

1
00:00:10,869 --> 00:00:23,799
I want to talk to you about intelligent

2
00:00:13,750 --> 00:00:26,278
life in the universe and I hope my ok it

3
00:00:23,800 --> 00:00:26,278
doesn't work

4
00:00:32,259 --> 00:00:42,759
yes it's always well one can also do it

5
00:00:37,880 --> 00:00:45,880
with just typing and written here okay

6
00:00:42,759 --> 00:00:49,308
okay what do we know about

7
00:00:45,880 --> 00:00:53,290
extraterrestrial intelligence man has

8
00:00:49,308 --> 00:00:57,519
always thought about the existence of

9
00:00:53,289 --> 00:01:01,159
non-human intelligent beings like gods

10
00:00:57,520 --> 00:01:04,549
like God's angel demons in towers or

11
00:01:01,159 --> 00:01:07,728
these awful reports what the science say

12
00:01:04,549 --> 00:01:12,039
about this unfortunately have to say

13
00:01:07,728 --> 00:01:14,390
that no contact exists with

14
00:01:12,040 --> 00:01:16,940
extraterrestrial intelligence and no

15
00:01:14,390 --> 00:01:17,540
trace of their existence has ever been

16
00:01:16,939 --> 00:01:20,689
found

17
00:01:17,540 --> 00:01:22,940
one can even give a sort of proof that

18
00:01:20,689 --> 00:01:25,759
this is the case because if you would

19
00:01:22,939 --> 00:01:29,118
find an artifact which could be

20
00:01:25,759 --> 00:01:31,879
identified as beyond human engineering

21
00:01:29,118 --> 00:01:34,010
you could sell it at international

22
00:01:31,879 --> 00:01:35,780
auction for billions of dollars and I

23
00:01:34,010 --> 00:01:38,570
think Bill Gates would like to buy it

24
00:01:35,780 --> 00:01:41,870
for for that amount of money and nobody

25
00:01:38,569 --> 00:01:44,569
could ever resist having a billion

26
00:01:41,870 --> 00:01:48,409
dollars on one's bank account but it is

27
00:01:44,569 --> 00:01:50,298
still we have to say that it's almost

28
00:01:48,409 --> 00:01:53,450
certain that extraterrestrial

29

00:01:50,299 --> 00:01:56,210
intelligent civilizations exist there

30
00:01:53,450 --> 00:01:58,909
are three arguments for this one is the

31
00:01:56,209 --> 00:02:02,658
astronomical argument that a very large

32
00:01:58,909 --> 00:02:06,530
number of earth-like planets exists on

33
00:02:02,659 --> 00:02:10,459
in the universe the biological argument

34
00:02:06,530 --> 00:02:13,669
that once given an earth-like planet you

35
00:02:10,459 --> 00:02:15,979
there is a high likelihood that life and

36
00:02:13,669 --> 00:02:17,750
even intelligent life will form on it

37
00:02:15,979 --> 00:02:20,419
now if you have that many

38
00:02:17,750 --> 00:02:22,789
extraterrestrial civilizations the

39
00:02:20,419 --> 00:02:26,089
question arises why don't we have

40
00:02:22,789 --> 00:02:30,019
contact and this is the so called Fermi

41
00:02:26,090 --> 00:02:32,629
paradox and I think an explanation can

42
00:02:30,019 --> 00:02:37,360
be given if you carefully think about

43
00:02:32,629 --> 00:02:37,359

the nature of extraterrestrial life

44

00:02:38,629 --> 00:02:45,049

here you see a map of the earth and the

45

00:02:41,330 --> 00:02:47,840

project the mean annual isotherms and

46

00:02:45,050 --> 00:02:53,719

here in the center of the Sahara you see

47

00:02:47,840 --> 00:02:57,400

a red region which encircles the region

48

00:02:53,719 --> 00:03:01,219

where you have more than 25 centigrades

49

00:02:57,400 --> 00:03:05,080

annually mean annual temperature where

50

00:03:01,219 --> 00:03:08,900

very few people live there and also very

51

00:03:05,080 --> 00:03:11,330

few animals and plants so this is

52

00:03:08,900 --> 00:03:14,420

essentially almost devoid of life a

53

00:03:11,330 --> 00:03:18,560

similar region is the Arctic region and

54

00:03:14,419 --> 00:03:20,899

the Antarctic region extending from 60

55

00:03:18,560 --> 00:03:26,180

degrees northern and southern latitudes

56

00:03:20,900 --> 00:03:30,050

and because cosine of 60 degrees is $\frac{1}{2}$

57

00:03:26,180 --> 00:03:34,040

this tells you that life is very

58
00:03:30,050 --> 00:03:36,800
sensitive to the solar radiation and the

59
00:03:34,039 --> 00:03:43,479
solar radiation can change only by a

60
00:03:36,800 --> 00:03:48,710
factor of 2 and translate this into the

61
00:03:43,479 --> 00:03:54,289
solar system you find this Exorcist is

62
00:03:48,710 --> 00:03:57,710
roughly 7 from 7 to 1.4 astronomical

63
00:03:54,289 --> 00:04:01,159
units which is roughly the region

64
00:03:57,710 --> 00:04:02,719
between the orbits of Venus and Mars now

65
00:04:01,159 --> 00:04:04,939
I don't want to talk more about

66
00:04:02,719 --> 00:04:08,389
habitable zones because there will be a

67
00:04:04,939 --> 00:04:11,719
talk on this I only want to mention that

68
00:04:08,389 --> 00:04:13,909
time dependent effect narrow this region

69
00:04:11,719 --> 00:04:17,660
very much to the so called continuously

70
00:04:13,909 --> 00:04:24,250
habitable zone which is around the

71
00:04:17,660 --> 00:04:24,250
Earth's orbit 0.95 to one point or one

72
00:04:24,970 --> 00:04:35,150
astronomical units now there is another

73
00:04:28,490 --> 00:04:38,240
problem for life existing on planets and

74
00:04:35,149 --> 00:04:40,759
this is has to do with the tides here

75
00:04:38,240 --> 00:04:43,100
you see the earth at a distance of one

76
00:04:40,759 --> 00:04:45,978
astronomical unit when you bring it

77
00:04:43,100 --> 00:04:49,909
closer to the Sun

78
00:04:45,978 --> 00:04:53,050
the tides which are due to the

79
00:04:49,908 --> 00:04:56,478
divergence of the gravitational field

80
00:04:53,050 --> 00:05:01,249
which rises with a third power of the

81
00:04:56,478 --> 00:05:05,810
distance gets very much bigger and there

82
00:05:01,249 --> 00:05:09,349
is an distance of 0.6 astronomical units

83
00:05:05,810 --> 00:05:12,168
where in a million years in a billion

84
00:05:09,348 --> 00:05:14,930
years the tides are so strong that it

85
00:05:12,168 --> 00:05:19,218
would hold the spin rotation of the

86

00:05:14,930 --> 00:05:22,519
planet and and that coal rotation excuse

87
00:05:19,218 --> 00:05:24,408
me at the coal rotation distance you

88
00:05:22,519 --> 00:05:28,250
have would have been a planet which

89
00:05:24,408 --> 00:05:31,278
almost faces one side to the Sun and the

90
00:05:28,250 --> 00:05:33,620
other side always away from it it's on

91
00:05:31,278 --> 00:05:37,009
such a planet the oceans would evaporate

92
00:05:33,620 --> 00:05:40,728
and deposit on the backside of the

93
00:05:37,009 --> 00:05:45,490
planet and life would not exist now how

94
00:05:40,728 --> 00:05:49,818
can we translate this now to other stars

95
00:05:45,490 --> 00:05:53,060
where is this and other stars now the

96
00:05:49,819 --> 00:05:56,900
other stars can be differentiated by the

97
00:05:53,060 --> 00:06:00,259
spectral type o be a fine girl or guy

98
00:05:56,899 --> 00:06:02,899
kiss me or something like this and you

99
00:06:00,259 --> 00:06:05,479
see that o stars this is a temperature

100
00:06:02,899 --> 00:06:07,968

classifications of the oysters hogs have

101

00:06:05,478 --> 00:06:10,218

very hot a surface temperature of thirty

102

00:06:07,968 --> 00:06:12,949

five thousand degrees and the habitable

103

00:06:10,218 --> 00:06:15,468

zone is far out four hundred to eight

104

00:06:12,949 --> 00:06:19,639

hundred astronomical units

105

00:06:15,468 --> 00:06:21,019

the Sun is a G star which has four or

106

00:06:19,639 --> 00:06:24,918

five thousand four hundred surface

107

00:06:21,019 --> 00:06:27,528

temperature and here we have just seen

108

00:06:24,918 --> 00:06:30,049

it the habitable zone is point seven to

