640 --> 00:30:49,980
of iron and nickel just like the earth

600
00:30:54,650 --> 00:30:52,650
but Europa has a thick frozen crust that

601
00:30:57,410 --> 00:30:54,660
is several several kilometers in thick

602
00:30:59,300 --> 00:30:57,420
that is full of cracks and there is

603
00:31:01,430 --> 00:30:59,310
evidence that under this ice there is a

604
00:31:03,260 --> 00:31:01,440
liquid ocean that is estimated to harbor

605
00:31:04,670 --> 00:31:03,270
twice as much water as the oceans of the

606
00:31:06,950 --> 00:31:04,680
earth and it is also believed that

607
00:31:11,630 --> 00:31:06,960
Europa has a tenuous atmosphere of

608
00:31:13,940 --> 00:31:11,640
oxygen how can there be liquid water

609
00:31:16,370 --> 00:31:13,950
inside Europe is it so far from the Sun

610
00:31:18,710 --> 00:31:16,380
right this is what we call the habitable

611
00:31:20,930 --> 00:31:18,720
zone is the area in the solar system

612
00:31:23,630 --> 00:31:20,940
where liquid water can exist on the

613
00:31:26,990 --> 00:31:23,640

surface only two planets are in this

614
00:31:30,110 --> 00:31:27,000
habitable zone in solar system Mars and

615
00:31:32,180 --> 00:31:30,120
and the earth and if you go to a to

616
00:31:34,370 --> 00:31:32,190
close scene is too hot and the water

617
00:31:38,210 --> 00:31:34,380
will evaporate and if you go too far out

618
00:31:40,250 --> 00:31:38,220
is to call and the water will be ice but

619
00:31:41,870 --> 00:31:40,260
liquid water can exist in Europa because

620
00:31:44,240 --> 00:31:41,880
it is very close to Jupiter and its

621
00:31:46,040 --> 00:31:44,250
enormous gravity produces tidal forces

622
00:31:48,440 --> 00:31:46,050
inside Europa data resource of energy

623
00:31:50,960 --> 00:31:48,450
these tidal forces are similar to those

624
00:31:52,790 --> 00:31:50,970
created by the moon on Earth's ocean

625
00:31:55,790 --> 00:31:52,800
that are responsible for the ocean tides

626
00:31:57,770 --> 00:31:55,800
so this tides in Europa are much

627
00:31:59,510 --> 00:31:57,780
stronger because Jupiter is very massive

628
00:32:02,330 --> 00:31:59,520
and they're so strong that they can

629
00:32:04,040 --> 00:32:02,340
cause geological activity similar to

630
00:32:06,560 --> 00:32:04,050
that of the tectonic plates on earth and

631
00:32:09,140 --> 00:32:06,570
this creates these cracks in the in the

632
00:32:09,870 --> 00:32:09,150
icy surface of Europa and through this

633
00:32:12,180 --> 00:32:09,880
crack

634
00:32:14,520 --> 00:32:12,190
seems that there is material from the

635
00:32:16,770 --> 00:32:14,530
frozen surface that sinks to the liquid

636
00:32:18,390 --> 00:32:16,780
ocean underneath and the other way

637
00:32:20,900 --> 00:32:18,400
around material from the liquid ocean

638
00:32:24,150 --> 00:32:20,910

underneath that rises to the surface and

639
00:32:25,530 --> 00:32:24,160
the reason why we know this is happening

640
00:32:29,190 --> 00:32:25,540
even though we haven't actually seen any

641
00:32:31,050 --> 00:32:29,200
robotic explorers project is any any any

642
00:32:33,390 --> 00:32:31,060
Explorer is there or any robotic

643
00:32:35,280 --> 00:32:33,400
explorers there is because we think that

644
00:32:38,310 --> 00:32:35,290
this brownish material that you see in

645
00:32:40,110 --> 00:32:38,320
the cracks is the salt that is coming

646
00:32:43,140 --> 00:32:40,120
from the liquid ocean underneath and we

647
00:32:46,980 --> 00:32:43,150
know this because when you put this type

648
00:32:49,500 --> 00:32:46,990
of salt in in a chamber and you put it

649
00:32:51,570 --> 00:32:49,510
under the temperature and the pressure

650
00:32:53,790 --> 00:32:51,580
that is in Europe I it comes out of a

651
00:32:57,360 --> 00:32:53,800
similar color as the one that we see in

652
00:32:59,400 --> 00:32:57,370
the cracks of Europa both the existence

653
00:33:01,590 --> 00:32:59,410
of liquid water in Europe and of that

654
00:33:04,350 --> 00:33:01,600
flow of material between the icy surface

655
00:33:05,910 --> 00:33:04,360
and the liquid or water underneath are

656
00:33:07,710 --> 00:33:05,920
very interested in the costal in the

657
00:33:09,960 --> 00:33:07,720
context of weather Europa could Harbor

658
00:33:13,290 --> 00:33:09,970
life and it has been speculated that

659
00:33:15,270 --> 00:33:13,300
there may be hydrothermal vents in that

660
00:33:18,450 --> 00:33:15,280
ocean of Europe as similar to the ones

661
00:33:20,270 --> 00:33:18,460
we have on earth and in on earth these

662
00:33:23,850 --> 00:33:20,280
vents are teeming with life

663
00:33:27,300 --> 00:33:23,860

sank to the heat exchange and the

664
00:33:29,340 --> 00:33:27,310
exchange of chemical compounds so Europe

665
00:33:31,290 --> 00:33:29,350
is also very interesting because it is

666
00:33:33,360 --> 00:33:31,300
very likely that it has the yetze of

667
00:33:37,070 --> 00:33:33,370
material that are will lunch into a

668
00:33:38,850 --> 00:33:37,080
space hundreds of kilometers high and

669
00:33:41,310 --> 00:33:38,860
similar to those that have been

670
00:33:43,140 --> 00:33:41,320
observing in another morning Enceladus

671
00:33:45,540 --> 00:33:43,150
one of Saturn's moon and this is an

672
00:33:47,460 --> 00:33:45,550
image of those yets of material taking

673
00:33:51,720 --> 00:33:47,470
with the Hubble Space Telescope by one

674
00:33:53,910 --> 00:33:51,730
of her researchers and this is an fel

675
00:33:56,460 --> 00:33:53,920
Enceladus so these are the yet thin

676
00:33:57,780 --> 00:33:56,470
Enceladus this is not a recreated image

677
00:34:00,420 --> 00:33:57,790
this is a real image

678
00:34:02,250 --> 00:34:00,430
Enceladus also have an icy surface and

679
00:34:04,350 --> 00:34:02,260
the debts are produced by geysers that

680
00:34:07,170 --> 00:34:04,360
form in the cracks that throw jets of

681
00:34:09,360 --> 00:34:07,180
water vapor into space and this water

682
00:34:11,399 --> 00:34:09,370
vapor then falls in the form of his snow

683
00:34:14,100 --> 00:34:11,409
to the surface a fraction of that

684
00:34:16,379 --> 00:34:14,110
material escapes into escape and becomes

685
00:34:18,270 --> 00:34:16,389
Saturn's ring and these geysers are one

686
00:34:20,129 --> 00:34:18,280
of the indications that like Europa that

687
00:34:24,159 --> 00:34:20,139
is liquid or ocean that there is a

688
00:34:26,079 --> 00:34:24,169

liquid water ocean under the surface

689
00:34:27,520 --> 00:34:26,089
of Enceladus also making it a very

690
00:34:30,609 --> 00:34:27,530
interesting target for the search of

691
00:34:32,349 --> 00:34:30,619
life and existence of these debts in

692
00:34:34,629 --> 00:34:32,359
salado's and in europe is particularly

693
00:34:36,190 --> 00:34:34,639
interesting because imagine trying to

694
00:34:38,919 --> 00:34:36,200
design experiments that actually look

695
00:34:40,059 --> 00:34:38,929
for that life in europa for example it

696
00:34:42,190 --> 00:34:40,069
will have to drill through ten

697
00:34:43,299 --> 00:34:42,200
kilometers of ice and this is very

698
00:34:44,980 --> 00:34:43,309
difficult to do on earth

699
00:34:47,919 --> 00:34:44,990
so imagine bringing all that equipment

700
00:34:51,609 --> 00:34:47,929
