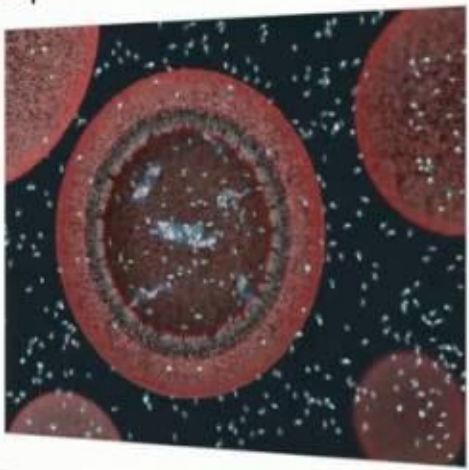
Compartmentalization/Cellularity



1
00:00:11,770 --> 00:00:09,040
welcome to the final day of pak-rat calm

2
00:00:14,350 --> 00:00:11,780
and thank you for making it this fairly

3
00:00:17,290 --> 00:00:14,360
on the final day of wealth sign state

4
00:00:18,460 --> 00:00:17,300
about going on why do I want one of the

5
00:00:20,380 --> 00:00:18,470
organizers and I'm going to be giving

6
00:00:23,380 --> 00:00:20,390
you a warm talk today that's kind of a

7
00:00:26,140 --> 00:00:23,390
crash course in biochemistry and the

8
00:00:27,970 --> 00:00:26,150
origins of life which you know I can

9
00:00:33,729 --> 00:00:27,980
totally government 30 minutes right um

10
00:00:35,350 --> 00:00:33,739
so completely blatantly I have liberally

11
00:00:37,660 --> 00:00:35,360
bharadwaja mayor Goldman and

12
00:00:40,900 --> 00:00:37,670
grasshoppers so lovely neither of them

13
00:00:43,779 --> 00:00:40,910

are here today look no so if any of you

14
00:00:48,910 --> 00:00:43,789
rather last year you may see some

15
00:00:51,309 --> 00:00:48,920
similar stuff um so first off I think a

16
00:00:52,930 --> 00:00:51,319
lot of presentations should probably

17
00:00:55,540 --> 00:00:52,940
have this the why do we care slide so

18
00:00:57,969 --> 00:00:55,550
this is gold three from the astrobiology

19
00:01:00,069 --> 00:00:57,979
roadmap so you know I'm going to be

20
00:01:01,360 --> 00:01:00,079
talking today and a lot of people are

21
00:01:03,579 --> 00:01:01,370
going to be talking today about life on

22
00:01:06,490 --> 00:01:03,589
Earth but why do we care alive America

23
00:01:09,370 --> 00:01:06,500
looks like life else but really has to

24
00:01:12,010 --> 00:01:09,380
do with we work with what we got kind of

25
00:01:14,679 --> 00:01:12,020
thing so we have this really beautiful

26
00:01:16,840 --> 00:01:14,689
complex system of life on Earth and the

27
00:01:20,350 --> 00:01:16,850
better that we understand it the better

28
00:01:22,420 --> 00:01:20,360
that we are able to know what to look

29
00:01:24,819 --> 00:01:22,430
for elsewhere in terms of bio signatures

30
00:01:27,100 --> 00:01:24,829
in terms of you know maybe what microbes

31
00:01:29,139 --> 00:01:27,110
look like that sort of thing so that's

32
00:01:30,609 --> 00:01:29,149
essentially why you're going to have a

33
00:01:34,840 --> 00:01:30,619
lot of people today talking about how

34
00:01:37,300 --> 00:01:34,850
life arose on earth this is the tree of

35
00:01:42,399 --> 00:01:37,310
life in even this is a pretty simplified

36
00:01:45,940 --> 00:01:42,409
version so we are I mean today modern

37
00:01:47,649 --> 00:01:45,950
biology is kind of here but I'm not

38
00:01:49,270 --> 00:01:47,659

going to talk about that at all today so

39
00:01:52,450 --> 00:01:49,280
these are all the interesting stuff

40
00:01:53,709 --> 00:01:52,460
we're in here plants East yeah now going

41
00:01:55,480 --> 00:01:53,719
to talk about any of that Jennifer is

42
00:01:58,330 --> 00:01:55,490
going to talk about that right after me

43
00:02:02,950 --> 00:01:58,340
so I'm going to go back here actually

44
00:02:04,899 --> 00:02:02,960
before here three four billion years ago

45
00:02:07,599 --> 00:02:04,909
depending on who you believe and I'm not

46
00:02:11,100 --> 00:02:07,609
going to get into that argument to the

47
00:02:15,460 --> 00:02:11,110
last Universal common ancestor which is

48
00:02:17,710 --> 00:02:15,470
essentially not necessarily one single

49
00:02:19,300 --> 00:02:17,720
cell that from which all life on Earth

50
00:02:23,440 --> 00:02:19,310
evolved from

51
00:02:26,140 --> 00:02:23,450
probably a population of cells with

52
00:02:28,540 --> 00:02:26,150
really rapidly changing or exchanging

53
00:02:31,300 --> 00:02:28,550
information so which is called the

54
00:02:33,280 --> 00:02:31,310
horizontal gene transfer today so the

55
00:02:35,110 --> 00:02:33,290
idea there is that the information can

56
00:02:37,780 --> 00:02:35,120
go back and forth really quickly and so

57
00:02:41,979 --> 00:02:37,790
things were happening very fast until at

58
00:02:43,870 --> 00:02:41,989
some point whether it was a physical

59
00:02:47,800 --> 00:02:43,880
barrier something that came up between

60
00:02:52,170 --> 00:02:47,810
the this ancestor and the ancestor of

61
00:02:56,710 --> 00:02:52,180
all bacteria or something chemical

62
00:02:58,690 --> 00:02:56,720
anyways caused caused the divergence so

63
00:02:59,800 --> 00:02:58,700

but yeah like I said I'm not going to

64
00:03:02,080 --> 00:02:59,810
talk about any of that today I'm going

65
00:03:05,470 --> 00:03:02,090
to basically try and get you from the

66
00:03:08,229 --> 00:03:05,480
origin of life which is here somewhere

67
00:03:12,820 --> 00:03:08,239
over here maybe to the last Universal

68
00:03:14,500 --> 00:03:12,830
common ancestor so one thing that is

69
00:03:17,979 --> 00:03:14,510
common the one thing we look at when

70
00:03:19,660 --> 00:03:17,989
we're trying to figure out the traits of

71
00:03:20,979 --> 00:03:19,670
the last Universal common ancestor are

72
00:03:23,110 --> 00:03:20,989
things that are common to all of life

73
00:03:24,940 --> 00:03:23,120
today this is the central dogma of

74
00:03:27,759 --> 00:03:24,950
molecular biology this is why our bodies

75
00:03:29,860 --> 00:03:27,769
work and it's common to all life on

76
00:03:33,160 --> 00:03:29,870
Earth so you have it protists have it

77
00:03:35,559 --> 00:03:33,170
everything so the way that this works is

78
00:03:38,319 --> 00:03:35,569
that you have double stranded DNA which

79
00:03:41,949 --> 00:03:38,329
is our information storage long-term

80
00:03:43,479 --> 00:03:41,959
storage it gets turned into RNA in a

81
00:03:44,710 --> 00:03:43,489
process called transcription or copied

82
00:03:48,789 --> 00:03:44,720
into RNA in a process called

83
00:03:50,229 --> 00:03:48,799
transcription and then RNA is sort of

84
00:03:53,620 --> 00:03:50,239
the short-term memory of life and it

85
00:03:54,670 --> 00:03:53,630
carries that information to a complex

86
00:03:56,559 --> 00:03:54,680
which we'll talk about a bit a little

87
00:03:58,390 --> 00:03:56,569
bit later which makes proteins proteins

88
00:04:01,300 --> 00:03:58,400

are what do the majority of the work in

89
00:04:03,550 --> 00:04:01,310
your body you know making all the

90
00:04:05,500 --> 00:04:03,560
molecules that you need to survive so

91
00:04:07,030 --> 00:04:05,510
yeah because this is common to all life

92
00:04:08,349 --> 00:04:07,040
on earth we can probably say that it was