109

00:06:27,528 --> 00:06:33,319

one point four as Roman units and when

110

00:06:30,050 --> 00:06:35,629

you go to any stars which are cool three

111

00:06:33,319 --> 00:06:38,539

two thousand six hundred degrees surface

112

00:06:35,629 --> 00:06:41,389

temperature there of the habitable zone

113

00:06:38,538 --> 00:06:45,288

is between point six and point one

114

00:06:41,389 --> 00:06:49,098

astronomical unit now in order to have

115
00:06:45,288 --> 00:06:51,800
intelligent life on a planet it will

116
00:06:49,098 --> 00:06:55,250
take a long time and on earth it took

117
00:06:51,800 --> 00:06:56,340
4.6 billion years and therefore the

118
00:06:55,250 --> 00:06:58,860
planet

119
00:06:56,339 --> 00:07:01,829
this central star has to live longer

120
00:06:58,860 --> 00:07:04,620
than this so all stars have only a

121
00:07:01,829 --> 00:07:07,589
lifetime of a million years so they

122
00:07:04,620 --> 00:07:11,490
certainly cannot be a seeds of life and

123
00:07:07,589 --> 00:07:13,529
even if stars for F stars the time the

124
00:07:11,490 --> 00:07:16,769
lifetime of the star is not long enough

125
00:07:13,529 --> 00:07:19,859
to develop intelligent life so these

126
00:07:16,769 --> 00:07:24,180
stars are excluded these types of stars

127
00:07:19,860 --> 00:07:27,000
that doesn't matter much because the F

128
00:07:24,180 --> 00:07:29,970
stars are the most frequent 4% of all

129
00:07:27,000 --> 00:07:32,490
stars and stars and the rest is even

130
00:07:29,970 --> 00:07:36,630
less so we can forget about these type

131
00:07:32,490 --> 00:07:39,389
of SARS seeds of life but the problem

132
00:07:36,629 --> 00:07:42,180
with the core rotation radius is a much

133
00:07:39,389 --> 00:07:44,939
bigger one here you see for the end

134
00:07:42,180 --> 00:07:48,000
stars which are so close that the

135
00:07:44,939 --> 00:07:50,310
habitable zone is very close far inside

136
00:07:48,000 --> 00:07:53,220
the core rotation radius and therefore

137
00:07:50,310 --> 00:07:58,168
planets orbiting here in this nice

138
00:07:53,220 --> 00:07:59,699
temperature zone will will Co rotate and

139
00:07:58,168 --> 00:08:02,549
therefore life will not be there and

140
00:07:59,699 --> 00:08:05,490
this all the same thing happens for the

141
00:08:02,550 --> 00:08:09,168
K stars and here we have a big problem

142
00:08:05,490 --> 00:08:14,668
because 72% of all stars in the galaxy

143

00:08:09,168 --> 00:08:16,740
galaxy M Stars and 40% case stars so

144
00:08:14,668 --> 00:08:20,060
what you conclude from this graph is

145
00:08:16,740 --> 00:08:24,030
only G stars are the ones which are

146
00:08:20,060 --> 00:08:29,209
expected to be seeds of life meaning the

147
00:08:24,029 --> 00:08:33,059
planets orbiting the G stars now what

148
00:08:29,209 --> 00:08:40,199
probability that some terrestrial planet

149
00:08:33,059 --> 00:08:43,109
will will orbit a g star and be in the

150
00:08:40,200 --> 00:08:44,970
continuously habitable zone for this I

151
00:08:43,110 --> 00:08:48,060
have to go a little bit into planet

152
00:08:44,970 --> 00:08:51,300
formation here you see the gap spiral

153
00:08:48,059 --> 00:08:55,889
galaxy m74 our Milky Way would look

154
00:08:51,299 --> 00:08:58,949
quite similar to this and the

155
00:08:55,889 --> 00:09:01,470
outstanding thing is spiral arms here

156
00:08:58,950 --> 00:09:06,450
but work on but we are mostly interested

157
00:09:01,470 --> 00:09:07,920

in are these very dark dust clouds which

158

00:09:06,450 --> 00:09:11,790
are associated

159

00:09:07,919 --> 00:09:15,289
large molecular clouds which are the

160

00:09:11,789 --> 00:09:19,230
seeds of star formation here you see

161

00:09:15,289 --> 00:09:22,639
from radio observations rate your line

162

00:09:19,230 --> 00:09:26,039
observation the outside of one of those

163

00:09:22,639 --> 00:09:29,759
one of those large molecular clouds and

164

00:09:26,039 --> 00:09:33,179
these are very cold and and because of

165

00:09:29,759 --> 00:09:38,519
dust they shield the inside from stellar

166

00:09:33,179 --> 00:09:42,088
radiation and they have very dense

167

00:09:38,519 --> 00:09:45,810
clumps and cold clumps which when they

168

00:09:42,089 --> 00:09:50,100
are disturbed in some way start to

169

00:09:45,809 --> 00:09:54,659
collapse due to their own self gravity

170

00:09:50,100 --> 00:09:57,500
and this collapse happens rather rapidly

171

00:09:54,659 --> 00:10:01,319
about five hundred thousand years and

172
00:09:57,500 --> 00:10:04,889
the radius changes by a factor of a

173
00:10:01,320 --> 00:10:07,860
thousand and already here you have a

174
00:10:04,889 --> 00:10:11,730
little rotation or everything rotates in

175
00:10:07,860 --> 00:10:15,959
the galaxies and this rotation gets

176
00:10:11,730 --> 00:10:18,539
strongly amplified because of

177
00:10:15,958 --> 00:10:21,419
conservation of angular momentum and as

178
00:10:18,539 --> 00:10:25,049
this collapse is not a homogeneous

179
00:10:21,419 --> 00:10:28,528
collapse but very inhomogeneous where

180
00:10:25,049 --> 00:10:32,490
you develop an entire star cluster

181
00:10:28,528 --> 00:10:35,159
and you get in individual blobs and

182
00:10:32,490 --> 00:10:38,339
these individual blobs themselves

183
00:10:35,159 --> 00:10:41,789
developed into accretion disks in which

184
00:10:38,339 --> 00:10:45,779
you form a protostar in the middle and

185
00:10:41,789 --> 00:10:48,389
then this plate like thing fanning out

186
00:10:45,778 --> 00:10:51,120
this accretion disks and in this

187
00:10:48,389 --> 00:10:53,970
accretion disk you have a dust Lane and

188
00:10:51,120 --> 00:11:00,120
the equator in which dust accumulates

189
00:10:53,970 --> 00:11:02,519
and dust coagulates and forms in in

190
00:11:00,120 --> 00:11:05,899
timescales of a thousand to a hundred

191
00:11:02,519 --> 00:11:09,750
thousand years performs planetesimals

192
00:11:05,899 --> 00:11:12,929
which grow to sizes of a kilometer to

193
00:11:09,750 --> 00:11:15,839
ten kilometers and they then eventually

194
00:11:12,929 --> 00:11:18,729
at ten million years or so accumulate to

195
00:11:15,839 --> 00:11:20,470
planets now

196
00:11:18,730 --> 00:11:23,440
here you have a somewhat older

197
00:11:20,470 --> 00:11:28,120
calculation which shows the planet

198
00:11:23,440 --> 00:11:30,459
formation in a rather nice way here you

199
00:11:28,120 --> 00:11:32,589
have the different types of stars and

200

00:11:30,458 --> 00:11:36,069
here the distance in a logarithmic scale

201
00:11:32,589 --> 00:11:38,740
and you have two interesting lines this

202
00:11:36,070 --> 00:11:43,209
green line in this red line the green

203
00:11:38,740 --> 00:11:46,060
line separates the the region close to

204
00:11:43,208 --> 00:11:48,989
the star and we are only interested in

205
00:11:46,059 --> 00:11:52,208
the G stars as you as you have heard

206
00:11:48,990 --> 00:11:54,610
this there the temperature from the

207
00:11:52,208 --> 00:11:56,739
protostar the produce pockets up the

208
00:11:54,610 --> 00:12:00,879
accretion disk the temperature is so

209
00:11:56,740 --> 00:12:03,789
high that dust evaporates and therefore

210
00:12:00,879 --> 00:12:05,528
no planetesimals are here and so the

211
00:12:03,789 --> 00:12:07,899
heat from here on them you have the

212
00:12:05,528 --> 00:12:10,230
terrestrial planets and then you come to

213
00:12:07,899 --> 00:12:13,419
the red line and this is the ice

214
00:12:10,230 --> 00:12:15,879

formation line there the temperature the

215

00:12:13,419 --> 00:12:18,129