to do that drilling in Europe is very

701
00:34:53,649 --> 00:34:51,619
difficult right but if there are jets

702
00:34:56,109 --> 00:34:53,659
there is much easier to design a special

703
00:34:59,500 --> 00:34:56,119
mission like the one you see here that

704
00:35:01,000 --> 00:34:59,510
flies through that those debts and in

705
00:35:02,829 --> 00:35:01,010
this is a scrub you could have

706
00:35:05,620 --> 00:35:02,839
instruments able to analyze the material

707
00:35:07,210 --> 00:35:05,630
coming out of this yet and which is a

708
00:35:08,829 --> 00:35:07,220
sample of the material that exists in

709
00:35:11,470 --> 00:35:08,839
the ocean and you can look for signs of

710
00:35:14,260 --> 00:35:11,480
life there so no need to drill and in

711
00:35:16,930 --> 00:35:14,270
fact scientists realize a few months ago

712
00:35:20,020 --> 00:35:16,940
that the spacecraft 20 years ago

713
00:35:21,970 --> 00:35:20,030

spacecraft named Galileo is thought to

714
00:35:23,799 --> 00:35:21,980
accidentally have flown over one of the

715
00:35:26,319 --> 00:35:23,809
Jets in Europa at the time we didn't

716
00:35:28,630 --> 00:35:26,329
know this yet existed now we do and

717
00:35:30,940 --> 00:35:28,640
Galileo shows an anomalies that now can

718
00:35:33,370 --> 00:35:30,950
be explained by the presence of these

719
00:35:35,289 --> 00:35:33,380
jets and there is indeed a mission

720
00:35:37,809 --> 00:35:35,299
called Europa clipper that NASA is

721
00:35:40,240 --> 00:35:37,819
planning to launch around 2023 that will

722
00:35:43,000 --> 00:35:40,250
be designed to do exactly that to fly

723
00:35:44,470 --> 00:35:43,010
through through the Jets in Europe and

724
00:35:48,420 --> 00:35:44,480
to analyze the material that is coming

725
00:35:51,789 --> 00:35:48,430
from those yet searching for life Titan

726
00:35:53,950 --> 00:35:51,799
and here's another image that we saw in

727
00:35:57,880 --> 00:35:53,960
the short film it's all explorers that

728
00:36:00,490 --> 00:35:57,890
are flying over the lakes of Titan Titan

729
00:36:02,380 --> 00:36:00,500
is a giant moon of Saturn that is larger

730
00:36:04,930 --> 00:36:02,390
than the planet Mercury about half the

731
00:36:06,849 --> 00:36:04,940
size of the earth is mainly composed of

732
00:36:08,549 --> 00:36:06,859
silicates and water and is their only

733
00:36:10,990 --> 00:36:08,559
Moon known to have a dense atmosphere

734
00:36:12,339 --> 00:36:11,000
composed mainly of nitrogen like the

735
00:36:15,579 --> 00:36:12,349
atmosphere of the earth and a bit of

736
00:36:18,880 --> 00:36:15,589
methane and other hydrocarbons Titan has

737
00:36:22,420 --> 00:36:18,890
an average temperature of minus 290

738
00:36:24,880 --> 00:36:22,430

Fahrenheit minus 180 degrees and at that

739
00:36:28,270 --> 00:36:24,890
temperature the methane can be in solid

740
00:36:30,700 --> 00:36:28,280
liquid or gaseous state just like the

741
00:36:33,130 --> 00:36:30,710
water on earth so instead of having a

742
00:36:35,770 --> 00:36:33,140
water cycle like in the earth we have a

743
00:36:37,290 --> 00:36:35,780
methane cycle and where the methane

744
00:36:39,380 --> 00:36:37,300
evaporates right

745
00:36:44,270 --> 00:36:39,390
into the atmosphere forms the clouds

746
00:36:47,040 --> 00:36:44,280
rains down and forms rivers and lakes

747
00:36:48,780 --> 00:36:47,050
here you have some of here you have the

748
00:36:51,510 --> 00:36:48,790
reflection in one of those lakes and

749
00:36:54,450 --> 00:36:51,520
here you have a one of those lakes where

750
00:36:58,740 --> 00:36:54,460
you see the coast you can see the coast

751
00:37:02,580 --> 00:36:58,750
how it changes as the liquid level rises

752
00:37:05,910 --> 00:37:02,590
and falls and it's actually one of the

753
00:37:08,220 --> 00:37:05,920
is it's actually the only place up in

754
00:37:11,010 --> 00:37:08,230
addition to the earth where in the solar

755
00:37:12,420 --> 00:37:11,020
system world you can have lakes and you

756
00:37:16,110 --> 00:37:12,430
can have far cheaper elegance and you

757
00:37:18,810 --> 00:37:16,120
can have Iceland's and the results of

758
00:37:21,090 --> 00:37:18,820
winning titan that forms dunes but the

759
00:37:22,500 --> 00:37:21,100
grains in the dues are not made of

760
00:37:23,970 --> 00:37:22,510
silicates like in the earth they're

761
00:37:27,030 --> 00:37:23,980
probably made of complex organic

762
00:37:28,980 --> 00:37:27,040
compounds so unknown Titan it is

763
00:37:30,960 --> 00:37:28,990

possible that there are also volcanoes

764
00:37:32,790 --> 00:37:30,970
but the lava would would be made of

765
00:37:34,980 --> 00:37:32,800
water and ammonia instead of silicates

766
00:37:37,410 --> 00:37:34,990
like in the earth and the energy source

767
00:37:39,420 --> 00:37:37,420
that will drive the volcanoes will be

768
00:37:41,160 --> 00:37:39,430
not only the radioactive elements like

769
00:37:44,370 --> 00:37:41,170
in the earth but also the tidal forces

770
00:37:46,320 --> 00:37:44,380
caused by Mars by sorry by Saturn that

771
00:37:49,560 --> 00:37:46,330
deforms the planet producing producing

772
00:37:52,710 --> 00:37:49,570
heat and it has also been a speculated

773
00:37:56,130 --> 00:37:52,720
that there is liquid or water under the

774
00:37:58,680 --> 00:37:56,140
the icy surface so the presence of all

775
00:38:01,050 --> 00:37:58,690
these complex organic compounds of lakes

776
00:38:03,720 --> 00:38:01,060
of an ocean under the surface of

777
00:38:05,430 --> 00:38:03,730
cryovolcanism of an exchange of chemical

778
00:38:07,920 --> 00:38:05,440
compounds between the atmosphere the

779
00:38:09,600 --> 00:38:07,930
surface the lake all this makes Titan an

780
00:38:11,520 --> 00:38:09,610
extraordinarily interesting place to

781
00:38:13,830 --> 00:38:11,530
search for life and people have done

782
00:38:15,810 --> 00:38:13,840
experiments in the lab or in the chamber

783
00:38:17,400 --> 00:38:15,820
they put the gases that they think are

784
00:38:19,500 --> 00:38:17,410
in the atmosphere on Titan and we put it

785
00:38:21,240 --> 00:38:19,510
at the temperature and the pressure that

786
00:38:22,650 --> 00:38:21,250
they think are on Titan and then they

787
00:38:24,540 --> 00:38:22,660
hit everything and what they find is

788
00:38:28,170 --> 00:38:24,550

very interesting they find that

789
00:38:30,600 --> 00:38:28,180
nucleotide bases form which are part of

790
00:38:32,820 --> 00:38:30,610
our DNA and RNA the building blocks of

791
00:38:34,680 --> 00:38:32,830
life they also find that amino acids

792
00:38:36,990 --> 00:38:34,690
form that are essential ingredients for

793
00:38:38,730 --> 00:38:37,000
of proteins and this is really

794
00:38:40,370 --> 00:38:38,740
extraordinary because it means that even

795
00:38:45,300 --> 00:38:40,380
in the absence of water

796
00:38:48,090 --> 00:38:45,310
m-disc these elements that are so

797
00:38:51,150 --> 00:38:48,100
important for for life can can emerge

798
00:38:54,290 --> 00:38:51,160
from simple simple organic

799
00:38:57,090 --> 00:38:54,300
molecules in fact it is possible that

800
00:38:58,500 --> 00:38:57,100
the atmosphere of Titan is very similar

801
00:39:01,460 --> 00:38:58,510