93
00:04:10,599 --> 00:04:08,359
pretty well established in the last

94
00:04:12,580 --> 00:04:10,609
Universal common ancestor as well but

95
00:04:15,430 --> 00:04:12,590
let's get a little bit more familiar

96
00:04:18,819 --> 00:04:15,440
with these guys sorry oh I should say

97
00:04:20,050 --> 00:04:18,829
this happens sometimes if you want to

98
00:04:21,340 --> 00:04:20,060
talk about viruses but nobody stock

99
00:04:24,969 --> 00:04:21,350
remove iris is today so I could ignore

100
00:04:27,520 --> 00:04:24,979
it where RNA gets transcribed back into

101
00:04:30,870 --> 00:04:27,530
DNA so yeah let's get a little bit more

102
00:04:32,740 --> 00:04:30,880
familiar with life life is based around

103
00:04:35,740 --> 00:04:32,750
polymers at least

104
00:04:39,280 --> 00:04:35,750
terms of the molecules involved in that

105
00:04:42,040 --> 00:04:39,290
central dogma so DNA is a polymer of

106
00:04:43,740 --> 00:04:42,050
this big long word deoxyribonucleotides

107
00:04:45,730 --> 00:04:43,750
all that means is that you have

108
00:04:48,370 --> 00:04:45,740
nucleotides that are attached to ribose

109
00:04:49,540 --> 00:04:48,380
sugars that are missing an oxygen at one

110
00:04:51,550 --> 00:04:49,550
position I'll show you the chemical

111
00:04:52,960 --> 00:04:51,560
structures of those in a minute proteins

112
00:04:54,250 --> 00:04:52,970
are polymers of amino acids we've

113
00:04:56,560 --> 00:04:54,260

already heard a lot of people talk about

114
00:04:58,600 --> 00:04:56,570
amino acids and where they could have

115
00:05:02,790 --> 00:04:58,610
come from whether their stellar in

116
00:05:06,070 --> 00:05:02,800
origin or earthbound in origin and then

117
00:05:07,900 --> 00:05:06,080
starches which are probably a little bit

118
00:05:11,230 --> 00:05:07,910
later addition but are still a

119
00:05:13,630 --> 00:05:11,240
biopolymer that all of these are

120
00:05:18,130 --> 00:05:13,640
products of dehydration reactions so the

121
00:05:21,040 --> 00:05:18,140
monomers lose a water and then they form

122
00:05:24,100 --> 00:05:21,050
these long-chain polymers sounds easy

123
00:05:26,440 --> 00:05:24,110
not really but in so in terms of the

124
00:05:29,830 --> 00:05:26,450
full chemical structure let's go for DNA

125
00:05:32,500 --> 00:05:29,840
and RNA first so this is DNA this is RNA

126
00:05:36,070 --> 00:05:32,510
the only there's only two differences

127
00:05:38,200 --> 00:05:36,080
here let's see first off I'm going to

128
00:05:40,540 --> 00:05:38,210
say that I want you to kind of consider

129
00:05:42,550 --> 00:05:40,550
these in sort of modular units today so

130
00:05:44,650 --> 00:05:42,560
there's these backbones which are

131
00:05:46,870 --> 00:05:44,660
exactly what they sound like they

132
00:05:48,930 --> 00:05:46,880
connect all of the informational units

133
00:05:51,880 --> 00:05:48,940
to each other they're made up of

134
00:05:56,760 --> 00:05:51,890
repeating phosphate groups and ribose

135
00:06:00,760 --> 00:05:56,770
sugar ribose is a five carbon sugar and

136
00:06:02,890 --> 00:06:00,770
so in the case of DNA there's no oxygen

137
00:06:04,900 --> 00:06:02,900
at this position it's just a hydrogen at

138
00:06:07,360 --> 00:06:04,910

this Kate position you have an O H so

139
00:06:10,510 --> 00:06:07,370
that's why this is a ribose sugar this

140
00:06:13,480 --> 00:06:10,520
is a deoxyribose sugar these are the

141
00:06:16,300 --> 00:06:13,490
actual informational units that make up

142
00:06:18,760 --> 00:06:16,310
our genetic code these are the short

143
00:06:22,060 --> 00:06:18,770
forms for themselves adenine and guanine

144
00:06:25,450 --> 00:06:22,070
are what are called purines which have

145
00:06:27,910 --> 00:06:25,460
these two rings aromatic rings and then

146
00:06:31,360 --> 00:06:27,920
you have cytosine thymine and uracil

147
00:06:37,240 --> 00:06:31,370
which are these just have the one six

148
00:06:39,430 --> 00:06:37,250
membered ring oh and the other

149
00:06:41,380 --> 00:06:39,440
difference is that thymine is a little

150
00:06:43,300 --> 00:06:41,390
bit different than your so if I mean has

151
00:06:47,429 --> 00:06:43,310
a methyl group right here your soul does

152
00:06:50,830 --> 00:06:47,439
not feel free to bait why

153
00:06:52,480 --> 00:06:50,840
so the big questions in terms of origins

154
00:06:54,399 --> 00:06:52,490
of life were why were any of these

155
00:06:55,929 --> 00:06:54,409
components chosen so why do we have a

156
00:06:58,209 --> 00:06:55,939
phosphate here why do we have a ribose

157
00:07:01,689 --> 00:06:58,219
here and why are these bases what they

158
00:07:04,510 --> 00:07:01,699
are and another big question is modern

159
00:07:06,640 --> 00:07:04,520
life uses only d sugars I don't really

160
00:07:08,589 --> 00:07:06,650
want to get into stereochemistry but

161
00:07:09,820 --> 00:07:08,599
said stereochemistry is basically

162
00:07:15,820 --> 00:07:09,830
molecules can have two different

163
00:07:17,439 --> 00:07:15,830

handedness so if you have a molecule or

164
00:07:20,399 --> 00:07:17,449
an atom carbon atom that has four

165
00:07:22,719 --> 00:07:20,409
substitutions it can either have one

166
00:07:25,089 --> 00:07:22,729
configuration this way so my carbon

167
00:07:30,450 --> 00:07:25,099
atoms here I can have my three arranged

168
00:07:33,249 --> 00:07:30,460
this way or yeah all right

169
00:07:36,550 --> 00:07:33,259
stereochemistry we can talk about it

170
00:07:39,339 --> 00:07:36,560
later if you really want so yeah but

171
00:07:44,320 --> 00:07:39,349
basically yeah one of the big questions

172
00:07:46,029 --> 00:07:44,330
is why only d sugars into a little bit

173
00:07:48,700 --> 00:07:46,039
more detail so there's a 3d structure of

174
00:07:50,800 --> 00:07:48,710
in this case DNA but here you can

175
00:07:53,290 --> 00:07:50,810
actually see how the information is

176
00:07:54,670 --> 00:07:53,300
transferred from the two different

177
00:07:57,399 --> 00:07:54,680
strands or told you DNA is

178
00:07:59,490 --> 00:07:57,409
double-stranded so that these are base

179
00:08:02,890 --> 00:07:59,500
pairing interactions where their

180
00:08:05,680 --> 00:08:02,900
complementary so thymine right here can

181
00:08:09,129 --> 00:08:05,690
base pair to a Dineen with these two

182
00:08:13,029 --> 00:08:09,139
hydrogen bonds so you have a donor and

183
00:08:15,490 --> 00:08:13,039
acceptor sorry all right I'm not a

184
00:08:19,390 --> 00:08:15,500
chemist Emma biochemist and then with

185
00:08:20,589 --> 00:08:19,400