ingredientes has dropped below one

216

00:12:15,879 --> 00:12:22,448

hundred and seventy degrees Kelvin and

217

00:12:18,129 --> 00:12:25,720

here then ice crystals developed from

218

00:12:22,448 --> 00:12:29,919

the rather abundant water vapour in

219

00:12:25,720 --> 00:12:32,620

these in in this accretion disk and they

220

00:12:29,919 --> 00:12:36,549

quickly grow these terrestrial planets

221

00:12:32,620 --> 00:12:40,810

that which form there grow accumulating

222

00:12:36,549 --> 00:12:43,149

ice crystals but then you get masses of

223

00:12:40,809 --> 00:12:46,088

the order of five to ten earth masses

224

00:12:43,149 --> 00:12:50,078

and these masses are then become so big

225

00:12:46,089 --> 00:12:53,230

that the gravity is enough to now

226

00:12:50,078 --> 00:12:55,778

accumulate also hydrogen the most

227

00:12:53,230 --> 00:12:59,278

frequent material in accretion disk and

228

00:12:55,778 --> 00:13:04,929

helium and then quickly in a runaway

229
00:12:59,278 --> 00:13:08,588
accretion from Jupiter planets of the

230
00:13:04,929 --> 00:13:12,129
order of 380 Earth masses also in about

231
00:13:08,589 --> 00:13:14,350
ten million years now there is no life

232
00:13:12,129 --> 00:13:16,659
on these planets out there you have

233
00:13:14,350 --> 00:13:19,149
smaller objects because there you are at

234
00:13:16,659 --> 00:13:24,399
the end of this blob from which all

235
00:13:19,149 --> 00:13:29,289
these formed now we come to an equation

236
00:13:24,399 --> 00:13:30,250
which I have the honour that Francis

237
00:13:29,289 --> 00:13:32,819
sits here

238
00:13:30,250 --> 00:13:36,059
was the originator of this type of

239
00:13:32,820 --> 00:13:40,690
equation let us estimate how many

240
00:13:36,059 --> 00:13:41,500
earth-like planets can we expect in our

241
00:13:40,690 --> 00:13:45,790
galaxy

242
00:13:41,500 --> 00:13:49,120
you start off with the number of stars

243
00:13:45,789 --> 00:13:51,579
in our galaxy one point six times ten to

244
00:13:49,120 --> 00:13:54,310
eleven and we have to multiply this

245
00:13:51,580 --> 00:13:56,680
times point one to account for the fact

246
00:13:54,309 --> 00:14:01,329
that we are only interested in G stars

247
00:13:56,679 --> 00:14:07,719
then we multiply with 0.6 because we

248
00:14:01,330 --> 00:14:13,270
need population one molecular metal

249
00:14:07,720 --> 00:14:16,450
abundance only metal rich material can

250
00:14:13,269 --> 00:14:21,100
form big enough terrestrial planets you

251
00:14:16,450 --> 00:14:24,940
need multiply times 0.3 which is the

252
00:14:21,100 --> 00:14:29,170
rate of single stars because 70% of all

253
00:14:24,940 --> 00:14:31,990
stars formed members of binary or

254
00:14:29,169 --> 00:14:36,459
multiple star systems and we want to

255
00:14:31,990 --> 00:14:40,180
have a very secure and safe development

256
00:14:36,460 --> 00:14:43,870
of planet so we exclude multiple systems

257

00:14:40,179 --> 00:14:46,509
then we come to the probability that a

258
00:14:43,870 --> 00:14:49,600
Tercel planet is just in the

259
00:14:46,509 --> 00:14:55,179
continuously habitable zone this zone

260
00:14:49,600 --> 00:14:58,810
had ever had diameter of this amount and

261
00:14:55,179 --> 00:15:01,870
you divide by the distance to the ice

262
00:14:58,809 --> 00:15:07,419
formation radius and because there are

263
00:15:01,870 --> 00:15:10,120
four terrestrial planets also formed you

264
00:15:07,419 --> 00:15:13,779
multiply times four and then you come

265
00:15:10,120 --> 00:15:16,690
finally to this rather severe factor

266
00:15:13,779 --> 00:15:21,120
back there this has to do with a

267
00:15:16,690 --> 00:15:24,880
migration of Jupiter's you know that in

268
00:15:21,120 --> 00:15:28,389
1995 the first extraterrestrial planet

269
00:15:24,879 --> 00:15:31,870
where they are discovered and these were

270
00:15:28,389 --> 00:15:34,750
Jupiter sized and it's a surprising

271
00:15:31,870 --> 00:15:38,070

thing was found that we have now about

272

00:15:34,750 --> 00:15:41,899

300 of these objects that most of these

273

00:15:38,070 --> 00:15:45,350

orbit very close to stars much

274

00:15:41,899 --> 00:15:48,829

closer than the ice formation distance

275

00:15:45,350 --> 00:15:51,889

now why are they around so close to

276

00:15:48,830 --> 00:15:55,310

their central stars the reason and the

277

00:15:51,889 --> 00:15:58,250

answer is they migrated from the dust

278

00:15:55,309 --> 00:16:01,369

from the ice formation distance down to

279

00:15:58,250 --> 00:16:07,778

these distances now how can you migrate

280

00:16:01,370 --> 00:16:12,289

I mean you have to you cannot you cannot

281

00:16:07,778 --> 00:16:15,338

trick the law of angular momentum so

282

00:16:12,289 --> 00:16:17,990

what you do is you have a massive

283

00:16:15,339 --> 00:16:20,960

accretion disk and you have many many

284

00:16:17,990 --> 00:16:25,009

planetesimals and these two Peter throw

285

00:16:20,960 --> 00:16:30,950

out planetesimals from the inner parts

286
00:16:25,009 --> 00:16:34,580
outside in this way can get lower their

287
00:16:30,950 --> 00:16:37,870
angular momentum and spiral in and on on

288
00:16:34,580 --> 00:16:40,520
their way doing this they eat up all the

289
00:16:37,870 --> 00:16:43,549
terrestrial planets on their way and now

290
00:16:40,519 --> 00:16:45,850
life will then be possible because they

291
00:16:43,549 --> 00:16:51,199
have all been swallowed by the Jupiter's

292
00:16:45,850 --> 00:16:56,389
so this point 303 is the factor of

293
00:16:51,200 --> 00:16:58,910
accretion discs which which have the

294
00:16:56,389 --> 00:17:03,528
fact that the Jupiter stone my trait so

295
00:16:58,909 --> 00:17:08,058
some have just the right mass where this

296
00:17:03,528 --> 00:17:12,109
video migration does not happen so when

297
00:17:08,058 --> 00:17:15,349
you do all these calculations you find 4

298
00:17:12,109 --> 00:17:20,109
times 10 to the 6 habitable planets in

299
00:17:15,349 --> 00:17:24,379
our solar system in our galaxy and this

300
00:17:20,109 --> 00:17:27,828
looks like much but actually you find

301
00:17:24,380 --> 00:17:31,670
that among 50,000 stellar systems only

302
00:17:27,828 --> 00:17:35,450
one has a planet in the continuously

303
00:17:31,670 --> 00:17:37,970
habitable zone so this is not much

304
00:17:35,450 --> 00:17:41,960
compared to the number of stars in our

305
00:17:37,970 --> 00:17:45,769
galaxy but if you multiply with 10 to

306
00:17:41,960 --> 00:17:50,720
the 11 which are the number of galaxies

307
00:17:45,769 --> 00:17:51,558
in the universe you have 10 to the 17 4

308
00:17:50,720 --> 00:17:55,069
times

309
00:17:51,558 --> 00:17:57,980
17 earth-like planets in the universe

310
00:17:55,069 --> 00:18:01,298
and this number alone tells you we

311
00:17:57,980 --> 00:18:04,940
cannot possibly be alone in the universe

312
00:18:01,298 --> 00:18:09,499
let me now come to the second part of my

313
00:18:04,940 --> 00:18:12,889
talk take an earth-like planet how

314

00:18:09,499 --> 00:18:16,159
probable is it that life develop on it

315
00:18:12,888 --> 00:18:20,599
here we have to get the information from

316
00:18:16,159 --> 00:18:24,528
the early history of the solar of our

317
00:18:20,599 --> 00:18:29,028
earth and if you look at this very of

318
00:18:24,528 --> 00:18:36,730
early time in the so called Hadean time

319
00:18:29,028 --> 00:18:41,480
of earth evolution you will have rock as

320
00:18:36,730 --> 00:18:46,399
rock liquid rock all the way 1700

321
00:18:41,480 --> 00:18:49,128