to the atmosphere that we think the

802
00:39:04,920 --> 00:39:01,470
primitive earth earth had when first

803
00:39:06,600 --> 00:39:04,930
when life first arose on our planet and

804
00:39:08,820 --> 00:39:06,610
this is why Titan is such an

805
00:39:10,530 --> 00:39:08,830
extraordinary laboratory to study the

806
00:39:13,110 --> 00:39:10,540
conditions that could have given rise to

807
00:39:15,360 --> 00:39:13,120
life on Earth and if there is an ocean

808
00:39:17,610 --> 00:39:15,370
beneath the surface of Titan is possible

809
00:39:19,290 --> 00:39:17,620
that it could Harbor life today that

810
00:39:21,540 --> 00:39:19,300
could survive thanks to the transfer of

811
00:39:25,850 --> 00:39:21,550
chemical compounds and heat between the

812
00:39:28,770 --> 00:39:25,860
ocean and the surface so if life were to

813
00:39:31,830 --> 00:39:28,780

exhibit exist in Titan or Enceladus or

814
00:39:34,590 --> 00:39:31,840
in Europa it will be under very extreme

815
00:39:36,630 --> 00:39:34,600
conditions but the truth is that life on

816
00:39:40,200 --> 00:39:36,640
Earth can survive under very extreme

817
00:39:42,980 --> 00:39:40,210
conditions for example in this water

818
00:39:47,750 --> 00:39:42,990
lakes in these geysers in Yellowstone

819
00:39:50,580 --> 00:39:47,760
life can survive and in extreme heap in

820
00:39:52,800 --> 00:39:50,590
extremely extremely cold environments

821
00:39:55,980 --> 00:39:52,810
and also in various heat environments

822
00:39:58,440 --> 00:39:55,990
like those inside the battery and if

823
00:40:00,000 --> 00:39:58,450
life were to exist in titan gyro power

824
00:40:01,530 --> 00:40:00,010
and salado's or somewhere else it would

825
00:40:03,810 --> 00:40:01,540
be probably very different from that on

826
00:40:06,870 --> 00:40:03,820
earth for example it has been speculated

827
00:40:08,490 --> 00:40:06,880
that life in the shallow mess and lakes

828
00:40:11,520 --> 00:40:08,500
of Titan instead of breathing oxygen

829
00:40:14,130 --> 00:40:11,530
will breathe hydrogen and it's death of

830
00:40:16,140 --> 00:40:14,140
exhaling co2 it will exhale methane and

831
00:40:18,420 --> 00:40:16,150
instead of using water as a solvent it

832
00:40:20,610 --> 00:40:18,430
will use methane liquid methane the

833
00:40:22,260 --> 00:40:20,620
bottom line is that we need to open up

834
00:40:24,060 --> 00:40:22,270
our mind regarding the search for life

835
00:40:26,520 --> 00:40:24,070
because what is out there is probably

836
00:40:28,080 --> 00:40:26,530
very different from what we know and we

837
00:40:30,120 --> 00:40:28,090
might not discover it if we are not

838
00:40:33,450 --> 00:40:30,130

ready for those surprises so the search

839
00:40:35,550 --> 00:40:33,460
for life needs a mindset change like the

840
00:40:37,590 --> 00:40:35,560
one that was required to under start the

841
00:40:41,700 --> 00:40:37,600
movement of the planets or the theory of

842
00:40:44,490 --> 00:40:41,710
evolution so well where do we come from

843
00:40:46,500 --> 00:40:44,500
how did life on Earth originate our

844
00:40:48,030 --> 00:40:46,510
species is a very curious one and this

845
00:40:50,400 --> 00:40:48,040
very question has followed us for

846
00:40:52,170 --> 00:40:50,410
thousands of years at first we have

847
00:40:54,810 --> 00:40:52,180
tried to address it through stories and

848
00:40:56,820 --> 00:40:54,820
myths because that was our the best way

849
00:40:59,040 --> 00:40:56,830
we had to make sense of what we did not

850
00:41:00,120 --> 00:40:59,050
understand and later who have been able

851
00:41:01,860 --> 00:41:00,130
to address it through careful

852
00:41:03,990 --> 00:41:01,870
observation of nature by carefully

853
00:41:04,560 --> 00:41:04,000
collecting the evidence lest in many

854
00:41:06,240 --> 00:41:04,570
hypotheses

855
00:41:09,270 --> 00:41:06,250
checking what it works what it doesn't

856
00:41:11,160 --> 00:41:09,280
work and this very question regarding

857
00:41:12,840 --> 00:41:11,170
the origin of life has also sent women

858
00:41:15,150 --> 00:41:12,850
and men to seek for our origins in the

859
00:41:17,700 --> 00:41:15,160
remotest corners of our planet and even

860
00:41:19,650 --> 00:41:17,710
beyond so what do we come from did life

861
00:41:22,350 --> 00:41:19,660
on Earth originate in our planet or did

862
00:41:24,810 --> 00:41:22,360
originate somewhere else

863
00:41:26,910 --> 00:41:24,820

good if there is life on Earth another

864
00:41:30,390 --> 00:41:26,920
planet or other moon in our solar system

865
00:41:32,820 --> 00:41:30,400
or in other planets in nearby stars

866
00:41:34,800 --> 00:41:32,830
could it have a common origin to ours or

867
00:41:36,480 --> 00:41:34,810
did it emerge independently cool life on

868
00:41:38,940 --> 00:41:36,490
Earth or the building blocks of life has

869
00:41:44,220 --> 00:41:38,950
spread to other planets and other moons

870
00:41:46,530 --> 00:41:44,230
or vice versa so look at this rock this

871
00:41:48,420 --> 00:41:46,540
is a meteorite meteorites are extremely

872
00:41:49,500 --> 00:41:48,430
valuable because they can teach us a lot

873
00:41:52,440 --> 00:41:49,510
about our origins

874
00:41:54,510 --> 00:41:52,450
if you years ago in 2011 after analyzing

875
00:41:56,310 --> 00:41:54,520
rocks like this in the lab people found

876
00:41:59,700 --> 00:41:56,320
that they contain some of the components

877
00:42:01,560 --> 00:41:59,710
of DNA and RNA and as you know these are

878
00:42:03,420 --> 00:42:01,570
the building blocks of life or of life

879
00:42:04,830 --> 00:42:03,430
they're like life's ligo's and people

880
00:42:07,830 --> 00:42:04,840
discover that these complex organic

881
00:42:11,130 --> 00:42:07,840
molecules adenine guanine confirm in a

882
00:42:13,590 --> 00:42:11,140
space it was also recently discovered

883
00:42:16,320 --> 00:42:13,600
that the does that exist in a space

884
00:42:18,840 --> 00:42:16,330
contains complex organic molecules like

885
00:42:21,180 --> 00:42:18,850
sugar that are also necessary for the

886
00:42:22,530 --> 00:42:21,190
formation of our name and of course the

887
00:42:23,880 --> 00:42:22,540
yolk when this was discovered is that

888
00:42:27,090 --> 00:42:23,890

the next thing astronomers will be

889
00:42:29,370 --> 00:42:27,100
seeking is caffeine and and this was

890
00:42:31,650 --> 00:42:29,380
found by analyzing the light that the

891
00:42:34,440 --> 00:42:31,660
dust emit and what people realize is

892
00:42:36,600 --> 00:42:34,450
that these sugars can form very rapidly

893
00:42:38,520 --> 00:42:36,610
around a stars even before the planets

894
00:42:40,970 --> 00:42:38,530
form and this is very exciting because

895
00:42:43,860 --> 00:42:40,980
it means that once the planets form

896
00:42:46,830 --> 00:42:43,870
these molecules can fall on the planets

897
00:42:50,820 --> 00:42:46,840
and facilitate the emergence of life so

898
00:42:54,690 --> 00:42:50,830
how do stars and planets form so stars

899
00:42:57,210 --> 00:42:54,700
are born in clouds of gas and dust one

900
00:42:59,610 --> 00:42:57,220
region of the cloud it gets very dense

901
00:43:04,500 --> 00:42:59,620
and very hot and collapses under its own