the cytosine and guanine you get three

186
00:08:23,589 --> 00:08:20,599
interactions so it's a little bit

187
00:08:26,050 --> 00:08:23,599
stronger and then because these are

188
00:08:27,790 --> 00:08:26,060

really nice planar molecules they stack

189
00:08:30,279 --> 00:08:27,800
really nicely on top of each other and

190
00:08:32,469 --> 00:08:30,289
that's also what causes the twist of the

191
00:08:34,180 --> 00:08:32,479
helix is the way that though that the

192
00:08:36,699 --> 00:08:34,190
bases prefer to stack on top of each

193
00:08:37,779 --> 00:08:36,709
other so that's why we have this really

194
00:08:39,670 --> 00:08:37,789
nice structure where you've got the

195
00:08:41,680 --> 00:08:39,680
bases all stacked on top of each other

196
00:08:45,370 --> 00:08:41,690
and then along the outside here are the

197
00:08:47,470 --> 00:08:45,380
sugars and the phosphates but one of the

198
00:08:48,910 --> 00:08:47,480
big questions like said is why did we

199
00:08:52,030 --> 00:08:48,920
use these specific ones you're going to

200
00:08:54,250 --> 00:08:52,040
hear about some maybe alternate nuclear

201
00:08:55,900 --> 00:08:54,260
bases later today so the ones that we

202
00:08:57,699 --> 00:08:55,910
actually use these are only the purines

203
00:08:59,310 --> 00:08:57,709
those larger ones the ones that we

204
00:09:03,180 --> 00:08:59,320
actually use are

205
00:09:05,580 --> 00:09:03,190
guanine but if you do like prebiotic

206
00:09:07,580 --> 00:09:05,590
chemistry in a lot of cases you can get

207
00:09:10,260 --> 00:09:07,590
many of these you know from stuff like

208
00:09:12,330 --> 00:09:10,270
form wide reactions or hcn

209
00:09:13,620 --> 00:09:12,340
polymerization that sort of thing you

210
00:09:15,330 --> 00:09:13,630
can get hypose anthing you can get

211
00:09:19,340 --> 00:09:15,340
xanthine so why did we end up with just

212
00:09:21,720 --> 00:09:19,350
these two rather than any of the rest

213
00:09:23,160 --> 00:09:21,730

similarly we can look at the amino acids

214
00:09:25,170 --> 00:09:23,170
which are what makes up all the proteins

215
00:09:27,870 --> 00:09:25,180
in our body for starters you can see

216
00:09:30,570 --> 00:09:27,880
there's obviously a lot more this might

217
00:09:33,360 --> 00:09:30,580
have to provide us with some hints as to

218
00:09:35,280 --> 00:09:33,370
why we use proteins for a lot of the

219
00:09:38,490 --> 00:09:35,290
business center our bodies now rather

220
00:09:40,650 --> 00:09:38,500
than nucleic acids because they're just

221
00:09:43,650 --> 00:09:40,660
a lot more chemically diverse so they

222
00:09:46,140 --> 00:09:43,660
can do more interesting chemistry so

223
00:09:47,820 --> 00:09:46,150
there's another question of which of

224
00:09:50,040 --> 00:09:47,830
these so I guess is kind of the inverse

225
00:09:54,780 --> 00:09:50,050
of the nucleobases you can't make all of

226
00:09:56,550 --> 00:09:54,790
these in prebiotic reactions so in that

227
00:10:00,090 --> 00:09:56,560
case why did we end up with some that

228
00:10:02,790 --> 00:10:00,100
are hard to make why did we there there

229
00:10:04,380 --> 00:10:02,800
are ones that you can make that didn't

230
00:10:06,240 --> 00:10:04,390
end up in life so why didn't we end up

231
00:10:07,260 --> 00:10:06,250
with those ones where they could have

232
00:10:08,850 --> 00:10:07,270
come from we said we've already had

233
00:10:13,130 --> 00:10:08,860
people have talked about you know

234
00:10:17,430 --> 00:10:13,140
stellar sources for amino acids and

235
00:10:21,720 --> 00:10:17,440
similarly to nucleic acids life only

236
00:10:25,680 --> 00:10:21,730
uses l-amino acids so the opposite kind

237
00:10:27,420 --> 00:10:25,690
of isomer so again a good question for

238
00:10:29,220 --> 00:10:27,430

that is why that came about

239
00:10:33,120 --> 00:10:29,230
unfortunately we don't have any of these

240
00:10:36,540 --> 00:10:33,130
I would love it if we did but I we'd all

241
00:10:38,010 --> 00:10:36,550
be out of jobs but because the laws of

242
00:10:39,210 --> 00:10:38,020
chemistry and the laws of physics have

243
00:10:41,130 --> 00:10:39,220
stayed the same over billions of years

244
00:10:44,460 --> 00:10:41,140
luckily we can extrapolate and say okay

245
00:10:46,140 --> 00:10:44,470
maybe we can sort of resurrect these

246
00:10:48,120 --> 00:10:46,150
processes that happen billions of years

247
00:10:51,450 --> 00:10:48,130
ago or at least some approximation of

248
00:10:52,890 --> 00:10:51,460
them and also we obviously need to know

249
00:10:54,360 --> 00:10:52,900
sort of what the environment was at the

250
00:10:55,830 --> 00:10:54,370
time so we can get a lot of information

251
00:10:57,210 --> 00:10:55,840
with that from the geologic record and

252
00:10:58,380 --> 00:10:57,220
I'm not going to talk about that this is

253
00:11:02,970 --> 00:10:58,390
not my specialty and you guys have heard

254
00:11:05,070 --> 00:11:02,980
about it for two days but a really brief

255
00:11:06,030 --> 00:11:05,080
history of sort of prebiotic chemistry

256
00:11:08,940 --> 00:11:06,040
and some of the really iconic

257
00:11:11,940 --> 00:11:08,950
experiments in it I could give you an

258
00:11:12,840 --> 00:11:11,950
hour-long talk just on interesting crew

259
00:11:15,780 --> 00:11:12,850
biochemistry

260
00:11:17,340 --> 00:11:15,790
but this sort of gives you a historical

261
00:11:19,319 --> 00:11:17,350
overview as well so this guy named glob

262
00:11:21,720 --> 00:11:19,329
way back in nineteen thirteen made

263
00:11:23,610 --> 00:11:21,730

glycine which you've heard talked about

264
00:11:25,410 --> 00:11:23,620
it's the simplest amino acid so it's

265
00:11:27,360 --> 00:11:25,420
pretty easy to make and the grand scheme

266
00:11:29,879 --> 00:11:27,370
of things so that's why you could do it

267
00:11:32,999 --> 00:11:29,889
a hundred years ago so all he did was

268
00:11:34,110 --> 00:11:33,009
pass a electric discharge simulating

269
00:11:36,509 --> 00:11:34,120
maybe lightning or something like that

270
00:11:38,430 --> 00:11:36,519
through carbon dioxide ammonia and water

271
00:11:39,960 --> 00:11:38,440
vapor so really simple chemicals that

272
00:11:43,680 --> 00:11:39,970
give you a building block of life when

273
00:11:45,809 --> 00:11:43,690
you add energy to them this guy named Bo

274
00:11:49,199 --> 00:11:45,819
dish made uracil which is one of the

275
00:11:51,960 --> 00:11:49,209
bases that's found in RNA and in that

276
00:11:55,040 --> 00:11:51,970
case it was just URI again really simple

277
00:11:58,650 --> 00:11:55,050