kilometers deep in the into the into the

322
00:18:46,398 --> 00:18:54,498
interior of the earth and then

323
00:18:49,128 --> 00:18:58,998
eventually the surface surface graphs

324
00:18:54,499 --> 00:19:04,639
build builds up and at about 4.4 billion

325
00:18:58,999 --> 00:19:08,740
years of the oceans development here you

326
00:19:04,638 --> 00:19:15,008
have to stage for the appearance of life

327
00:19:08,740 --> 00:19:20,480
we know that the the solar system

328
00:19:15,009 --> 00:19:24,889

started from a meteorite with that fell

329

00:19:20,480 --> 00:19:28,009

in in in in Kazakhstan the eighth most

330

00:19:24,888 --> 00:19:31,788

common meteorite and from this we get an

331

00:19:28,009 --> 00:19:35,990

age of 0.56 seven billion years then

332

00:19:31,788 --> 00:19:38,628

fourteen million years later the moon

333

00:19:35,990 --> 00:19:41,259

formed in a collision of a mars-sized

334

00:19:38,628 --> 00:19:46,998

object called Theia

335

00:19:41,259 --> 00:19:49,730

with the earth and then for 0.45 billion

336

00:19:46,999 --> 00:19:52,970

as I already said oceans and continents

337

00:19:49,730 --> 00:19:54,769

form and there is recently a paper in

338

00:19:52,970 --> 00:19:58,269

Nature which has already been mentioned

339

00:19:54,769 --> 00:20:01,230

which just came out one or two weeks ago

340

00:19:58,269 --> 00:20:04,769

which claims that maybe

341

00:20:01,230 --> 00:20:08,150

here you already have the first simple

342

00:20:04,769 --> 00:20:13,829

forms of life which was unlike our

343
00:20:08,150 --> 00:20:16,759
present known life then was something

344
00:20:13,829 --> 00:20:20,639
which I was corrected by the expert

345
00:20:16,759 --> 00:20:23,129
people a lot of people in the field

346
00:20:20,640 --> 00:20:27,590
assumed that there was this late heavy

347
00:20:23,130 --> 00:20:33,690
bombardment going on and this was

348
00:20:27,589 --> 00:20:38,369
supposed to be nailed down with moon

349
00:20:33,690 --> 00:20:42,779
lunar observations this bombardment had

350
00:20:38,369 --> 00:20:46,759
had produced these very large Mars and

351
00:20:42,779 --> 00:20:49,619
the moon and not only was this

352
00:20:46,759 --> 00:20:53,160
discovered on on moon but also on

353
00:20:49,619 --> 00:20:57,539
Mercury and it would have also affected

354
00:20:53,160 --> 00:20:59,730
the Earth and Venus and it would have

355
00:20:57,539 --> 00:21:03,058
affected the earth much more than it has

356
00:20:59,730 --> 00:21:07,048
because it has 81 times the mass of the

357
00:21:03,058 --> 00:21:09,899
moon now immediately after the late

358
00:21:07,048 --> 00:21:14,490
heavy bombardment the idea is that then

359
00:21:09,900 --> 00:21:16,769
the broad GNote the first league living

360
00:21:14,490 --> 00:21:20,759
organism developed or maybe it has

361
00:21:16,769 --> 00:21:27,259
survived and is somewhere on earth maybe

362
00:21:20,759 --> 00:21:30,140
deep in the rocks from earlier epochs

363
00:21:27,259 --> 00:21:36,058
3.8 billion years there is this is a

364
00:21:30,140 --> 00:21:39,900
reasonable age for the Luca the last

365
00:21:36,058 --> 00:21:43,859
Universal common ancestor which already

366
00:21:39,900 --> 00:21:47,429
had DNA as memory molecules and it's the

367
00:21:43,859 --> 00:21:52,379
ancestor of all life of present life on

368
00:21:47,429 --> 00:21:59,190
earth 3.8 billion years also 3.8 billion

369
00:21:52,380 --> 00:22:03,320
years there is evidence in rocks from in

370
00:21:59,190 --> 00:22:10,909
Greenland and the ECR formation about

371

00:22:03,319 --> 00:22:13,048
special unusual c13 c12 isotope ratio

372
00:22:10,909 --> 00:22:16,019
which was interpreted

373
00:22:13,048 --> 00:22:22,378
as being a science of life being there

374
00:22:16,019 --> 00:22:26,329
this is controversial but it it seems to

375
00:22:22,378 --> 00:22:30,209
be logical that life must have been

376
00:22:26,329 --> 00:22:34,589
present at that time because 3.5 billion

377
00:22:30,210 --> 00:22:38,100
years you have confirmed micro fossils

378
00:22:34,589 --> 00:22:40,970
and stromatolites which are bacterial

379
00:22:38,099 --> 00:22:44,730
mats for sea life bacterial mats and

380
00:22:40,970 --> 00:22:47,339
therefore this is already a a very

381
00:22:44,730 --> 00:22:52,399
developed life so it must have formed

382
00:22:47,339 --> 00:22:56,038
earlier about the environment we had

383
00:22:52,398 --> 00:22:59,729
extensive volcanism hot dusty dark a

384
00:22:56,038 --> 00:23:02,730
thin crust frequent impact the moon was

385
00:22:59,730 --> 00:23:06,298

ten times closer at those days and

386

00:23:02,730 --> 00:23:10,169

therefore the tides were 1,000 times

387

00:23:06,298 --> 00:23:14,569

stronger than today from sequencing of

388

00:23:10,169 --> 00:23:20,460

the DNA and and and ribosomes of

389

00:23:14,569 --> 00:23:23,189

bacteria you find that that those who

390

00:23:20,460 --> 00:23:25,950

lived at those days where must have been

391

00:23:23,190 --> 00:23:29,159

thermophilic heat-loving bacteria you

392

00:23:25,950 --> 00:23:30,119

also think that these are hollow philic

393

00:23:29,159 --> 00:23:32,879

acid-loving

394

00:23:30,118 --> 00:23:37,259

so you would assume a very aggressive

395

00:23:32,878 --> 00:23:40,349

chemistry at this those times you have

396

00:23:37,259 --> 00:23:44,159

because of the dust a lot of static

397

00:23:40,349 --> 00:23:47,368

electricity and these charges electric

398

00:23:44,159 --> 00:23:50,369

discharges with hoo-wee UV radiation and

399

00:23:47,368 --> 00:23:53,730

you have ever parading like lagoons

400
00:23:50,368 --> 00:23:56,249
which concentrates the chemistry and so

401
00:23:53,730 --> 00:23:59,700
you have at this guy Gantt ik chemistry

402
00:23:56,249 --> 00:24:07,019
lab earth which produced enormous number

403
00:23:59,700 --> 00:24:11,350
of organic material which has been which

404
00:24:07,019 --> 00:24:14,558
has been done in the laboratory

405
00:24:11,349 --> 00:24:17,319
and in the Miller experiments now I want

406
00:24:14,558 --> 00:24:22,480
to tell you about why do we does life

407
00:24:17,319 --> 00:24:26,710
take so long to develop on earth until

408
00:24:22,480 --> 00:24:32,380
you get intelligence yeah and that is

409
00:24:26,710 --> 00:24:37,840
the fact the the fact is that life

410
00:24:32,380 --> 00:24:41,080
happens on our planet for 3.5 billion

411
00:24:37,839 --> 00:24:44,408
years only in the ocean and only in the

412
00:24:41,079 --> 00:24:48,548
last 500 million years did life conquer

413
00:24:44,409 --> 00:24:52,840
the land and work towards informed

414
00:24:48,548 --> 00:24:57,609
intelligence the reason was because from

415
00:24:52,839 --> 00:25:00,759
this first Luca a prokaryotic cell it

416
00:24:57,609 --> 00:25:03,629
took a tremendous time to form the so

417
00:25:00,759 --> 00:25:07,740
called a periodic cells which are

418
00:25:03,630 --> 00:25:09,850
fabulously complicated machines with

419
00:25:07,740 --> 00:25:14,798
internal organs called

420
00:25:09,849 --> 00:25:16,388
organelles nucleus flagella and so on

421
00:25:14,798 --> 00:25:19,329
all kind peroxisomes

422
00:25:16,388 --> 00:25:23,288
micro country yeah and so on and so on

423
00:25:19,329 --> 00:25:27,269
so this in this absolutely complicated

424
00:25:23,288 --> 00:25:32,740
machine was a precursor and this was

425
00:25:27,269 --> 00:25:36,788
roughly 1.5 billion years ago the final

426
00:25:32,740 --> 00:25:39,730
stages of this development this was the

427
00:25:36,788 --> 00:25:42,759
precursor for the next step of life