902
00:43:06,450 --> 00:43:04,510
gravity and at some point the star

903
00:43:08,910 --> 00:43:06,460
ignites and and and this is when the

904
00:43:11,280 --> 00:43:08,920
star is born around these protesters

905
00:43:13,410 --> 00:43:11,290
there is an envelope of gas and dust and

906
00:43:15,150 --> 00:43:13,420
because everything is rotating because

907
00:43:17,460 --> 00:43:15,160
of conservation of angular momentum you

908
00:43:19,980 --> 00:43:17,470
form a disk

909
00:43:23,250 --> 00:43:19,990
so this is what we call a protoplanetary

910
00:43:25,170 --> 00:43:23,260
disk so some of the gas in the dust

911
00:43:28,740 --> 00:43:25,180
some of the gas on the desk in the star

912
00:43:30,270 --> 00:43:28,750
is secreted to the star and on some of

913
00:43:32,790 --> 00:43:30,280

the guys on the dust in the disk is

914
00:43:34,650 --> 00:43:32,800
secreted to the star and some other part

915
00:43:37,530 --> 00:43:34,660
of the material is ejected in this yes

916
00:43:39,390 --> 00:43:37,540
but let's see what happens to the gas

917
00:43:41,040 --> 00:43:39,400
and dust that the stays in the disk that

918
00:43:43,080 --> 00:43:41,050
the remains entities the disk is very

919
00:43:45,960 --> 00:43:43,090
dense and the dust particles are

920
00:43:47,820 --> 00:43:45,970
colliding with each other and frequently

921
00:43:49,920 --> 00:43:47,830
this collision makes the particle spring

922
00:43:51,630 --> 00:43:49,930
into a smaller pieces but they or they

923
00:43:53,520 --> 00:43:51,640
bounce but in many times they stick

924
00:43:55,560 --> 00:43:53,530
together and when I stick to whether you

925
00:43:58,200 --> 00:43:55,570
start they start forming larger and

926
00:44:00,150 --> 00:43:58,210
larger aggregates they first form like

927
00:44:02,520 --> 00:44:00,160
people styles then it's like you know

928
00:44:05,310 --> 00:44:02,530
Boulder size then it's like asteroid

929
00:44:08,339 --> 00:44:05,320
type size until they form the planets

930
00:44:09,900 --> 00:44:08,349
and also they form planets much more

931
00:44:11,849 --> 00:44:09,910
massive than the than the earth like

932
00:44:13,740 --> 00:44:11,859
around ten times the mass of the Earth

933
00:44:15,390 --> 00:44:13,750
and at that point these planets are

934
00:44:17,700 --> 00:44:15,400
sufficiently massive that they start

935
00:44:18,930 --> 00:44:17,710
attracting the gas ended in the disk to

936
00:44:21,660 --> 00:44:18,940
form

937
00:44:24,359 --> 00:44:21,670
jaian atmospheres like the planet

938
00:44:27,990 --> 00:44:24,369

Jupiter or the planet Saturn and later

939
00:44:32,640 --> 00:44:28,000
when the star dies a part of that

940
00:44:34,740 --> 00:44:32,650
material is returned to a space and to

941
00:44:37,740 --> 00:44:34,750
become part of the new clouds of dust

942
00:44:39,660 --> 00:44:37,750
and gas that from where from from where

943
00:44:42,150 --> 00:44:39,670
new stars will be born so all this

944
00:44:43,770 --> 00:44:42,160
material is recycled and that is how

945
00:44:46,170 --> 00:44:43,780
some of those complex organic molecules

946
00:44:48,140 --> 00:44:46,180
that are so interesting for life that

947
00:44:52,740 --> 00:44:48,150
come forth in a space or around other

948
00:44:57,630 --> 00:44:52,750
dynastars can get to the jungle to the

949
00:44:59,339 --> 00:44:57,640
young forming planets so and here you

950
00:45:01,500 --> 00:44:59,349
have real images that capture how it

951
00:45:03,450 --> 00:45:01,510
starts on planet form this is an image

952
00:45:07,220 --> 00:45:03,460
of the clouds of gas and dust where the

953
00:45:10,620 --> 00:45:07,230
planets and the stars are born this is

954
00:45:12,780 --> 00:45:10,630
of course taking with Hubble this is

955
00:45:14,820 --> 00:45:12,790
another image taking with Hubble of the

956
00:45:15,839 --> 00:45:14,830
protis stars and their discs where the

957
00:45:18,270 --> 00:45:15,849
planets will be born

958
00:45:21,359 --> 00:45:18,280
seen here in silhouette so here you have

959
00:45:23,970 --> 00:45:21,369
a disk and here you have the the newborn

960
00:45:27,810 --> 00:45:23,980
star and here you see it more face on

961
00:45:30,030 --> 00:45:27,820
here you see in h on and this is a disc

962
00:45:33,060 --> 00:45:30,040
where the large planets have

963
00:45:36,720 --> 00:45:33,070

formerly had begun to accrete the gas in

964
00:45:39,510 --> 00:45:36,730
the disc so these dark areas is all the

965
00:45:41,280 --> 00:45:39,520
the gas depleted regions in the disk

966
00:45:43,710 --> 00:45:41,290
that has already accreted into the

967
00:45:46,290 --> 00:45:43,720
atmosphere of the forming planets and

968
00:45:49,760 --> 00:45:46,300
here is a family photo of baby planetary

969
00:45:52,740 --> 00:45:49,770
systems being born so here you like

970
00:45:55,080 --> 00:45:52,750
their babies some of them are face-on

971
00:45:56,940 --> 00:45:55,090
some of them are its own and some of

972
00:45:58,920 --> 00:45:56,950
them have this cometary along with its

973
00:46:00,870 --> 00:45:58,930
shape because they happened to be very

974
00:46:03,000 --> 00:46:00,880
close to a very massive star that is

975
00:46:05,370 --> 00:46:03,010
blowing away with its strong wind some

976
00:46:07,680 --> 00:46:05,380
of the material in the disc and this is

977
00:46:09,960 --> 00:46:07,690
a family picture picture of the elderly

978
00:46:12,090 --> 00:46:09,970
showing the spectacular wasting with

979
00:46:14,520 --> 00:46:12,100
some stars when they become very all

980
00:46:17,480 --> 00:46:14,530
returned material to a space for its

981
00:46:20,370 --> 00:46:17,490
reciting another beautiful Hubble image

982
00:46:22,380 --> 00:46:20,380
so I have told you that they are very

983
00:46:24,450 --> 00:46:22,390
interesting molecules that form in a

984
00:46:26,820 --> 00:46:24,460
space around this type of stars that can

985
00:46:29,730 --> 00:46:26,830
get to the young planets and maybe help

986
00:46:31,170 --> 00:46:29,740
life to emerge and another molecule that

987
00:46:35,550 --> 00:46:31,180
got here from a space that is very

988
00:46:38,070 --> 00:46:35,560

important for life is water after and

989
00:46:41,790 --> 00:46:38,080
when the earth was formed it was very

990
00:46:44,850 --> 00:46:41,800
dry I'm very hot it was more than a

991
00:46:46,920 --> 00:46:44,860
thousand Celsius so around 2000

992
00:46:49,830 --> 00:46:46,930
Fahrenheit now he's nice and cool and

993
00:46:52,020 --> 00:46:49,840
about 3/4 of the surface are covered by

994
00:46:53,790 --> 00:46:52,030
liquid water but the still if you

995
00:46:56,640 --> 00:46:53,800
considered the black of the bulk of the

996
00:46:58,740 --> 00:46:56,650
planet the earth is very dry but what

997
00:46:59,250 --> 00:46:58,750
did all this water in the surface come

998
00:47:01,260 --> 00:46:59,260
from

999
00:47:03,420 --> 00:47:01,270
after analyzing different types of

1000
00:47:05,460 --> 00:47:03,430
comets and asteroids in our solar system

1001
00:47:07,830 --> 00:47:05,470
people realized that they may come from

1002
00:47:09,600 --> 00:47:07,840
these objects that fell on the earth

1003
00:47:11,400 --> 00:47:09,610
when the earth was very young and we