compounds malic acid is a very small

278
00:12:00,780 --> 00:11:58,660
very small acid with sulfuric acid which

279
00:12:03,230 --> 00:12:00,790
some people believe would would have

280
00:12:05,730 --> 00:12:03,240
been around in prebiotic times as well

281
00:12:07,650 --> 00:12:05,740
open and halt dein were two theorists

282
00:12:11,360 --> 00:12:07,660
that came up with a lot of the sort of

283
00:12:13,829 --> 00:12:11,370
general theoretical framework of the

284
00:12:16,740 --> 00:12:13,839
conditions on early Earth and how those

285
00:12:17,970 --> 00:12:16,750
could have led to life and then Stanley

286
00:12:20,460 --> 00:12:17,980
Miller you guys heard about yesterday

287
00:12:23,220 --> 00:12:20,470
who's responsible for the probably the

288
00:12:26,189 --> 00:12:23,230

most iconic prebiotic chemistry reaction

289
00:12:29,490 --> 00:12:26,199
in which you're simulating volcanic

290
00:12:31,350 --> 00:12:29,500
lightning in a in an atmosphere and

291
00:12:33,829 --> 00:12:31,360
again really simple compounds that give

292
00:12:36,629 --> 00:12:33,839
you a bunch of different amino acids

293
00:12:40,170 --> 00:12:36,639
it's in some cases ones that are in life

294
00:12:42,569 --> 00:12:40,180
in some cases ones that aren't this is

295
00:12:44,790 --> 00:12:42,579
my view of prebiotic chemistry provided

296
00:12:47,790 --> 00:12:44,800
chemistry's job is to get us from those

297
00:12:49,590 --> 00:12:47,800
really simple molecules that should have

298
00:12:50,910 --> 00:12:49,600
been available on early Earth to the

299
00:12:53,579 --> 00:12:50,920
building blocks of life and then

300
00:12:56,160 --> 00:12:53,589
ultimately to long-chain polymers that

301
00:12:57,689 --> 00:12:56,170
we not necessarily of the lengths that

302
00:13:00,290 --> 00:12:57,699
we have today but long enough that they

303
00:13:04,319 --> 00:13:00,300
can actually do interesting things

304
00:13:05,879 --> 00:13:04,329
without so I guess if you really want to

305
00:13:06,809 --> 00:13:05,889
get into sort of definitions of life you

306
00:13:10,470 --> 00:13:06,819
could say that you're going you know

307
00:13:12,240 --> 00:13:10,480
from abiotic to a more biotic synthesis

308
00:13:13,949 --> 00:13:12,250
of interesting molecules and stuff like

309
00:13:15,329 --> 00:13:13,959
that when you have some of these longer

310
00:13:16,800 --> 00:13:15,339
chain polymers I'm not saying they need

311
00:13:19,620 --> 00:13:16,810
to look exactly like what we have today

312
00:13:21,750 --> 00:13:19,630
because for various reasons some of

313
00:13:23,759 --> 00:13:21,760

those components aren't necessarily

314
00:13:25,229 --> 00:13:23,769
perfect

315
00:13:26,910 --> 00:13:25,239
of energetics in terms of stability

316
00:13:28,769 --> 00:13:26,920
stuff like that but if we get to

317
00:13:31,040 --> 00:13:28,779
something look similar then i would say

318
00:13:33,720 --> 00:13:31,050
prebiotic chemistry he's done this job

319
00:13:35,249 --> 00:13:33,730
another thing that could help prebiotic

320
00:13:37,290 --> 00:13:35,259
chemistry do this job once you've got

321
00:13:41,009 --> 00:13:37,300
some of the more complex molecules

322
00:13:42,389 --> 00:13:41,019
there's this idea called self assembly

323
00:13:44,249 --> 00:13:42,399
which is exactly what it sounds like you

324
00:13:46,739 --> 00:13:44,259
put these molecules together and then

325
00:13:48,989 --> 00:13:46,749
they self-assemble into long long

326
00:13:51,239 --> 00:13:48,999
structures the long complex structures

327
00:13:54,949 --> 00:13:51,249
this is kind of a way that you might be

328
00:13:57,780 --> 00:13:54,959
able to make a big stuff that looks like

329
00:14:00,210 --> 00:13:57,790
RNA or DNA or proteins today but without

330
00:14:02,789 --> 00:14:00,220
having them actually covalently bound to

331
00:14:05,249 --> 00:14:02,799
each other so in this case these are I

332
00:14:07,979 --> 00:14:05,259
mean these do kind of look like purines

333
00:14:09,840 --> 00:14:07,989
in the middle here and these assemble

334
00:14:11,699 --> 00:14:09,850
mostly based on just the stacking

335
00:14:13,829 --> 00:14:11,709
interactions of these surfaces so again

336
00:14:15,239 --> 00:14:13,839
they're nice like flat molecules and

337
00:14:16,619 --> 00:14:15,249
they can just stack on top of each other

338
00:14:18,689 --> 00:14:16,629

over and over and over until you get

339
00:14:22,280 --> 00:14:18,699
these really huge long complexes that

340
00:14:24,900 --> 00:14:22,290
you can see with like light microscopes

341
00:14:28,889 --> 00:14:24,910
so once you've got long-chain polymers

342
00:14:30,600 --> 00:14:28,899
you get into hypotheses about what came

343
00:14:33,019 --> 00:14:30,610
first which is sort of a chicken the egg

344
00:14:35,759 --> 00:14:33,029
idea there are people that believe that

345
00:14:37,379 --> 00:14:35,769
RNA came first and I'm of that school

346
00:14:40,799 --> 00:14:37,389
because that's where I do my research in

347
00:14:42,689 --> 00:14:40,809
but and luckily we don't have I don't

348
00:14:45,359 --> 00:14:42,699
think any we might have a couple people

349
00:14:47,220 --> 00:14:45,369
that might disagree with me but there's

350
00:14:50,639 --> 00:14:47,230
also the idea that proteins came first

351
00:14:52,530 --> 00:14:50,649
or the metabolism came first but I'm the

352
00:14:55,169 --> 00:14:52,540
majority of the talks that you guys are

353
00:14:56,910 --> 00:14:55,179
going to hear about this sort of we have

354
00:14:59,039 --> 00:14:56,920
some polymers but not really complex

355
00:15:00,929 --> 00:14:59,049
life are going to deal with the RNA

356
00:15:02,549 --> 00:15:00,939
world so the RNA world hypothesis states

357
00:15:06,210 --> 00:15:02,559
that early in evolution again we're

358
00:15:08,249 --> 00:15:06,220
still talking well before Luca RNA

359
00:15:10,350 --> 00:15:08,259
served both informational and functional

360
00:15:14,789 --> 00:15:10,360
roles so it carried the information even

361
00:15:17,699 --> 00:15:14,799
though it's not as stable as DNA is and

362
00:15:20,059 --> 00:15:17,709
it also carried out more functional the

363
00:15:23,489 --> 00:15:20,069

functional roles in terms of like making

364
00:15:25,379 --> 00:15:23,499
amino acids or making themselves making

365
00:15:29,609 --> 00:15:25,389
you know making nucleobases that sort of

366
00:15:32,699 --> 00:15:29,619
thing so eventually DNA replaced the

367
00:15:34,409 --> 00:15:32,709
archival informational role of RNA again

368
00:15:36,980 --> 00:15:34,419