428

00:25:39,730 --> 00:25:45,788
which was multicellular life and the

429
00:25:42,759 --> 00:25:48,509
which which developed about a billion

430
00:25:45,788 --> 00:25:50,950
years ago and the important thing about

431
00:25:48,509 --> 00:25:54,220
multicellular life is that the

432
00:25:50,950 --> 00:25:57,038
individual cells can specialize so you

433
00:25:54,220 --> 00:25:59,769
can have liver cells that you have brain

434
00:25:57,038 --> 00:26:03,339
cells and you have skin cells and so on

435
00:25:59,769 --> 00:26:06,028
and so on and so the only when you have

436
00:26:03,339 --> 00:26:10,750
this was it possible to conquer the land

437
00:26:06,028 --> 00:26:17,970
and to then subsequently develop

438
00:26:10,750 --> 00:26:20,769
intelligence only a few years ago

439
00:26:17,970 --> 00:26:23,569
evolutionary biologists said

440
00:26:20,769 --> 00:26:26,118
intelligence is something which have it

441
00:26:23,569 --> 00:26:29,599
very seldom on earth it was an other

442
00:26:26,118 --> 00:26:32,898

chance you know and a lot of books are

443

00:26:29,599 --> 00:26:36,469

written on this thing but now one finds

444

00:26:32,898 --> 00:26:40,278

that intelligence develops in the animal

445

00:26:36,470 --> 00:26:43,399

kingdom on a broad basis already fish

446

00:26:40,278 --> 00:26:46,099

are quite intelligence has been recently

447

00:26:43,398 --> 00:26:48,469

studied they memorize the rock

448

00:26:46,099 --> 00:26:52,219

formations to escape and a predator

449

00:26:48,470 --> 00:26:57,429

comes Velociraptor who has been

450

00:26:52,220 --> 00:27:02,210

portrayed in this Jurassic Park movie is

451

00:26:57,429 --> 00:27:05,690

thought to be a Turkish I sized animal

452

00:27:02,210 --> 00:27:10,429

which already had feathers but couldn't

453

00:27:05,690 --> 00:27:14,599

fly the flight was not developed or not

454

00:27:10,429 --> 00:27:17,509

in this yeah and and they were very

455

00:27:14,598 --> 00:27:23,058

intelligent they hunted in groups they

456

00:27:17,509 --> 00:27:28,329

breed it in groups and then there was

457
00:27:23,058 --> 00:27:31,098
there is another step of intelligence

458
00:27:28,329 --> 00:27:32,538
that can be reached and this is

459
00:27:31,098 --> 00:27:37,009
so-called mirror

460
00:27:32,538 --> 00:27:40,970
self recognition what is this if you put

461
00:27:37,009 --> 00:27:45,200
a mirror in front of an animal it will

462
00:27:40,970 --> 00:27:45,798
it can recognize that this is an enemy

463
00:27:45,200 --> 00:27:50,538
yeah

464
00:27:45,798 --> 00:27:53,628
and in react that one finds that if you

465
00:27:50,538 --> 00:27:56,808
have animals above a certain

466
00:27:53,628 --> 00:27:59,388
intelligence they will recognize that

467
00:27:56,808 --> 00:28:02,358
this what looks out from a mirror are

468
00:27:59,388 --> 00:28:05,949
actually themselves and this about two

469
00:28:02,358 --> 00:28:08,769
years ago it has been shown by crows

470
00:28:05,950 --> 00:28:11,899
Cossack also called Corbett's

471
00:28:08,769 --> 00:28:14,690
Ravens grows and so on this type of bird

472
00:28:11,898 --> 00:28:17,268
family that they have mirror self

473
00:28:14,690 --> 00:28:20,048
recognition they recognize themselves in

474
00:28:17,269 --> 00:28:24,440
the mirror but it has also been found

475
00:28:20,048 --> 00:28:28,720
with capuchin monkeys dolphins elephants

476
00:28:24,440 --> 00:28:31,629
and naturally by all higher Apes like

477
00:28:28,720 --> 00:28:35,940
orangutans gorillas and chimpanzees

478
00:28:31,628 --> 00:28:39,699
chimpanzee actually is the closest

479
00:28:35,940 --> 00:28:42,130
being in the animal world and it is more

480
00:28:39,700 --> 00:28:47,980
and more discovered how intelligence the

481
00:28:42,130 --> 00:28:50,590
chimpanzee is from the line from the

482
00:28:47,980 --> 00:28:53,680
chimp going to the chimpanzee and to

483
00:28:50,589 --> 00:28:59,039
humans separate about 6 billion 6

484
00:28:53,680 --> 00:29:03,370
million years ago and here the first

485

00:28:59,039 --> 00:29:06,220
beings from from Thai at the time going

486
00:29:03,369 --> 00:29:07,739
along this hominid line while the

487
00:29:06,220 --> 00:29:13,690
australopithecines

488
00:29:07,740 --> 00:29:17,289
these are upright working animals which

489
00:29:13,690 --> 00:29:22,120
had a brain somewhat bigger than then

490
00:29:17,289 --> 00:29:25,329
then the human see the reason why you

491
00:29:22,119 --> 00:29:29,679
have upright walking boss because at

492
00:29:25,329 --> 00:29:34,119
that time the earth was moving towards

493
00:29:29,680 --> 00:29:38,259
the Ice Age and the big rain forests in

494
00:29:34,119 --> 00:29:40,479
Africa receded to give way to extended

495
00:29:38,259 --> 00:29:44,019
savannas and interventive you have a lot

496
00:29:40,480 --> 00:29:46,450
of grass and you have to look over the

497
00:29:44,019 --> 00:29:50,710
grass and see the brighter approaching

498
00:29:46,450 --> 00:29:54,340
you and therefore this had to be upright

499
00:29:50,710 --> 00:29:58,990

walking 2 million years ago the first

500

00:29:54,339 --> 00:30:04,269

humans appeared here I have shown you're

501

00:29:58,990 --> 00:30:08,440

a homo erectus Homo erectus not only had

502

00:30:04,269 --> 00:30:13,569

a sophisticated stone axe culture but it

503

00:30:08,440 --> 00:30:18,309

also produced Spears hunting Spears from

504

00:30:13,569 --> 00:30:23,319

special woods with with fine Peaks and

505

00:30:18,309 --> 00:30:28,329

in hunted and also used fire as a tool

506

00:30:23,319 --> 00:30:33,879

since 1.5 million years ago now let me

507

00:30:28,329 --> 00:30:36,730

summarize what we have found so far we

508

00:30:33,880 --> 00:30:39,730

have the astronomical argument that we

509

00:30:36,730 --> 00:30:42,700

have 4 times 10 to 70 earth-like planets

510

00:30:39,730 --> 00:30:46,299

in the universe and we have just seen

511

00:30:42,700 --> 00:30:47,220

that it is most likely that life in

512

00:30:46,299 --> 00:30:49,500

intelligent

513

00:30:47,220 --> 00:30:53,220

develops on earth-like planets together

514
00:30:49,500 --> 00:30:55,769
these to give you a conclusion it is

515
00:30:53,220 --> 00:30:59,130
quite certain that extraterrestrial

516
00:30:55,769 --> 00:31:02,700
intelligent life exists now the problem

517
00:30:59,130 --> 00:31:06,630
is why have you no contact what is the

518
00:31:02,700 --> 00:31:08,960
explanation for the Fermi paradox and I

519
00:31:06,630 --> 00:31:11,039
think thinking about the nature of

520
00:31:08,960 --> 00:31:13,400
extraterrestrials will give you an

521
00:31:11,038 --> 00:31:13,400
answer

522
00:31:14,069 --> 00:31:19,470
you have to pose a couple of questions I

523
00:31:17,069 --> 00:31:20,038
don't want to go into this but right

524
00:31:19,470 --> 00:31:24,298
away

525
00:31:20,038 --> 00:31:28,019
let me start with a question when do you

526
00:31:24,298 --> 00:31:32,009
expect the first intelligent beings in

527
00:31:28,019 --> 00:31:34,740
our galaxy here you have to go a little

528
00:31:32,009 --> 00:31:39,079
bit into the history of the galaxy the

529
00:31:34,740 --> 00:31:45,710
history Lexi started at the Big Bang

530
00:31:39,079 --> 00:31:51,480
13.7 billion years ago and the fireball

531
00:31:45,710 --> 00:31:55,620
got very quickly x/x extinguished and it

532
00:31:51,480 --> 00:32:00,089
got very quickly dark by the expansion

533
00:31:55,619 --> 00:32:03,178
of space and then a Dark Age developed

534
00:32:00,089 --> 00:32:06,269
which lasts about 200 million years

535