1004
00:47:14,070 --> 00:47:11,410
know this by analyzing the type of water

1005
00:47:16,770 --> 00:47:14,080
that is detected in asteroids and comets

1006
00:47:19,500 --> 00:47:16,780
and and comparing it to the water that

1007
00:47:22,050 --> 00:47:19,510
is on earth because water as you know is

1008
00:47:24,990 --> 00:47:22,060
made of 2 a atoms of hydrogen and one

1009
00:47:28,410 --> 00:47:25,000
atom of oxygen but sometimes you have a

1010
00:47:30,810 --> 00:47:28,420
an extra Neutron in the hydrogen instead

1011
00:47:33,660 --> 00:47:30,820
of dehydrate the standard Hydra you have

1012
00:47:35,640 --> 00:47:33,670
the Tyrion at that ratio of how many

1013
00:47:38,550 --> 00:47:35,650

water molecules percent that extra

1014
00:47:40,770 --> 00:47:38,560
Neutron compared to what the so you

1015
00:47:43,170 --> 00:47:40,780
compare that that ratio of the water

1016
00:47:43,430 --> 00:47:43,180
with we have on earth to that fire found

1017
00:47:46,130 --> 00:47:43,440
in

1018
00:47:47,960 --> 00:47:46,140
and comets that ratio is very similar to

1019
00:47:49,490 --> 00:47:47,970
what we find in in this type of solar

1020
00:47:52,069 --> 00:47:49,500
system obvious so it is very possible

1021
00:47:54,349 --> 00:47:52,079
that the water in our planet comes from

1022
00:47:56,150 --> 00:47:54,359
from them so the next time you are on

1023
00:47:57,620 --> 00:47:56,160
the beach think that that water have not

1024
00:47:59,690 --> 00:47:57,630
always been there that it came from

1025
00:48:02,750 --> 00:47:59,700
outer space that it connects you to the

1026
00:48:04,280 --> 00:48:02,760
universe and yes as it rain on earth it

1027
00:48:07,460 --> 00:48:04,290
also did it on other planets around

1028
00:48:09,800 --> 00:48:07,470
other stars where it may have created a

1029
00:48:13,880 --> 00:48:09,810
fantastic landscape enjoy by other

1030
00:48:17,329 --> 00:48:13,890
wonderful creators like you so let's

1031
00:48:19,040 --> 00:48:17,339
look at some numbers so when did the

1032
00:48:20,750 --> 00:48:19,050
earth form and when did it meet the

1033
00:48:23,660 --> 00:48:20,760
necessary conditions for life to emerge

1034
00:48:28,040 --> 00:48:23,670
so this is for perspective this is how

1035
00:48:31,490 --> 00:48:28,050
all the Sun the solar system is this is

1036
00:48:35,059 --> 00:48:31,500
how all the earth is this is how all we

1037
00:48:37,849 --> 00:48:35,069
think life is how all our animals how

1038
00:48:40,609 --> 00:48:37,859

all our mammals how all our humans and

1039
00:48:42,230 --> 00:48:40,619
to be honest I have to make this thicker

1040
00:48:44,420 --> 00:48:42,240
than I should because otherwise you

1041
00:48:46,670 --> 00:48:44,430
wouldn't see it it's really mind-blowing

1042
00:48:53,390 --> 00:48:46,680
so let's talk a bit about how do we know

1043
00:48:55,250 --> 00:48:53,400
this part the top part so so how do we

1044
00:48:57,620 --> 00:48:55,260
know for example how is the solar system

1045
00:49:00,349 --> 00:48:57,630
we can measure it in the lab how all are

1046
00:49:03,559 --> 00:49:00,359
they all these meteorites this is a type

1047
00:49:06,200 --> 00:49:03,569
of meteorite called secon roots and they

1048
00:49:08,300 --> 00:49:06,210
have these white inclusions here these

1049
00:49:09,920 --> 00:49:08,310
are called calcium aluminum inclusions

1050
00:49:12,530 --> 00:49:09,930
because they are made out of calcium and

1051
00:49:16,220 --> 00:49:12,540
aluminum these these white specks here

1052
00:49:17,960 --> 00:49:16,230
and if you analyze them they are four

1053
00:49:19,790 --> 00:49:17,970
thousand five hundred and seventy

1054
00:49:22,690 --> 00:49:19,800
million years old and it is thought that

1055
00:49:24,470 --> 00:49:22,700
they form and when the gas in that

1056
00:49:26,690 --> 00:49:24,480
protoplanetary disk that I showed you

1057
00:49:28,670 --> 00:49:26,700
before that surrounded the jounce and

1058
00:49:30,500 --> 00:49:28,680
condensed like when water vapor

1059
00:49:33,760 --> 00:49:30,510
condenses into clouds form in the

1060
00:49:35,720 --> 00:49:33,770
raindrops and we think this is how these

1061
00:49:37,280 --> 00:49:35,730
solids form and it is thought that these

1062
00:49:39,770 --> 00:49:37,290
are they all the solids in the solar

1063
00:49:42,410 --> 00:49:39,780

system so we think they the Sun is that

1064
00:49:46,160 --> 00:49:42,420
all around four thousand five hundred

1065
00:49:49,339 --> 00:49:46,170
and seventy million years so we think

1066
00:49:52,819 --> 00:49:49,349
that 43 million years after the the

1067
00:49:54,950 --> 00:49:52,829
solar system form the young earth

1068
00:49:56,870 --> 00:49:54,960
collided with a planet the size of Mars

1069
00:50:00,499 --> 00:49:56,880
and out of the debris of that

1070
00:50:02,569 --> 00:50:00,509
collision the moon form and we we can

1071
00:50:06,920 --> 00:50:02,579
date that because we can date the rocks

1072
00:50:10,039 --> 00:50:06,930
in the in the moon and if you if you

1073
00:50:12,529 --> 00:50:10,049
date them you seen a Half Moon tungsten

1074
00:50:14,660 --> 00:50:12,539
a chronometry of the lunar magma it

1075
00:50:17,210 --> 00:50:14,670
tells you that they are very old they

1076
00:50:19,880 --> 00:50:17,220
only form they form only 43 million

1077
00:50:21,980 --> 00:50:19,890
years after the sand form but the young

1078
00:50:24,079 --> 00:50:21,990
earth was not a habitable planet because

1079
00:50:27,529 --> 00:50:24,089
he was hole covered by lava so when did

1080
00:50:29,240 --> 00:50:27,539
the surface of the earth cool down so it

1081
00:50:31,249 --> 00:50:29,250
is thought that this happened 70 million

1082
00:50:32,660 --> 00:50:31,259
years after the solar system form and we

1083
00:50:35,210 --> 00:50:32,670
know this because we can measure the

1084
00:50:38,569 --> 00:50:35,220
ages of microscopic minerals called

1085
00:50:41,749 --> 00:50:38,579
circles and this quartzite conglomerate

1086
00:50:44,059 --> 00:50:41,759
how Nina in Australia and has these

1087
00:50:46,309 --> 00:50:44,069
circles and people think the circles

1088
00:50:48,380 --> 00:50:46,319

firm from the crystallization of magma

1089
00:50:50,299 --> 00:50:48,390
that contained molten earth crust that

1090
00:50:52,789 --> 00:50:50,309
was billion recycle and that had been in

1091
00:50:54,410 --> 00:50:52,799
contact with water near the surface so

1092
00:50:56,720 --> 00:50:54,420
that's the critical part that circles

1093
00:51:00,079 --> 00:50:56,730
are evidence evidence of water near the

1094
00:51:01,519 --> 00:51:00,089
surface and other circles they the

1095
00:51:08,210 --> 00:51:01,529
presence of liquid water on earth

1096
00:51:10,099 --> 00:51:08,220
between 600 165 million years and 280

1097
00:51:13,450 --> 00:51:10,109
million years after the solar system

1098
00:51:16,309 --> 00:51:13,460
forms so pretty far pretty fast

1099
00:51:19,130 --> 00:51:16,319
so once the earth cooled down and there

1100
00:51:20,749 --> 00:51:19,140
was liquid water on the surface how long

1101
00:51:22,999 --> 00:51:20,759
would like to emerge where we don't

1102
00:51:24,920 --> 00:51:23,009
really know but studies show that it