unless your virus but I don't have to

369
00:15:38,570 --> 00:15:36,990
talk about viruses today

370
00:15:39,889 --> 00:15:38,580
so because DNA is a little bit more

371
00:15:41,690 --> 00:15:39,899
stable so it's better for a long-term

372
00:15:45,170 --> 00:15:41,700
storage think of it as your heart your

373
00:15:46,670 --> 00:15:45,180
body's hard drive rather and protein

374
00:15:48,019 --> 00:15:46,680
like I said before because the amino

375
00:15:51,440 --> 00:15:48,029
acids the building blocks are more

376
00:15:53,630 --> 00:15:51,450
chemically varied that ended up

377
00:15:55,490 --> 00:15:53,640
replacing a lot of the functional roles

378
00:15:56,990 --> 00:15:55,500
of RNA because you can do more interest

379
00:16:00,260 --> 00:15:57,000
in chemistry with proteins than in most

380
00:16:02,630 --> 00:16:00,270
cases you can do with RNA but RNA still

381
00:16:06,139 --> 00:16:02,640
serves both the these purposes today so

382
00:16:09,230 --> 00:16:06,149
that's the real sort of linchpin to the

383
00:16:11,300 --> 00:16:09,240
RNA world is that there's RNA still

384
00:16:14,840 --> 00:16:11,310
carries information from one place to

385
00:16:16,850 --> 00:16:14,850
another in the cell in all life on earth

386
00:16:24,079 --> 00:16:16,860
it serves as the short-term memory or

387
00:16:26,030 --> 00:16:24,089
the RAM of life and the the ribosome

388
00:16:27,470 --> 00:16:26,040

which is what makes all of life on earth

389
00:16:29,840 --> 00:16:27,480
so again that's sort of a

390
00:16:32,360 --> 00:16:29,850
chicken-and-egg conundrum you have the

391
00:16:36,579 --> 00:16:32,370
ribosomes functional parts are mostly

392
00:16:40,010 --> 00:16:36,589
made of RNA so with that you can't have

393
00:16:41,810 --> 00:16:40,020
you can't have protein without the thing

394
00:16:43,550 --> 00:16:41,820
that makes protein which is made of RNA

395
00:16:45,500 --> 00:16:43,560
so again another pretty good piece of

396
00:16:47,990 --> 00:16:45,510
evidence that RNA probably came first

397
00:16:49,699 --> 00:16:48,000
and then ribozymes which are responsible

398
00:16:52,040 --> 00:16:49,709
for a lot of gene regulation stuff like

399
00:16:54,949 --> 00:16:52,050
that are basically exactly what they

400
00:16:56,360 --> 00:16:54,959
sound like they're RNA enzymes and

401
00:17:00,290 --> 00:16:56,370
there's tons of those left over in life

402
00:17:02,000 --> 00:17:00,300
today to wait at that time all right all

403
00:17:04,429 --> 00:17:02,010
right so let's get back to this central

404
00:17:07,910 --> 00:17:04,439
dogma I'm not going to talk about this

405
00:17:10,809 --> 00:17:07,920
trend this transition going from DNA to

406
00:17:14,240 --> 00:17:10,819
RNA but it's called transcription it's

407
00:17:16,100 --> 00:17:14,250
performed mostly by protein enzymes but

408
00:17:18,770 --> 00:17:16,110
I am going to talk about translation

409
00:17:21,020 --> 00:17:18,780
which is exactly what it sounds like

410
00:17:23,809 --> 00:17:21,030
it's translating the genetic code into

411
00:17:25,370 --> 00:17:23,819
functional proteins so what is

412
00:17:28,640 --> 00:17:25,380
responsible for that because I just said

413
00:17:33,200 --> 00:17:28,650

is the ribosome it reads the messenger

414
00:17:34,610 --> 00:17:33,210
RNA and turns it into through the these

415
00:17:36,950 --> 00:17:34,620
other functional RNAs which are called

416
00:17:38,750 --> 00:17:36,960
transfer RNAs which carry the amino

417
00:17:42,860 --> 00:17:38,760
acids the building blocks of proteins to

418
00:17:46,820 --> 00:17:42,870
the ribosome they make in a coated and

419
00:17:50,380 --> 00:17:46,830
sort of logical way this peptide chain

420
00:17:57,470 --> 00:17:53,590
so I need to say about that for it now I

421
00:18:00,140 --> 00:17:57,480
have grossly oversimplified things for

422
00:18:02,810 --> 00:18:00,150
the purposes of time this is actually a

423
00:18:04,310 --> 00:18:02,820
little bit more in-depth what the sort

424
00:18:05,900 --> 00:18:04,320
of informational network of life looks

425
00:18:07,669 --> 00:18:05,910
like what I'm not going to give in to it

426
00:18:10,909 --> 00:18:07,679
we again we can talk heard it later if

427
00:18:13,700 --> 00:18:10,919
you want yeah but essentially you need

428
00:18:15,980 --> 00:18:13,710
to know that DNA said so goes to

429
00:18:17,960 --> 00:18:15,990
functional and informational roles both

430
00:18:19,520 --> 00:18:17,970
of those interact with proteins and then

431
00:18:22,669 --> 00:18:19,530
these functional networks are stuff like

432
00:18:24,380 --> 00:18:22,679
metabolism which is grossly complex but

433
00:18:26,690 --> 00:18:24,390
people are still going to try and

434
00:18:31,669 --> 00:18:26,700
explain to you today and I do not envy

435
00:18:33,529 --> 00:18:31,679
them that so once you've got proteins in

436
00:18:36,440 --> 00:18:33,539
life proteins evolved in a very

437
00:18:39,919 --> 00:18:36,450
interesting way where it's not in a lot

438
00:18:42,110 --> 00:18:39,929

of cases it's not you know really small

439
00:18:44,960 --> 00:18:42,120
changes especially probably early in

440
00:18:46,430 --> 00:18:44,970
evolution they evolve in modular ways so

441
00:18:48,289 --> 00:18:46,440
rather than having just you know you

442
00:18:50,330 --> 00:18:48,299
change one building block here one

443
00:18:55,789 --> 00:18:50,340
building block there they're kind of

444
00:19:00,320 --> 00:18:55,799
like I can't really use Lego because

445
00:19:03,110 --> 00:19:00,330
that's building blocks but essentially

446
00:19:05,360 --> 00:19:03,120
big globular chunks of proteins that

447
00:19:08,210 --> 00:19:05,370
sort of interchange with each other to

448
00:19:10,490 --> 00:19:08,220
give you different functions and

449
00:19:11,750 --> 00:19:10,500
different proteins so proteins are

450
00:19:13,820 --> 00:19:11,760
really interesting in that they can

451
00:19:15,440 --> 00:19:13,830
combine functions so if you know there's

452
00:19:17,480 --> 00:19:15,450
two functions that are kind of related

453
00:19:18,950 --> 00:19:17,490
at some point in evolution a lot of

454
00:19:21,710 --> 00:19:18,960
cases they'll say hey let's get together

455
00:19:23,659 --> 00:19:21,720
and we'll do this as one protein rather

456
00:19:25,430 --> 00:19:23,669
than two so that's kind of what I'm

457
00:19:27,440 --> 00:19:25,440
getting at in terms of the modular

458
00:19:29,450 --> 00:19:27,450
structure protein evolution so in this

459
00:19:31,010 --> 00:19:29,460
case you can see this enzyme called gtp

460
00:19:35,480 --> 00:19:31,020