00:32:03,179 --> 00:32:10,009
until the first so-called population 3

536
00:32:06,269 --> 00:32:15,179
stars formed these were stars completely

537
00:32:10,009 --> 00:32:19,460
built from hydrogen and helium and in

538
00:32:15,179 --> 00:32:23,298
the center by nuclear fusion produced

539
00:32:19,460 --> 00:32:26,870
heavier elements up to iron and

540
00:32:23,298 --> 00:32:30,889
subsequently in a supernova explosion

541
00:32:26,869 --> 00:32:33,869
the stars were completely disrupted and

542

00:32:30,890 --> 00:32:37,650
also they are the other elements formed

543
00:32:33,869 --> 00:32:42,139
up to uranium and this material was

544
00:32:37,650 --> 00:32:44,850
thrown into the hydrogen and helium

545
00:32:42,140 --> 00:32:47,970
gases which server which came from the

546
00:32:44,849 --> 00:32:51,149
Big Bang and this way enriched this

547
00:32:47,970 --> 00:32:53,880
material and then other stars formed the

548
00:32:51,150 --> 00:32:56,788
so-called population two stars were

549
00:32:53,880 --> 00:33:00,120
which had had a more heavy elements and

550
00:32:56,788 --> 00:33:02,819
so this went on for several generation

551
00:33:00,119 --> 00:33:08,119
and eventually about ten billion years

552
00:33:02,819 --> 00:33:12,149
ago the chemical abundances of

553
00:33:08,119 --> 00:33:15,949
population 1 stars was formed and

554
00:33:12,150 --> 00:33:19,130
therefore the first earth-like planets

555
00:33:15,950 --> 00:33:22,048
because with population 2 stars the

556
00:33:19,130 --> 00:33:25,679

material planets would have two small

557

00:33:22,048 --> 00:33:30,660

mass and so at about 10 billion years

558

00:33:25,679 --> 00:33:34,679

the first earth-like planet was was came

559

00:33:30,660 --> 00:33:37,190

into being and then if you say okay it

560

00:33:34,679 --> 00:33:40,590

took about four and a half billion years

561

00:33:37,190 --> 00:33:44,808

till intelligent develops you would have

562

00:33:40,589 --> 00:33:49,289

an estimate that 5.5 billion years ago

563

00:33:44,808 --> 00:33:53,639

the first intelligent life was present

564

00:33:49,289 --> 00:33:57,089

in our galaxy now here I have shown the

565

00:33:53,640 --> 00:34:00,960

history of the earth and the earth form

566

00:33:57,089 --> 00:34:03,359

4.6 billion years ago and the first

567

00:34:00,960 --> 00:34:06,090

intelligent life of our type of

568

00:34:03,359 --> 00:34:08,429

intelligent life develop out two million

569

00:34:06,089 --> 00:34:13,590

years ago which is sort of the width of

570

00:34:08,429 --> 00:34:18,570

this of of this dashed line so you see

571
00:34:13,590 --> 00:34:21,780
in this gigantic time of four or five

572
00:34:18,570 --> 00:34:24,600
point five billion years this would give

573
00:34:21,780 --> 00:34:29,100
room or for extraterrestrial

574
00:34:24,599 --> 00:34:32,309
civilizations can we imagine intelligent

575
00:34:29,099 --> 00:34:36,179
beings that are a billion years older

576
00:34:32,309 --> 00:34:40,608
than we I think our brain is not good

577
00:34:36,179 --> 00:34:45,690
enough to ever ever come close to to an

578
00:34:40,608 --> 00:34:51,079
imagination how these beings are we can

579
00:34:45,690 --> 00:34:54,960
only make sort of a comparison a crude

580
00:34:51,079 --> 00:34:59,639
comparison and that is if we compare

581
00:34:54,960 --> 00:35:03,420
ourselves to what happened back in the

582
00:34:59,639 --> 00:35:06,000
history 1 billion years ago let's say 1

583
00:35:03,420 --> 00:35:07,409
billion year in the future we compare it

584
00:35:06,000 --> 00:35:12,539
with something 1 billion

585
00:35:07,409 --> 00:35:16,759
ago and that was before multicellularity

586
00:35:12,539 --> 00:35:20,279
so the difference between these

587
00:35:16,760 --> 00:35:25,110
extraterrestrial beings and us should be

588
00:35:20,280 --> 00:35:28,710
of the same magnitude in quality as the

589
00:35:25,110 --> 00:35:31,740
difference between us and a one cell

590
00:35:28,710 --> 00:35:34,349
animal in the ocean 1 billion years ago

591
00:35:31,739 --> 00:35:37,739
on earth we should always keep this

592
00:35:34,349 --> 00:35:39,659
gigantic difference in mind and if you

593
00:35:37,739 --> 00:35:42,479
switch on the television set at night

594
00:35:39,659 --> 00:35:45,599
and use in the evening and you see the

595
00:35:42,480 --> 00:35:48,630
star blade movies and see these Klingons

596
00:35:45,599 --> 00:35:55,440
or whatever looking at you you will say

597
00:35:48,630 --> 00:35:59,579
this is ridiculous now what can be

598
00:35:55,440 --> 00:36:07,170
expected how are these people how are

599

00:35:59,579 --> 00:36:10,409
these intelligent beings sorry what can

600
00:36:07,170 --> 00:36:13,889
we say about them compared to us they

601
00:36:10,409 --> 00:36:16,440
must have almost infinitely mentally

602
00:36:13,889 --> 00:36:20,219
more knowledge I mean we have done

603
00:36:16,440 --> 00:36:22,829
research for 2,000 years now they have a

604
00:36:20,219 --> 00:36:27,419
billion years of research behind them

605
00:36:22,829 --> 00:36:30,690
they have therefore from this knowledge

606
00:36:27,420 --> 00:36:34,730
an almost infinite greater power than we

607
00:36:30,690 --> 00:36:39,570
have and they probably have solved

608
00:36:34,730 --> 00:36:44,820
mortality and all except the accidental

609
00:36:39,570 --> 00:36:47,690
death they will have switch off can we

610
00:36:44,820 --> 00:36:50,840
say something about the body forms of

611
00:36:47,690 --> 00:36:54,139
extraterrestrial life

612
00:36:50,840 --> 00:37:00,000
do you know that a few years ago we have

613
00:36:54,139 --> 00:37:05,309

decoded the human genome and this is a

614

00:37:00,000 --> 00:37:09,090

3.5 letter construction plan of a human

615

00:37:05,309 --> 00:37:13,769

body and it is written in these four

616

00:37:09,090 --> 00:37:19,640

different letters and what you find

617

00:37:13,769 --> 00:37:21,329

today is you have about 25,000 genes and

618

00:37:19,639 --> 00:37:23,969

about

619

00:37:21,329 --> 00:37:27,298

a number of switches which control the

620

00:37:23,969 --> 00:37:29,729

genes to let's say make cell liver cells

621

00:37:27,298 --> 00:37:33,239

brain cells and so on and so on this is

622

00:37:29,728 --> 00:37:37,588

a matter of the switches and people are

623

00:37:33,239 --> 00:37:41,099

there to investigate and to especially

624

00:37:37,588 --> 00:37:43,920

to study these switches because people

625

00:37:41,099 --> 00:37:47,940

want to to grow organs and things like

626

00:37:43,920 --> 00:37:51,269

this now it is quite certain that a

627

00:37:47,940 --> 00:37:54,479

certain stretch here only marked is an

628
00:37:51,268 --> 00:37:57,689
indication a certain stretch will tell

629
00:37:54,478 --> 00:38:01,199
you the construction plan of a human

630
00:37:57,690 --> 00:38:03,630
brain and it's quite certain that we

631
00:38:01,199 --> 00:38:07,679
will soon know this construction plan

632
00:38:03,630 --> 00:38:12,420
because already fifty percent of of the

633
00:38:07,679 --> 00:38:14,669
genes are already known what they do so

634
00:38:12,420 --> 00:38:17,909
in a few years time maybe a hundred

635
00:38:14,670 --> 00:38:20,940
years or so we will have the exact

636
00:38:17,909 --> 00:38:24,690
construction plan of a human brain and

637
00:38:20,940 --> 00:38:27,449
as you know every construction plan will

638
00:38:24,690 --> 00:38:32,190
always will be worked over by engineers

639
00:38:27,449 --> 00:38:35,579
to try to improve it but secondly this

640
00:38:32,190 --> 00:38:39,108