1103
00:51:27,620 --> 00:51:24,930
could have happened very quickly between

1104
00:51:31,190 --> 00:51:27,630
0.3 and 3 million years it could have

1105
00:51:33,019 --> 00:51:31,200
happen if life arose in shallow pools

1106
00:51:35,630 --> 00:51:33,029
like this one where you see this has

1107
00:51:38,930 --> 00:51:35,640
Rommel to light a microbial carpets in

1108
00:51:41,660 --> 00:51:38,940
fact the oldest indisputable evidence of

1109
00:51:43,370 --> 00:51:41,670
life on Earth come precisely from

1110
00:51:45,230 --> 00:51:43,380
fossils that this is like a

1111
00:51:49,849 --> 00:51:45,240
cross-section that look exactly like

1112
00:51:51,349 --> 00:51:49,859
this and they are this all there are a

1113
00:51:55,039 --> 00:51:51,359

thousand five hundred and seventy

1114
00:51:56,749 --> 00:51:55,049
million years all so not meteor no not

1115
00:52:01,670 --> 00:51:56,759
million years old but million years

1116
00:52:04,249 --> 00:52:01,680
after the solar system form so or it

1117
00:52:06,920 --> 00:52:04,259
could be that life arose even faster in

1118
00:52:09,120 --> 00:52:06,930
hydrothermal vents like this ones found

1119
00:52:11,520 --> 00:52:09,130
at the bottom of the ocean

1120
00:52:15,330 --> 00:52:11,530
actually they're always evidence of life

1121
00:52:19,290 --> 00:52:15,340
this is more disputed and maybe these

1122
00:52:20,700 --> 00:52:19,300
fossils in this microorganisms here that

1123
00:52:22,950 --> 00:52:20,710
are much older than the stromatolites

1124
00:52:26,760 --> 00:52:22,960
that I showed you earlier and that are

1125
00:52:29,130 --> 00:52:26,770
found in rocks that form between 290 and

1126
00:52:34,740 --> 00:52:29,140
800 million years after the solar system

1127
00:52:37,470 --> 00:52:34,750
form so very quick so as you can see we

1128
00:52:39,870 --> 00:52:37,480
are not certain when life arose on this

1129
00:52:41,520 --> 00:52:39,880
planet and if I mean what type of

1130
00:52:43,470 --> 00:52:41,530
environment and we don't know either

1131
00:52:45,840 --> 00:52:43,480
what was the role of extraterrestrial

1132
00:52:47,490 --> 00:52:45,850
material falling on earth if it provided

1133
00:52:51,000 --> 00:52:47,500
the building blocks of life in addition

1134
00:52:53,220 --> 00:52:51,010
to water but the next time your child or

1135
00:52:55,020 --> 00:52:53,230
your grandchild bends down to pick up

1136
00:52:57,090 --> 00:52:55,030
some pebbles and you hear yourself

1137
00:52:58,710 --> 00:52:57,100
saying don't bring that home like I

1138
00:53:00,680 --> 00:52:58,720

sometimes say with my six and my two

1139
00:53:03,210 --> 00:53:00,690
year old daughter's Luna and Estella and

1140
00:53:04,830 --> 00:53:03,220
fill up their pockets with rocks gather

1141
00:53:06,360 --> 00:53:04,840
even from the parking lot and then I

1142
00:53:11,670 --> 00:53:06,370
hear those pills in the washing machine

1143
00:53:14,820 --> 00:53:11,680
so remember that those rocks are a real

1144
00:53:17,400 --> 00:53:14,830
treat for the intriguing mind of the

1145
00:53:19,710 --> 00:53:17,410
inquiring mind of a child that they are

1146
00:53:22,140 --> 00:53:19,720
collecting and inspecting the evidence

1147
00:53:23,790 --> 00:53:22,150
and that they answer to those existence

1148
00:53:25,590 --> 00:53:23,800
of questions regarding an origin

1149
00:53:27,510 --> 00:53:25,600
probably is lock in a handful of rocks

1150
00:53:32,150 --> 00:53:27,520
that is waiting to be discovered by them

1151
00:53:34,380 --> 00:53:32,160
and the source film the source film show

1152
00:53:36,480 --> 00:53:34,390
people have long dream about the

1153
00:53:38,820 --> 00:53:36,490
possibility of visiting other planets

1154
00:53:41,850 --> 00:53:38,830
even setting up colonies there here are

1155
00:53:44,250 --> 00:53:41,860
some advertisements from NASA's

1156
00:53:46,860 --> 00:53:44,260
exoplanet forum a fictional travel

1157
00:53:49,530 --> 00:53:46,870
agency for travellers to visit recently

1158
00:53:52,950 --> 00:53:49,540
discovered exoplanets these of course

1159
00:53:56,880 --> 00:53:52,960
are fictional you see Enceladus it says

1160
00:54:00,180 --> 00:53:56,890
you know visit beautiful southern axilla

1161
00:54:04,080 --> 00:54:00,190
doors you know more than 100

1162
00:54:07,040 --> 00:54:04,090
breathtaking geysers you have Titan it

1163
00:54:11,690 --> 00:54:07,050

says right the tight throughout the

1164
00:54:14,520 --> 00:54:11,700
throat of Kraken here's the kepler 16b

1165
00:54:16,380 --> 00:54:14,530
where your shadow always have a company

1166
00:54:18,020 --> 00:54:16,390
because it's a double star right here

1167
00:54:20,160 --> 00:54:18,030
you have trapeze

1168
00:54:22,050 --> 00:54:20,170
planet-hopping trapeze because you have

1169
00:54:25,110 --> 00:54:22,060
all these you know planets

1170
00:54:28,380 --> 00:54:25,120
so here you have a super jump right in

1171
00:54:35,220 --> 00:54:28,390
an atmosphere experience the gravity of

1172
00:54:38,340 --> 00:54:35,230
HD forty 370 GS uber so this these

1173
00:54:40,500 --> 00:54:38,350
posters are of course made to make you

1174
00:54:41,820 --> 00:54:40,510
laugh and to make you dream but also to

1175
00:54:44,370 --> 00:54:41,830
make you reflect on the extraordinary

1176
00:54:46,080 --> 00:54:44,380
diversity literacy how it starting early

1177
00:54:48,630 --> 00:54:46,090
diverse clientele systems are and

1178
00:54:50,940 --> 00:54:48,640
extraordinary livers life forms that

1179
00:54:52,770 --> 00:54:50,950
they could Harbor but I would like to

1180
00:54:54,780 --> 00:54:52,780
finish this top with some wise words

1181
00:54:57,270 --> 00:54:54,790
from Carl Sagan because this human

1182
00:54:59,250 --> 00:54:57,280
curiosity of ours that has allow us to

1183
00:55:00,870 --> 00:54:59,260
better understand our planets our place

1184
00:55:03,270 --> 00:55:00,880
in the universe to learn how it stars

1185
00:55:05,340 --> 00:55:03,280
and planets form and how the worst

1186
00:55:06,990 --> 00:55:05,350
voluntary systems and life can be this

1187
00:55:09,150 --> 00:55:07,000
human curiosity that has allowed us to

1188
00:55:11,040 --> 00:55:09,160

adapt to the world around us so we can

1189
00:55:13,050 --> 00:55:11,050
live in it more comfortably this

1190
00:55:15,480 --> 00:55:13,060
curiosity of us has also allow us to

1191
00:55:17,670 --> 00:55:15,490
adapt the world to an hour our own needs

1192
00:55:19,680 --> 00:55:17,680
and this comes with a responsibility a

1193
00:55:22,470 --> 00:55:19,690
responsibility to protect the earth and

1194
00:55:25,080 --> 00:55:22,480
also the species that inhabit it to live

1195
00:55:27,030 --> 00:55:25,090
a sustainable life that doesn't exhaust

1196
00:55:29,160 --> 00:55:27,040
the earth resources and to protect the

1197
00:55:31,050 --> 00:55:29,170
environment and this is what Carl Sagan

1198
00:55:33,660 --> 00:55:31,060
talks about in this short movie because

1199
00:55:35,520 --> 00:55:33,670
so far no matter what our dreams are the

1200
00:55:40,200 --> 00:55:35,530
earth is the only planet we can live in

1201
00:56:00,070 --> 00:55:40,210
all right do we have any questions for

1202
00:56:00,080 --> 00:56:04,370
[Music]