hydrolase on both of these by the way

461
00:19:37,100 --> 00:19:35,490
our ribosome affiliated proteins so you

462
00:19:38,659 --> 00:19:37,110
can see kind of the general structure

463
00:19:41,510 --> 00:19:38,669

this is just a cartoon diagram that

464
00:19:43,370 --> 00:19:41,520
shows you the not all of the side chains

465
00:19:45,710 --> 00:19:43,380
but just the backbone confirmations of

466
00:19:47,899 --> 00:19:45,720
the protein but you can see here that

467
00:19:50,390 --> 00:19:47,909
this looks really similar to this which

468
00:19:52,460 --> 00:19:50,400
is also found associated with the

469
00:19:55,520 --> 00:19:52,470
ribosomes so you have these hela seas

470
00:20:00,830 --> 00:19:55,530
here and it has you know its own

471
00:20:03,260 --> 00:20:00,840
separate domains as well yes so enzymes

472
00:20:06,020 --> 00:20:03,270
today carry out most of the

473
00:20:09,080 --> 00:20:06,030
complex chemistry in the body through

474
00:20:11,450 --> 00:20:09,090
mechanisms like this where I'm not an

475
00:20:13,270 --> 00:20:11,460
organic chemist either but you know

476
00:20:20,050 --> 00:20:13,280
you're you're shuttling electrons around

477
00:20:22,370 --> 00:20:20,060
and yes so that is this is just one of

478
00:20:24,410 --> 00:20:22,380
millions and millions and millions of

479
00:20:26,660 --> 00:20:24,420
proteins that are active in life today

480
00:20:32,000 --> 00:20:26,670
in a network that looks something like

481
00:20:33,530 --> 00:20:32,010
this and again really complex not going

482
00:20:34,760 --> 00:20:33,540
to try and go into it too much but there

483
00:20:36,650 --> 00:20:34,770
is somebody today that's going to try

484
00:20:38,630 --> 00:20:36,660
and go into this part of it at least so

485
00:20:42,190 --> 00:20:38,640
this is amino acid amino acid

486
00:20:45,920 --> 00:20:42,200
biosynthesis which like I said in

487
00:20:48,560 --> 00:20:45,930
previous we probably had to do this

488
00:20:50,840 --> 00:20:48,570

abiotic lee but today we have you know

489
00:20:52,610 --> 00:20:50,850
tons of proteins that actually take over

490
00:20:57,260 --> 00:20:52,620
on this and make all the amino acids

491
00:20:59,480 --> 00:20:57,270
that put together life today at some

492
00:21:01,670 --> 00:20:59,490
point in all of this process pre Luca

493
00:21:04,730 --> 00:21:01,680
I'm not going to try and say when you

494
00:21:07,670 --> 00:21:04,740
had to have an event where the all these

495
00:21:10,520 --> 00:21:07,680
processes become compartmentalised so

496
00:21:11,930 --> 00:21:10,530
that it's basically when interesting

497
00:21:13,280 --> 00:21:11,940
things are happening you don't want them

498
00:21:15,230 --> 00:21:13,290
to float away you want them to stay

499
00:21:16,970 --> 00:21:15,240
nearby so that they can do more

500
00:21:20,870 --> 00:21:16,980
interesting things and stay near the

501
00:21:23,720 --> 00:21:20,880
other interesting molecules so this is

502
00:21:27,110 --> 00:21:23,730
just a simple vision of what's called a

503
00:21:29,600 --> 00:21:27,120
protocell which is a version of cell

504
00:21:32,690 --> 00:21:29,610
that is just really basic and that it

505
00:21:36,980 --> 00:21:32,700
only has like some really essential like

506
00:21:39,920 --> 00:21:36,990
replication and a few metabolic

507
00:21:41,690 --> 00:21:39,930
functions so yes so you can see just

508
00:21:43,310 --> 00:21:41,700
little tiny pieces of RNA in here that

509
00:21:44,900 --> 00:21:43,320
are encapsulated by like a lipid

510
00:21:47,900 --> 00:21:44,910
membrane pretty similar to what we have

511
00:21:50,090 --> 00:21:47,910
today so that's another thing that is

512
00:21:51,560 --> 00:21:50,100
pretty widely accepted to have happened

513
00:21:54,380 --> 00:21:51,570

before the last Universal common

514
00:21:58,970 --> 00:21:54,390
ancestor I think I'm getting to the end

515
00:22:00,470 --> 00:21:58,980
yes so in our history of evolution this

516
00:22:03,320 --> 00:22:00,480
is basically what I've tried to drive

517
00:22:04,850 --> 00:22:03,330
home to you today that you know we had

518
00:22:06,490 --> 00:22:04,860
all these processes that got us up to

519
00:22:08,600 --> 00:22:06,500
the last unit Universal common ancestor

520
00:22:10,070 --> 00:22:08,610
people are going to help fill in those

521
00:22:12,020 --> 00:22:10,080
some of those gaps today in their talks

522
00:22:14,480 --> 00:22:12,030
but that it was cellular

523
00:22:16,310 --> 00:22:14,490
compartmentalised that it probably had a

524
00:22:17,220 --> 00:22:16,320
DNA genome because DNA is more stable

525
00:22:20,370 --> 00:22:17,230
than RNA

526
00:22:24,960 --> 00:22:20,380
and the processes that are involved in

527
00:22:26,909 --> 00:22:24,970
turning DNA into RNA are very old we can

528
00:22:29,400 --> 00:22:26,919
tell based on the sequences of the

529
00:22:31,110 --> 00:22:29,410
proteins that they're similar enough in

530
00:22:32,730 --> 00:22:31,120
all of life that they probably came

531
00:22:34,830 --> 00:22:32,740
before life started branching off from

532
00:22:37,350 --> 00:22:34,840
each other had a sophisticated

533
00:22:40,740 --> 00:22:37,360
translation system so again that to get

534
00:22:42,690 --> 00:22:40,750
from the RNA to the protein and had a

535
00:22:45,600 --> 00:22:42,700
lot of genes but nowhere near the number

536
00:22:48,270 --> 00:22:45,610
that we have today so in the takeaway

537
00:22:50,130 --> 00:22:48,280
for this morning I just want you guys to

538
00:22:52,740 --> 00:22:50,140

remember the central dogma modern modern

539
00:22:57,780 --> 00:22:52,750
molecular biology and it did not hold

540
00:23:01,380 --> 00:22:57,790
true necessarily for you know millions

541
00:23:04,650 --> 00:23:01,390
or hundreds of millions of years in pre

542
00:23:07,650 --> 00:23:04,660
Luca where you go from DNA to RNA to

543
00:23:09,510 --> 00:23:07,660
functional protein pre biochemistry

544
00:23:10,919 --> 00:23:09,520
who's shown the feasibility of many that

545
00:23:14,000 --> 00:23:10,929
you can make many of life's building

546
00:23:17,730 --> 00:23:14,010
blocks with really simple compounds in

547
00:23:20,909 --> 00:23:17,740
earlier various different agreed-upon

548
00:23:22,830 --> 00:23:20,919
early earth conditions protein enzymes

549
00:23:24,510 --> 00:23:22,840
now fulfill most of the functional roles

550
00:23:26,070 --> 00:23:24,520
in life but RNA is still really

551
00:23:29,700 --> 00:23:26,080
important and that is kind of the idea

552
00:23:34,190 --> 00:23:29,710