construction plan can be used to be

641
00:38:35,579 --> 00:38:42,690
translated into computer technology and

642
00:38:39,108 --> 00:38:45,659
therefore Andrew a drill rights will be

643
00:38:42,690 --> 00:38:51,539
built there is no way in preventing this

644
00:38:45,659 --> 00:38:54,389
and therefore what we cannot predict

645
00:38:51,539 --> 00:38:57,420
what the how these extraterrestrial

646
00:38:54,389 --> 00:38:59,879
intelligent beings look like it's quite

647
00:38:57,420 --> 00:39:02,519
impossible to predict if they are very

648
00:38:59,880 --> 00:39:06,289
likely in organic miniaturized and maybe

649
00:39:02,518 --> 00:39:10,588
have even a free choice of their body

650
00:39:06,289 --> 00:39:13,319
let's have more questions can we say

651
00:39:10,588 --> 00:39:16,078
something of the average lifespan of

652
00:39:13,318 --> 00:39:17,788
such a civilization this is a different

653
00:39:16,079 --> 00:39:21,509
aggression because we don't even know it

654
00:39:17,789 --> 00:39:24,719
for ourselves can we say something about

655
00:39:21,509 --> 00:39:28,259
the number of et civilizations in our

656

00:39:24,719 --> 00:39:33,858
galaxy this was your prime interest your

657
00:39:28,259 --> 00:39:33,858
prime motivation for your Drake Equation

658
00:39:35,929 --> 00:39:45,250
the impact the lifespan depends how easy

659
00:39:41,389 --> 00:39:49,250
it is that civilization dies there are

660
00:39:45,250 --> 00:39:52,670
external dangers you remember the

661
00:39:49,250 --> 00:39:56,389
dinosaurs which were killed by asteroid

662
00:39:52,670 --> 00:39:59,059
impact I don't think these are dangerous

663
00:39:56,389 --> 00:40:04,339
which today the Mavi have to seriously

664
00:39:59,059 --> 00:40:06,920
consider because if an impact is

665
00:40:04,340 --> 00:40:10,220
imminent we could try to destroy the

666
00:40:06,920 --> 00:40:11,900
impact or we can't hide and then just

667
00:40:10,219 --> 00:40:13,849
suffer the consequences but I think

668
00:40:11,900 --> 00:40:17,210
human beings will not be extinguished

669
00:40:13,849 --> 00:40:24,069
because of this I think that the only

670
00:40:17,210 --> 00:40:27,699

and greatest and most the the most

671

00:40:24,070 --> 00:40:31,280

dangerous thing is that with increasing

672

00:40:27,699 --> 00:40:34,669

knowledge we are getting increasingly

673

00:40:31,280 --> 00:40:37,430

more powerful to destroy ourselves and

674

00:40:34,670 --> 00:40:40,880

this is the internal thing and this is

675

00:40:37,429 --> 00:40:46,609

the only danger which grows with time

676

00:40:40,880 --> 00:40:50,680

the more human beings understand the the

677

00:40:46,610 --> 00:40:55,820

more there are possibilities to kill and

678

00:40:50,679 --> 00:40:58,819

so how can we make an estimate we can

679

00:40:55,820 --> 00:41:04,280

say well we have already discussed that

680

00:40:58,820 --> 00:41:06,440

maybe these beings which were which came

681

00:41:04,280 --> 00:41:09,170

about very early in the history of the

682

00:41:06,440 --> 00:41:11,329

universe who are 10 to the 9 years are

683

00:41:09,170 --> 00:41:14,030

still around this is the optimist view

684

00:41:11,329 --> 00:41:17,480

and the pessimist will say oh we will

685
00:41:14,030 --> 00:41:19,580
not survive the next 1000 years we will

686
00:41:17,480 --> 00:41:22,010
kill surely kill ourselves if he

687
00:41:19,579 --> 00:41:25,789
continued the way it was Hitler and bin

688
00:41:22,010 --> 00:41:27,800
Laden and and and the other nice guys so

689
00:41:25,789 --> 00:41:31,730
we do not survive more than a thousand

690
00:41:27,800 --> 00:41:34,519
years but we have already lived too

691
00:41:31,730 --> 00:41:37,280
a billion two million years so you have

692
00:41:34,519 --> 00:41:40,130
these two numbers and you can make a

693
00:41:37,280 --> 00:41:43,450
logarithmic mean between these numbers

694
00:41:40,130 --> 00:41:46,640
you come up with some reasonable or some

695
00:41:43,449 --> 00:41:50,389
unreasonable number and the guess is

696
00:41:46,639 --> 00:41:53,210
let's say 10 to the 7 years okay if this

697
00:41:50,389 --> 00:41:53,868
is the lifetime what does follow from

698
00:41:53,210 --> 00:41:57,199
this

699

00:41:53,869 --> 00:42:01,010

here you have plotted the number of

700

00:41:57,199 --> 00:42:03,980

earth-like planets versus time and we

701

00:42:01,010 --> 00:42:08,950

set the first earth-like planet

702

00:42:03,980 --> 00:42:12,619

developed about 10 billion years ago and

703

00:42:08,949 --> 00:42:14,899

it increased and if the rate of

704

00:42:12,619 --> 00:42:17,630

formation of earth-like planets were

705

00:42:14,900 --> 00:42:19,760

sort of continuous over time we have

706

00:42:17,630 --> 00:42:23,510

today for all times ten to the six

707

00:42:19,760 --> 00:42:25,820

earth-like planets as I had derived I

708

00:42:23,510 --> 00:42:30,800

mean all these numbers are naturally not

709

00:42:25,820 --> 00:42:33,920

very certain but now we see that first

710

00:42:30,800 --> 00:42:38,390

intelligent life was came about four

711

00:42:33,920 --> 00:42:40,430

five point five billion years ago but

712

00:42:38,389 --> 00:42:43,400

then in ten to the seven years in ten

713

00:42:40,429 --> 00:42:46,190
million years it dies then other planets

714
00:42:43,400 --> 00:42:48,530
came about and then this life died too

715
00:42:46,190 --> 00:42:53,769
and so and so on and this whole blue

716
00:42:48,530 --> 00:42:57,050
regions are all intelligent

717
00:42:53,769 --> 00:42:58,969
civilizations which later had died under

718
00:42:57,050 --> 00:43:00,820
the assumption that they only lived ten

719
00:42:58,969 --> 00:43:06,769
to the seven years and the only

720
00:43:00,820 --> 00:43:10,460
intelligent civilization surviving they

721
00:43:06,769 --> 00:43:15,619
are formed by planets which have been

722
00:43:10,460 --> 00:43:19,699
created ten million years earlier than

723
00:43:15,619 --> 00:43:23,050
the earth and so they survived to today

724
00:43:19,699 --> 00:43:26,358
and this is a very tiny number of only

725
00:43:23,050 --> 00:43:32,800
40,000 civilizations which should be

726
00:43:26,358 --> 00:43:32,799
presently a life in the galaxy

727
00:43:35,400 --> 00:43:47,829

4,000 excuse me did I say four a four

728

00:43:39,579 --> 00:43:50,230

thousand four thousand only now can we

729

00:43:47,829 --> 00:43:54,130

say something about for how far away

730

00:43:50,230 --> 00:43:57,519

they are to see whether they could come

731

00:43:54,130 --> 00:44:02,769

here and could we say whether we can

732

00:43:57,519 --> 00:44:08,079

identify us that could be a reason why

733

00:44:02,769 --> 00:44:15,989

they have not come here now to estimate

734

00:44:08,079 --> 00:44:19,480

the distance of the next life in

735

00:44:15,989 --> 00:44:22,989

civilization in our galaxy

736

00:44:19,480 --> 00:44:27,358

you take the galaxy as a big box which

737

00:44:22,989 --> 00:44:30,729

are diameter of 100,000 light years and

738

00:44:27,358 --> 00:44:33,190

thickness of 13 hundred light years and

739

00:44:30,730 --> 00:44:36,789

in this box you throne our four thousand

740

00:44:33,190 --> 00:44:40,389

planets and distribute them equally and

741

00:44:36,789 --> 00:44:44,980

then measure or calculate the distance

742
00:44:40,389 --> 00:44:48,519
between to and you find one thousand

743
00:44:44,980 --> 00:44:51,309
seven hundred light-years this is the

744
00:44:48,519 --> 00:44:55,000
reason why City hasn't found much

745
00:44:51,309 --> 00:45:03,190