1203
00:56:18,740 --> 00:56:08,760
some say that microbial life could found

1204
00:56:26,130 --> 00:56:23,610
yes I don't have any comments that

1205
00:56:29,430 --> 00:56:26,140
absolutely and I think they you know

1206
00:56:32,280 --> 00:56:29,440
they are actively searching for science

1207
00:56:34,140 --> 00:56:32,290
that that to see if that is still the

1208
00:56:37,380 --> 00:56:34,150
case if we take stills you know

1209
00:56:41,250 --> 00:56:37,390
could survive there but and it's so

1210
00:56:44,040 --> 00:56:41,260
close right we it's just mind-blowing

1211
00:56:47,700 --> 00:56:44,050
that it's actually a real possibility

1212
00:56:51,000 --> 00:56:47,710
but this could happen yes and also

1213
00:56:52,590 --> 00:56:51,010

another thing there is M there is a lot

1214
00:56:55,470 --> 00:56:52,600
of material that is exchanged between

1215
00:56:57,660 --> 00:56:55,480
the planets in the solar system a lot of

1216
00:57:00,300 --> 00:56:57,670
solid material so you know if that was a

1217
00:57:03,980 --> 00:57:00,310
case they are meteorites that come from

1218
00:57:10,620 --> 00:57:03,990
Mars that would have Harbor you know

1219
00:57:14,010 --> 00:57:10,630
this type of microorganisms so yes I

1220
00:57:16,440 --> 00:57:14,020
noticed in the and in the pictures that

1221
00:57:18,120 --> 00:57:16,450
you have of Europa and Titan how

1222
00:57:20,250 --> 00:57:18,130
pristine and clear was you could

1223
00:57:24,170 --> 00:57:20,260
actually see right down there and then

1224
00:57:27,660 --> 00:57:24,180
when you had a picture of on the earth

1225
00:57:30,780 --> 00:57:27,670
that there were clouds on the earth that

1226
00:57:33,630 --> 00:57:30,790
makes me think is do these other planets

1227
00:57:36,540 --> 00:57:33,640
or moons have any kind of atmospheres

1228
00:57:43,890 --> 00:57:36,550
yes and is the atmosphere is necessary

1229
00:57:47,040 --> 00:57:43,900
for life to develop M well as I said you

1230
00:57:48,870 --> 00:57:47,050
need a mindset change right so I would

1231
00:57:51,780 --> 00:57:48,880
say yes that you would you need an

1232
00:57:53,760 --> 00:57:51,790
atmosphere if you have an ocean you have

1233
00:57:55,500 --> 00:57:53,770
an atmosphere and you need you need

1234
00:57:57,420 --> 00:57:55,510
liquid water so probably yes you need an

1235
00:58:00,060 --> 00:57:57,430
atmosphere in there so yes I would say

1236
00:58:02,340 --> 00:58:00,070
yes you need an atmosphere and it will

1237
00:58:05,070 --> 00:58:02,350
Titan has an atmosphere Mars has an

1238
00:58:08,250 --> 00:58:05,080

atmosphere Enceladus has a thin

1239
00:58:11,070 --> 00:58:08,260
atmosphere as well so um so yeah they

1240
00:58:14,370 --> 00:58:11,080
all have had much fears and but like

1241
00:58:16,050 --> 00:58:14,380
like you so Titan has has beautiful

1242
00:58:19,170 --> 00:58:16,060
clouds so the image of the clouds in

1243
00:58:20,640 --> 00:58:19,180
Titan that it really dissymmetry maybe

1244
00:58:23,730 --> 00:58:20,650
you thought that it was an image of the

1245
00:58:26,790 --> 00:58:23,740
earth but this is actually an image of

1246
00:58:28,890 --> 00:58:26,800
Titan is a real image of Titan this is a

1247
00:58:31,550 --> 00:58:28,900
real image of Titan and that's an image

1248
00:58:34,980 --> 00:58:31,560
of this type of clouds in the earth so

1249
00:58:39,510 --> 00:58:34,990
and these are real images these are real

1250
00:58:40,950 --> 00:58:39,520
photographs so of course the composition

1251
00:58:42,510 --> 00:58:40,960
the atmosphere makes it's very different

1252
00:58:45,420 --> 00:58:42,520
oh yes the composition is very different

1253
00:58:46,970 --> 00:58:45,430
right you know 97% carbon dioxide on

1254
00:58:50,390 --> 00:58:46,980
Venus

1255
00:58:53,060 --> 00:58:50,400
this is yes all nitrogen s methane and

1256
00:58:55,609 --> 00:58:53,070
if I remember from my courses course

1257
00:58:57,500 --> 00:58:55,619
work oxygen in the early earth

1258
00:58:59,720 --> 00:58:57,510
atmosphere would have been bad for the

1259
00:59:01,970 --> 00:58:59,730
development right this oxygen didn't up

1260
00:59:10,250 --> 00:59:01,980
until about two billion years ago thanks

1261
00:59:21,319 --> 00:59:10,260
through life right so yeah all right

1262
00:59:24,230 --> 00:59:21,329
microphone over to hear this say our

1263
00:59:26,359 --> 00:59:24,240

moon is tidally locked but these other

1264
00:59:31,000 --> 00:59:26,369
bodies aren't necessarily and that's

1265
00:59:33,170 --> 00:59:31,010
providing the heating anything about I

1266
00:59:35,900 --> 00:59:33,180
know they're covered with ice

1267
00:59:37,940 --> 00:59:35,910
is there anything like higher low tides

1268
00:59:40,760 --> 00:59:37,950
with the ice and is that visible in any

1269
00:59:43,069 --> 00:59:40,770
photographs and I think that you cannot

1270
00:59:44,990 --> 00:59:43,079
see the tight Sunday on the ice but you

1271
00:59:48,290 --> 00:59:45,000
can see evidence that that is these

1272
00:59:50,990 --> 00:59:48,300
diverse stresses that are producing that

1273
00:59:53,540 --> 00:59:51,000
are a source of heat and this is what is

1274
00:59:55,520 --> 00:59:53,550
producing the cryovolcanism that we

1275
00:59:57,829 --> 00:59:55,530
think it is taking place in some of

1276
01:00:00,650 --> 00:59:57,839
these objects this is what is producing

1277
01:00:02,660 --> 01:00:00,660
the the balkan is him on Io you see you

1278
01:00:05,270 --> 01:00:02,670
know volcanoes erupting of an iron and

1279
01:00:08,780 --> 01:00:05,280
it is because of the this title forces

1280
01:00:10,550 --> 01:00:08,790
created by you Peter and so yeah so

1281
01:00:13,250 --> 01:00:10,560
that's that's a very significant source

1282
01:00:14,329 --> 01:00:13,260
of energy for this month and just to

1283
01:00:16,430 --> 01:00:14,339
clarify some things for the online

1284
01:00:18,140 --> 01:00:16,440
audience there was a chat about

1285
01:00:19,790 --> 01:00:18,150
volcanism and they were assuming it was

1286
01:00:22,280 --> 01:00:19,800
volcanism like here on earth but you

1287
01:00:24,890 --> 01:00:22,290
said specifically just to repeat

1288
01:00:28,540 --> 01:00:24,900

cryovolcano which occurs at extremely

1289
01:00:33,220 --> 01:00:28,550
cold temperatures right right right

1290
01:00:35,349 --> 01:00:34,940
Herman's got a question in the back

1291
01:00:37,250 --> 01:00:35,359
there

1292
01:00:42,589 --> 01:00:37,260
hold on Herman we got to get the

1293
01:00:46,560 --> 01:00:42,599
microphone up to you sometimes the

1294
01:00:51,180 --> 01:00:46,570
online audience likes no - well he very

1295
01:00:54,690 --> 01:00:51,190
my father's based on DNA and RNA the

1296
01:01:00,780 --> 01:00:54,700
very earliest life on Earth sorry it

1297
01:01:05,280 --> 01:01:00,790
wasn't based on DNA and RNA you got me

1298
01:01:08,670 --> 01:01:05,290
there you know I work on I think it was

1299
01:01:10,380 --> 01:01:08,680
it was based on DNA right did you get

1300
01:01:21,210 --> 01:01:10,390
that I can't imagine it wouldn't be

1301
01:01:23,400 --> 01:01:21,220
right yeah yeah yeah yeah sorry I work

1302
01:01:25,380 --> 01:01:23,410
at the other side my expertise is at the

1303
01:01:29,070 --> 01:01:25,390
other side of the spectrum is in forming

1304
01:01:31,080 --> 01:01:29,080
the planets destroying them I have a

1305
01:01:33,950 --> 01:01:31,090
question excellent presentation but a

1306
01:01:37,680 --> 01:01:33,960
lot of exciting work worlds out there

1307
01:01:41,090 --> 01:01:37,690
and I don't want to wait is it a funding

1308
01:01:43,740 --> 01:01:41,100
thing from NASA or is it a lack of

1309
01:01:46,830 --> 01:01:43,750
technology or why we have to wait to

1310
01:01:50,100 --> 01:01:46,840
2023 and do you envision continued

1311
01:01:52,260 --> 01:01:50,110
collaboration with other countries space

1312
01:01:53,400 --> 01:01:52,270
agencies and private investment I mean

1313
01:01:55,890 --> 01:01:53,410

it sounds really exciting I don't want

1314
01:01:58,710 --> 01:01:55,900
to wait about 2023 yeah but it's a

1315
01:02:00,600 --> 01:01:58,720
balance right because it's a lot of

1316
01:02:02,520 --> 01:02:00,610
money right it's a question of funding

1317
01:02:04,020 --> 01:02:02,530