of that RNA is a molecular fossil sort

553
00:23:37,320 --> 00:23:34,200
of left over from the RNA world and that

554
00:23:39,780 --> 00:23:37,330
the very in a pretty simple way the

555
00:23:41,430 --> 00:23:39,790
processes of that are common to all of

556
00:23:43,380 --> 00:23:41,440
life on earth were well established at

557
00:23:45,810 --> 00:23:43,390
the time of the last Universal common

558
00:23:51,510 --> 00:23:45,820
ancestor with that I will happily take

559
00:24:13,600 --> 00:24:10,630
wow I'm thirsty nothing okay Elena um

560
00:24:16,600 --> 00:24:13,610
mainly because of the the similarity of

561
00:24:18,460 --> 00:24:16,610
all life on earth there's so much so

562
00:24:20,350 --> 00:24:18,470
many genes that have really similar

563
00:24:21,460 --> 00:24:20,360

sequences that just the probabilities

564
00:24:23,940 --> 00:24:21,470
that they proud that they would have

565
00:24:26,470 --> 00:24:23,950
independently arose are just so small

566
00:24:27,820 --> 00:24:26,480
and not only in terms of sequences but

567
00:24:29,620 --> 00:24:27,830
in terms of structures so if you take

568
00:24:31,740 --> 00:24:29,630
the ribosome in particular and i'm using

569
00:24:35,020 --> 00:24:31,750
this solely because it's what I work on

570
00:24:43,120 --> 00:24:35,030
there are parts structurally if you

571
00:24:45,730 --> 00:24:43,130
overlay if you overlay the 3d structure

572
00:24:47,289 --> 00:24:45,740
molecular structure of an RKO ribosome

573
00:24:50,080 --> 00:24:47,299
with a bacterial ribosome there are

574
00:24:52,030 --> 00:24:50,090
parts of the core that are that have

575
00:24:53,560 --> 00:24:52,040
moved fractions of an angstrom in

576
00:24:55,390 --> 00:24:53,570
billions and billions of years of

577
00:24:56,890 --> 00:24:55,400
evolution so I'd say that's pretty good

578
00:24:59,770 --> 00:24:56,900
evidence that at some point they came

579
00:25:02,919 --> 00:24:59,780
from the same place that being said like

580
00:25:06,159 --> 00:25:02,929
said Luca is not one organism it's you

581
00:25:08,770 --> 00:25:06,169
know a bunch of communal organisms kind

582
00:25:10,299 --> 00:25:08,780
of living in a very hippie commune way

583
00:25:13,180 --> 00:25:10,309
where they're all sharing stuff back and

584
00:25:16,180 --> 00:25:13,190
forth you know so that they get to the

585
00:25:19,570 --> 00:25:16,190
point where at some point something gets

586
00:25:23,140 --> 00:25:19,580
a bit yeah so and then at some point

587
00:25:24,370 --> 00:25:23,150
some opportunist says I'm going off on

588
00:25:26,669 --> 00:25:24,380

my own and that's when you start getting

589
00:25:42,289 --> 00:25:26,679
these branches in the tree of life

590
00:25:55,019 --> 00:25:53,399
so oh so the question is if we did find

591
00:25:57,659 --> 00:25:55,029
life somewhere else on earth that just

592
00:26:00,960 --> 00:25:57,669
happened to have ribosomes and if they

593
00:26:03,810 --> 00:26:00,970
looked very similar to the ribosomes

594
00:26:05,580 --> 00:26:03,820
that we have on earth does that say that

595
00:26:08,460 --> 00:26:05,590
the ribosomes on earth might have

596
00:26:17,220 --> 00:26:08,470
independently originated rather than I

597
00:26:20,070 --> 00:26:17,230
guess that is an excellent question i

598
00:26:21,810 --> 00:26:20,080
mean there's there's multiple people

599
00:26:24,779 --> 00:26:21,820
right now that are trying to well

600
00:26:31,979 --> 00:26:24,789
actually yes so there's somebody that

601
00:26:34,369 --> 00:26:31,989
has made a very simple ribose RNA based

602
00:26:36,299 --> 00:26:34,379
system that is capable of transferring

603
00:26:39,060 --> 00:26:36,309
making peptide bonds which is

604
00:26:41,909 --> 00:26:39,070
essentially the job of the ribosome it's

605
00:26:44,070 --> 00:26:41,919
only about nine nucleotides really small

606
00:26:47,940 --> 00:26:44,080
with that case it was selected

607
00:26:50,279 --> 00:26:47,950
artificially in a lab so yeah I think

608
00:26:55,320 --> 00:26:50,289
it's entirely possible that there could

609
00:26:57,210 --> 00:26:55,330
be another kind of ribosome I would I'm

610
00:26:59,279 --> 00:26:57,220
skeptical i would say that if we found

611
00:27:02,129 --> 00:26:59,289
ribosomes that look really like the ones

612
00:27:04,499 --> 00:27:02,139
on earth i think that a ribosome could

613
00:27:06,869 --> 00:27:04,509

would probably independently arise

614
00:27:09,529 --> 00:27:06,879
somewhere else that was very different

615
00:27:12,029 --> 00:27:09,539
from what we have here i mean the the

616
00:27:15,269 --> 00:27:12,039
structural space that RNA is able the

617
00:27:19,950 --> 00:27:15,279
sample is just so massive you know

618
00:27:22,799 --> 00:27:19,960
there's yeah there's just way too many

619
00:27:25,950 --> 00:27:22,809
different confirmations that could that

620
00:27:28,099 --> 00:27:25,960
could form and i I'm sure that there are

621
00:27:30,840 --> 00:27:28,109
dozens if not hundreds of other

622
00:27:32,220 --> 00:27:30,850
confirmations that could make ribosome

623
00:27:34,139 --> 00:27:32,230
so ribosome is really interesting in

624
00:27:36,119 --> 00:27:34,149
that the way that it works today it

625
00:27:39,869 --> 00:27:36,129
doesn't work like any other enzyme in

626
00:27:41,849 --> 00:27:39,879
life all it's an entropy entropy trap it

627
00:27:44,279 --> 00:27:41,859
puts things in the right place so that

628
00:27:48,450 --> 00:27:44,289
the bonds can form between the amino

629
00:27:49,950 --> 00:27:48,460
acids on those tRNAs it it's very I

630
00:27:51,190 --> 00:27:49,960
would say it's pretty arguable whether

631
00:27:53,820 --> 00:27:51,200
or not the

632
00:27:58,750 --> 00:27:53,830
a ribosome actually has any chemical

633
00:28:00,430 --> 00:27:58,760
impact in that bond formation so I mean

634
00:28:01,720 --> 00:28:00,440
I think it's entirely possible that you

635
00:28:04,990 --> 00:28:01,730
could make a similar sort of entropy

636
00:28:27,940 --> 00:28:05,000
cage out of maybe something that isn't

637
00:28:29,980 --> 00:28:27,950
even RNA yes anybody um it's a really

638
00:28:32,379 --> 00:28:29,990

tough question so the question is is

639
00:28:34,720 --> 00:28:32,389
there a big energetic or is there any

640
00:28:37,379 --> 00:28:34,730
energetic advantage between the

641
00:28:39,220 --> 00:28:37,389
different isomers that life is chosen

642
00:28:40,779 --> 00:28:39,230
some people would say yes some people

643
00:28:43,450 --> 00:28:40,789
would say no some people would say if

644
00:28:45,759 --> 00:28:43,460
you can get a tiny tiny enantiomeric