according to my opinion yeah this is

746
00:44:55,000 --> 00:45:06,068
very far away and now is there it's the

747
00:45:03,190 --> 00:45:08,369
problem of these beings that they don't

748
00:45:06,068 --> 00:45:12,909
know where we are

749
00:45:08,369 --> 00:45:17,470
this can be answered with this picture

750
00:45:12,909 --> 00:45:19,989
here this is the infrared spectra from

751
00:45:17,469 --> 00:45:23,169
the solar system and you see this the

752
00:45:19,989 --> 00:45:27,219
Venus you see Earth and Mars in the

753
00:45:23,170 --> 00:45:30,548
infrared and you see the very big carbon

754
00:45:27,219 --> 00:45:33,789
dioxide bands here in all of these

755
00:45:30,548 --> 00:45:37,480
planets but only on earth do you have

756
00:45:33,789 --> 00:45:41,019
the water vapor band and this water

757
00:45:37,480 --> 00:45:44,190
vapor bed is already there since 4.4

758
00:45:41,019 --> 00:45:46,019
billion years so it cannot be overlooked

759
00:45:44,190 --> 00:45:49,980
for very long

760
00:45:46,019 --> 00:45:53,730
I mean also already ozone is there which

761
00:45:49,980 --> 00:45:57,449
is a sure sign of life and B it's there

762
00:45:53,730 --> 00:46:00,349
already - since 2.5 billion years

763
00:45:57,449 --> 00:46:06,239
now in a few years time we will be able

764
00:46:00,349 --> 00:46:09,509
to resolve all the terrestrial planets

765
00:46:06,239 --> 00:46:12,029
on all stars of our Milky Way with

766
00:46:09,510 --> 00:46:14,880
gigantic telescopes floating in the

767
00:46:12,030 --> 00:46:20,550
solar system and communicated with laser

768
00:46:14,880 --> 00:46:24,570
beams and they we will be able to see

769
00:46:20,550 --> 00:46:27,150
the infrared spectra of these planets in

770

00:46:24,570 --> 00:46:30,600
a few let's say a hundred years or so

771
00:46:27,150 --> 00:46:34,500
and therefore we'll all know on which

772
00:46:30,599 --> 00:46:39,089
planet in our galaxy life exists let me

773
00:46:34,500 --> 00:46:41,190
come to the last slide we have learned

774
00:46:39,090 --> 00:46:43,950
about extraterrestrial intelligent

775
00:46:41,190 --> 00:46:46,950
civilization that compared to us they

776
00:46:43,949 --> 00:46:49,789
are almost Omni signed compared to us

777
00:46:46,949 --> 00:46:52,409
they are imaginably advanced

778
00:46:49,789 --> 00:46:57,619
technologically therefore there is

779
00:46:52,409 --> 00:47:01,949
absolutely no problem contacting us and

780
00:46:57,619 --> 00:47:08,150
visiting us because they are essentially

781
00:47:01,949 --> 00:47:11,969
in a immortal but we have also learned

782
00:47:08,150 --> 00:47:15,059
with this very advanced knowledge comes

783
00:47:11,969 --> 00:47:18,980
the extreme danger of self-destruction

784
00:47:15,059 --> 00:47:22,429

and only those societies will survive

785

00:47:18,980 --> 00:47:26,250
which have developed a stable

786

00:47:22,429 --> 00:47:30,000
responsible civilization to master this

787

00:47:26,250 --> 00:47:33,949
danger and therefore from these beings

788

00:47:30,000 --> 00:47:37,110
you cannot expect irresponsible behavior

789

00:47:33,949 --> 00:47:39,239
now there is the sole hypothesis which

790

00:47:37,110 --> 00:47:43,050
explains the Fermi paradox

791

00:47:39,239 --> 00:47:45,449
it says developed by Baal and sagen they

792

00:47:43,050 --> 00:47:50,940
know where we are but they don't want

793

00:47:45,449 --> 00:47:54,269
any contact because because contact

794

00:47:50,940 --> 00:47:56,250
would be extremely irresponsible just

795

00:47:54,269 --> 00:47:58,619
think what would happen it would

796

00:47:56,250 --> 00:48:00,420
something much worse would have

797

00:47:58,619 --> 00:48:06,210
and then happened to the American

798

00:48:00,420 --> 00:48:11,309
Indians when Columbus came we would we

799

00:48:06,210 --> 00:48:15,869

would have to forget all what we have

800

00:48:11,309 --> 00:48:20,099

learned in science yeah because they

801

00:48:15,869 --> 00:48:23,539

have a billion-year more science than we

802

00:48:20,099 --> 00:48:26,249

we could forget all of our cultural and

803

00:48:23,539 --> 00:48:31,019

Mozart and so on because they have so

804

00:48:26,248 --> 00:48:33,298

much more and bigger things and this

805

00:48:31,018 --> 00:48:36,989

would be a tragedy because we would have

806

00:48:33,298 --> 00:48:39,960

we would have to forget our own destiny

807

00:48:36,989 --> 00:48:43,768

in our own things and we could never

808

00:48:39,960 --> 00:48:48,179

show what could become of us in a

809

00:48:43,768 --> 00:48:51,379

billion years time so it would be

810

00:48:48,179 --> 00:48:55,518

utterly irresponsible and it cannot be

811

00:48:51,380 --> 00:48:59,809

expected from these animal from these

812

00:48:55,518 --> 00:49:03,538

aliens from these aliens that they will

813
00:48:59,809 --> 00:49:07,079
contact us because if they would be

814
00:49:03,539 --> 00:49:10,440
capable of irresponsibility they would

815
00:49:07,079 --> 00:49:14,960
long have killed themselves let me

816
00:49:10,440 --> 00:49:16,889
summarize what I was what I said I said

817
00:49:14,960 --> 00:49:21,509
extraterrestrial intelligent beings

818
00:49:16,889 --> 00:49:26,298
exist they avoid all contacts and

819
00:49:21,509 --> 00:49:30,869
actually I claim that they observers

820
00:49:26,298 --> 00:49:33,509
because intelligent societies are the

821
00:49:30,869 --> 00:49:36,119
most interesting things in our galaxy

822
00:49:33,509 --> 00:49:39,230
black holes they know since billions of

823
00:49:36,119 --> 00:49:43,818
years nothing mysterious and even

824
00:49:39,230 --> 00:49:47,548
asteroids and so on but intelligent

825
00:49:43,818 --> 00:49:50,880
societies are very individualistic are

826
00:49:47,548 --> 00:49:53,278
very scarce in the in our galaxy and

827

00:49:50,880 --> 00:49:55,499
therefore we must be intensely

828
00:49:53,278 --> 00:49:58,909
interesting probably the only very

829
00:49:55,498 --> 00:50:04,048
interesting thing in our galaxy and now

830
00:49:58,909 --> 00:50:08,710
you will say that I has lost screw up

831
00:50:04,048 --> 00:50:12,338
here I claim that they are here on earth

832
00:50:08,710 --> 00:50:14,380
or maybe in the solar system my

833
00:50:12,338 --> 00:50:20,019
reasoning is the following thing the

834
00:50:14,380 --> 00:50:24,608
only time when these beings might be

835
00:50:20,019 --> 00:50:27,009
tempted to intervene would be when there

836
00:50:24,608 --> 00:50:29,500
would be a super bin-laden here to press

837
00:50:27,010 --> 00:50:31,960
the red button and kill all of mankind

838
00:50:29,500 --> 00:50:34,659
they would have observed that for two

839
00:50:31,960 --> 00:50:37,409
million years and to see what comes out

840
00:50:34,659 --> 00:50:40,269
of us yeah but will develop out of us

841
00:50:37,409 --> 00:50:44,049

and then one guy will finish the

842

00:50:40,269 --> 00:50:47,289

experiment now in order to prevent this

843

00:50:44,050 --> 00:50:49,089

they might actually be tempted to change

844

00:50:47,289 --> 00:50:52,690

this guy a little bit without him

845

00:50:49,088 --> 00:50:56,608

knowing it yeah but in order to do that

846

00:50:52,690 --> 00:50:59,440

they cannot observe from 1700

847

00:50:56,608 --> 00:51:01,420

light-years away because if they would

848

00:50:59,440 --> 00:51:05,318

then come the whole thing would be

849

00:51:01,420 --> 00:51:08,710

finished yeah they can only do it if

850

00:51:05,318 --> 00:51:12,420

they were here and so I claim and they

851

00:51:08,710 --> 00:51:12,420

are here thank you very much