of course is limited by funding we have

1318
01:02:06,180 --> 01:02:04,030
a lot of ideas that in some cases this

1319
01:02:08,970 --> 01:02:06,190
technology development right I mean we

1320
01:02:10,680 --> 01:02:08,980
would love to send explorers to Mars but

1321
01:02:12,440 --> 01:02:10,690
there are actual limit is not only

1322
01:02:15,750 --> 01:02:12,450
expensive at their actual limitations

1323
01:02:18,870 --> 01:02:15,760
sending sending human you know human

1324
01:02:21,390 --> 01:02:18,880
exploration has actual imitations so we

1325
01:02:24,360 --> 01:02:21,400
you know here at this Institute we are

1326
01:02:26,700 --> 01:02:24,370
working on a wonderful space telescope

1327
01:02:28,560 --> 01:02:26,710
that will be come in that will be

1328
01:02:30,840 --> 01:02:28,570
overlapping with with Hubble the James

1329
01:02:33,330 --> 01:02:30,850
Webb Space Telescope but this is

1330
01:02:35,850 --> 01:02:33,340
technologically very challenging so so

1331
01:02:37,800 --> 01:02:35,860
it's both you are limited by technology

1332
01:02:40,980 --> 01:02:37,810
they need to technology of technology

1333
01:02:42,810 --> 01:02:40,990
development but also they need to to

1334
01:02:49,039 --> 01:02:42,820
have a sustainable budget right

1335
01:03:05,599 --> 01:03:02,509
but or no Neymar's right yeah yeah yeah

1336
01:03:09,079 --> 01:03:05,609
but the Viking program in the 80s for

1337
01:03:11,059 --> 01:03:09,089
the online audience yes okay

1338
01:03:13,159 --> 01:03:11,069

so the online audience was spurred by

1339
01:03:15,620 --> 01:03:13,169
the mention of cryovolcanism and they

1340
01:03:17,419 --> 01:03:15,630
wanted to know how prevalent is

1341
01:03:20,269 --> 01:03:17,429
cryovolcanism in the solar system so

1342
01:03:22,399 --> 01:03:20,279
we've got I oh we've seen it we've seen

1343
01:03:26,059 --> 01:03:22,409
evidence of it on Pluto right on Pluto

1344
01:03:28,579 --> 01:03:26,069
on Europa on on Enceladus I'll show this

1345
01:03:30,499 --> 01:03:28,589
all at least those first at least

1346
01:03:32,419 --> 01:03:30,509
several places were there how well do we

1347
01:03:33,919 --> 01:03:32,429
understand cryovolcanoes because when I

1348
01:03:36,309 --> 01:03:33,929
went to graduate school there was no

1349
01:03:39,919 --> 01:03:36,319
there was no section on cryovolcanism

1350
01:03:43,099 --> 01:03:39,929
that I remember - yes I yeah I don't

1351
01:03:46,489 --> 01:03:43,109
know I don't know and it's it's yeah

1352
01:03:49,549 --> 01:03:46,499
it's here I mean I know that the the

1353
01:03:55,249 --> 01:03:49,559
prevalence of it on Pluto was rather

1354
01:03:57,139 --> 01:03:55,259
surprising right right yeah yes yes so I

1355
01:03:57,799 --> 01:03:57,149
guess there's still plenty to learn this

1356
01:04:00,829 --> 01:03:57,809
solar system

1357
01:04:03,679 --> 01:04:00,839
yes absolutely the new horizon really

1358
01:04:06,699 --> 01:04:03,689
opening a new world to us yes okay we

1359
01:04:10,370 --> 01:04:06,709
got a question up that up there I saw

1360
01:04:13,099 --> 01:04:10,380
you mentioned the space the James Webb

1361
01:04:16,519 --> 01:04:13,109
telescope and you work and that project

1362
01:04:19,370 --> 01:04:16,529
could you give an update on what is the

1363
01:04:23,599 --> 01:04:19,380

next year's or for that project - oh

1364
01:04:27,379 --> 01:04:23,609
yeah we are we are launching in you know

1365
01:04:30,589 --> 01:04:27,389
probably official launch date is March

1366
01:04:34,219 --> 01:04:30,599
twenty twenty one so it will it's coming

1367
01:04:36,620 --> 01:04:34,229
up and we are getting ready yeah it's

1368
01:04:38,839 --> 01:04:36,630
it's coming up we are there is already

1369
01:04:41,479 --> 01:04:38,849
approved proposals approve observing

1370
01:04:43,939 --> 01:04:41,489
proposals there is already grant money

1371
01:04:46,309 --> 01:04:43,949
flowing into the proposers and they're

1372
01:04:49,789 --> 01:04:46,319
getting ready for it so yeah

1373
01:04:53,120 --> 01:04:49,799
this building is boiling with ideas of

1374
01:04:55,969 --> 01:04:53,130
how to make it work and and it will be

1375
01:04:58,789 --> 01:04:55,979
wonderful yeah so it's coming up we only

1376
01:04:59,329 --> 01:04:58,799
get one shot at this one get it right

1377
01:05:02,760 --> 01:04:59,339
the first time

1378
01:05:05,760 --> 01:05:02,770
yes I'm sorry good

1379
01:05:10,350 --> 01:05:05,770
please refresh my memory as to what

1380
01:05:13,290 --> 01:05:10,360
Cairo volcanism is cryovolcanism cryo

1381
01:05:15,359 --> 01:05:13,300
kryolan's whatever volcanic activity at

1382
01:05:18,630 --> 01:05:15,369
extremely low temperatures cryogenic

1383
01:05:21,450 --> 01:05:18,640
temperatures right and generally the

1384
01:05:42,780 --> 01:05:21,460
heat source will be title hitting right

1385
01:05:44,640 --> 01:05:42,790
I have news as well yes yes sorry there

1386
01:05:46,050 --> 01:05:44,650
was a yes there was a good area I

1387
01:05:47,570 --> 01:05:46,060
thought I thought you wanted to comment

1388
01:05:49,620 --> 01:05:47,580

on that yes

1389
01:05:52,170 --> 01:05:49,630
what's the future of the Hubble

1390
01:05:55,980 --> 01:05:52,180
telescope when when James Webb is flying

1391
01:05:57,960 --> 01:05:55,990
Oh have a voice keep operating Hubble

1392
01:05:59,370 --> 01:05:57,970
can operate for many years from now so

1393
01:06:01,560 --> 01:05:59,380
we have it

1394
01:06:03,800 --> 01:06:01,570
we are planning a long future for Hubble

1395
01:06:06,180 --> 01:06:03,810
and it will be wonderful to have both

1396
01:06:07,770 --> 01:06:06,190
that we will work hard telescope

1397
01:06:09,990 --> 01:06:07,780
operated simultaneous because because

1398
01:06:12,750 --> 01:06:10,000
they can complement each other in a

1399
01:06:16,109 --> 01:06:12,760
wonderful way so I will say more about

1400
01:06:18,390 --> 01:06:16,119
the cryovolcanism on Io or Nile so on Io

1401
01:06:21,150 --> 01:06:18,400
is it cryovolcanism I think it's it's

1402
01:06:22,770 --> 01:06:21,160
sulfur dioxide I know that I don't know

1403
01:06:23,340 --> 01:06:22,780
what temperature that would yeah I don't

1404
01:06:31,080 --> 01:06:23,350
know either

1405
01:06:32,609 --> 01:06:31,090
not it's but I don't know I don't know

1406
01:06:35,790 --> 01:06:32,619
the surface of Io is completely ice

1407
01:06:39,890 --> 01:06:35,800
correct this ice right so so it's yeah

1408
01:06:43,290 --> 01:06:39,900
so I don't know I don't know all right

1409
01:06:45,570 --> 01:06:43,300
question over here keeping the evidence

1410
01:06:48,930 --> 01:06:45,580
and everything though that we know right

1411
01:06:51,540 --> 01:06:48,940
now what which do you feel personally

1412
01:06:56,010 --> 01:06:51,550
which do you feel three candidates is

1413
01:06:58,220 --> 01:06:56,020

the best has the best chance for some

1414
01:07:01,650 --> 01:06:58,230
kind of life

1415
01:07:08,790 --> 01:07:01,660
Enceladus Titan Europa which do you

1416
01:07:12,450 --> 01:07:08,800
think well I would say Titan but maybe

1417
01:07:14,280 --> 01:07:12,460
I'm biased because I spent you know many

1418
01:07:16,500 --> 01:07:14,290
years at the University of Arizona and

1419
01:07:18,090 --> 01:07:16,510
that's you know I speak Titan X

1420
01:07:22,320 --> 01:07:18,100
in there so we had all these wonderful

1421
01:07:25,050 --> 01:07:22,330
things about Titan but I think we will

1422
01:07:27,450 --> 01:07:25,060
have much more to say about this when

1423
01:07:30,840 --> 01:07:27,460
Europa clipper gets to Europe right the

1424
01:07:33,240 --> 01:07:30,850
first body the first of these planets

1425
01:07:33,870 --> 01:07:33,250
many planets that we will explore is

1426
01:07:36,720 --> 01:07:33,880
Europa

1427
01:07:40,080 --> 01:07:36,730
so there are no plans to explore Titan

1428
01:07:44,340 --> 01:07:40,090
in the near future so so we'll cross our

1429
01:07:48,810 --> 01:07:44,350
fingers for Europa yeah alright any last

1430
01:07:52,530 --> 01:07:48,820
questions here alright if not next month

1431
01:07:54,660 --> 01:07:52,540
we will have my talk on the film and do

1432
01:07:57,420 --> 01:07:54,670
you feel the impossible magnitude of our

1433
01:08:00,360 --> 01:07:57,430
universe will include a talk as well as