645
00:28:47,379 --> 00:28:45,769
excess of one in some probiotic reaction

646
00:28:49,960 --> 00:28:47,389
or something like that that would be

647
00:28:54,810 --> 00:28:49,970
enough to take hold in over millions or

648
00:28:57,549 --> 00:28:54,820
billions of years would you would get

649
00:28:59,620 --> 00:28:57,559
yeah you would get home homogenous

650
00:29:01,389 --> 00:28:59,630
isomer incorporation and that's not to

651
00:29:04,600 --> 00:29:01,399
say that early in life we didn't have

652
00:29:10,590 --> 00:29:04,610
proteins that were made up of D&L amino

653
00:29:14,430 --> 00:29:10,600
acids or yeah D&L ribose sugars or

654
00:29:16,539 --> 00:29:14,440
whatever sugars were originally in RNA

655
00:29:18,700 --> 00:29:16,549
but the problem with that is that they

656
00:29:21,460 --> 00:29:18,710
wouldn't fold as regularly and so

657
00:29:25,269 --> 00:29:21,470
there's a definite advantage at least in

658
00:29:32,960 --> 00:29:25,279
terms of overall structure to having won

659
00:29:45,500 --> 00:29:42,049
oh yeah I'd say evolution is well in

660
00:29:49,130 --> 00:29:45,510
place by the time of Luca selection yeah

661
00:29:51,740 --> 00:29:49,140
pressures for sure it might not be

662
00:29:55,640 --> 00:29:51,750
exactly how we recognize evolution today

663
00:29:58,039 --> 00:29:55,650

but there's the idea of one of the

664
00:29:59,570 --> 00:29:58,049
really sort of most simple things that

665
00:30:01,549 --> 00:29:59,580
you need to get in place to get from

666
00:30:04,610 --> 00:30:01,559
simple life to complex life are

667
00:30:07,250 --> 00:30:04,620
replicators so probably some small piece

668
00:30:08,360 --> 00:30:07,260
of RNA well I say small me fifty or

669
00:30:10,520 --> 00:30:08,370
hundred nucleotides or something like

670
00:30:13,789 --> 00:30:10,530
that that's capable of making more of

671
00:30:16,370 --> 00:30:13,799
itself that is a huge advantage in terms

672
00:30:19,850 --> 00:30:16,380
of evolution you know we talk about

673
00:30:21,590 --> 00:30:19,860
evolution in terms of like I can run one

674
00:30:24,020 --> 00:30:21,600
percent faster than this guy kind of

675
00:30:26,750 --> 00:30:24,030
thing that's like you know ten thousand

676
00:30:28,549 --> 00:30:26,760
percent better performance and something

677
00:30:31,789 --> 00:30:28,559
like that is going to stick around a lot

678
00:30:34,580 --> 00:30:31,799
longer and just it's really evolution in

679
00:30:36,230 --> 00:30:34,590
an early life comes down to persistence

680
00:30:38,330 --> 00:30:36,240
more than anything how long you can

681
00:30:40,940 --> 00:30:38,340
stick around and how much more you can

682
00:30:57,470 --> 00:30:40,950
make of yourself that's my point of view

683
00:30:57,480 --> 00:31:08,530
so I guess my question

684
00:31:15,640 --> 00:31:14,320
that is a very tough question um yeah

685
00:31:19,410 --> 00:31:15,650
one I don't think I have a really good

686
00:31:22,930 --> 00:31:19,420
answer for its yeah it's really tricky

687
00:31:26,200 --> 00:31:22,940
if anybody has anything feel free I'm

688
00:31:32,500 --> 00:31:26,210

biochemist I all I know is that that's

689
00:31:35,950 --> 00:31:32,510
what we have now oh sorry so the

690
00:31:40,780 --> 00:31:35,960
question was if we did find life on Mars

691
00:31:43,630 --> 00:31:40,790
or elsewhere that also has d sugars and

692
00:31:44,530 --> 00:31:43,640
l-amino acids if we if that would mean

693
00:31:46,150 --> 00:31:44,540
that we could say that life

694
00:31:50,020 --> 00:31:46,160
independently arose twice in the

695
00:32:07,020 --> 00:31:50,030
universe and yeah and I don't have a

696
00:32:07,030 --> 00:32:15,730
you

697
00:32:20,110 --> 00:32:17,890
and there is something to the fact that

698
00:32:22,000 --> 00:32:20,120
I mean the rules of chemistry are the

699
00:32:23,470 --> 00:32:22,010
same everywhere in the universe I mean

700
00:32:24,490 --> 00:32:23,480
there's different environmental factors

701
00:32:28,570 --> 00:32:24,500
and stuff like that you have to take

702
00:32:32,890 --> 00:32:28,580
into account but so it depends on how

703
00:32:35,140 --> 00:32:32,900
much of it is chemical in origin and how

704
00:32:37,870 --> 00:32:35,150
much of it is biotic in origin how much

705
00:32:39,850 --> 00:32:37,880
of it is life that took hold and said

706
00:32:42,820 --> 00:32:39,860
hey let's just use these ones and how

707
00:32:44,919 --> 00:32:42,830
much of it is you know a tendency to

708
00:33:43,320 --> 00:32:44,929
create a biotic ly more of one than the

709
00:33:47,830 --> 00:33:45,850
there are some people who think that

710
00:33:49,660 --> 00:33:47,840
stuff like stellar radiation and that

711
00:33:51,820 --> 00:33:49,670
sort of thing could influence one in the

712
00:33:58,330 --> 00:33:51,830
other but I mean that's again way out of

713
00:33:59,620 --> 00:33:58,340

my yeah yeah exactly yeah so there are

714
00:34:01,510 --> 00:33:59,630
some people that think that the

715
00:34:03,160 --> 00:34:01,520
polarization polarized light in the

716
00:34:08,409 --> 00:34:03,170
stellar radiation might be enough to

717
00:34:12,010 --> 00:34:08,419
cause small tiny excesses in one isomer

718
00:34:14,290 --> 00:34:12,020
or the other so in that case yeah then

719
00:34:16,780 --> 00:34:14,300
maybe if something like that holds true

720
00:34:18,220 --> 00:34:16,790
and those excesses are enough that life

721
00:34:23,919 --> 00:34:18,230
takes hold of it and takes it to

722
00:34:31,210 --> 00:34:23,929
completion then then yeah perhaps you

723
00:34:42,830 --> 00:34:39,680
me too that's why we need those

724
00:34:44,379 --> 00:34:42,840
tortoises all right everybody do one

725
00:35:06,170 --> 00:34:44,389
more question we gotta move on to jen's

726
00:35:11,940 --> 00:35:09,660
yeah well I'm end yeah exactly if

727
00:35:14,610 --> 00:35:11,950
there's one thing that is on the side of

728
00:35:16,680 --> 00:35:14,620
the formation of life it's time you know

729
00:35:19,110 --> 00:35:16,690
we have tons of time to get stuff done

730
00:35:21,690 --> 00:35:19,120
so you can make the slowest process in

731
00:35:24,390 --> 00:35:21,700
the lab ever and as long as it you know

732
00:35:26,490 --> 00:35:24,400
still happens on a millions of your time

733
00:35:31,320 --> 00:35:26,500
scale it's still feasible in terms of

734
00:35:33,960 --> 00:35:31,330
the origins of life I think we got to

735
00:35:36,660 --> 00:35:33,970
keep going cuz Jen also has about a half

736
00:35:38,160 --> 00:35:36,670
hour worth of warm-up talk to give if