Ask An Astrobiologist

Episode 4: March 1st, 2017

Dr. George Cooper

NASA Astrobiology Program

1
00:00:00,510 --> 00:00:30,609
[Music]

2
00:00:35,180 --> 00:00:32,870
greetings friends of astrobiology

3
00:00:37,729 --> 00:00:35,190
welcome back to a new episode of ask an

4
00:00:39,740 --> 00:00:37,739
astrobiologist this program is the show

5
00:00:41,660 --> 00:00:39,750
of the websites a gannett org where we

6
00:00:44,270 --> 00:00:41,670
celebrate science diversity in science

7
00:00:45,920 --> 00:00:44,280
and scientists this program is made

8
00:00:49,130 --> 00:00:45,930
possible by contributions from the NASA

9
00:00:51,830 --> 00:00:49,140
Astrobiology program LC the earth Life

10
00:00:53,569 --> 00:00:51,840
Science Institute and a non profit blue

11
00:00:55,880 --> 00:00:53,579
marble space my name is Sandra um but

12
00:00:58,459 --> 00:00:55,890
before we start this is your a

13
00:01:00,080 --> 00:00:58,469

background quiz like every month so Mike

14
00:01:04,039 --> 00:01:00,090
if you could put up the background from

15
00:01:05,780 --> 00:01:04,049
last month it is actually if nobody got

16
00:01:07,880 --> 00:01:05,790
it right there was no suggestions for

17
00:01:10,219 --> 00:01:07,890
what it is I was asking you guys to kind

18
00:01:11,719 --> 00:01:10,229
of identify what the little mounds were

19
00:01:15,140 --> 00:01:11,729
on the bottom left of the image and

20
00:01:18,499 --> 00:01:15,150
those are actually modern stromatolites

21
00:01:21,109 --> 00:01:18,509
so those are microbial mats that grow up

22
00:01:23,030 --> 00:01:21,119
towards the the sunlight of course and

23
00:01:24,980 --> 00:01:23,040
they form mounds and they're the model

24
00:01:27,649 --> 00:01:24,990
there are modern analogs of some of the

25
00:01:29,840 --> 00:01:27,659
most ancient fossils of life we know on

26
00:01:31,910 --> 00:01:29,850
earth so the ones from the background

27
00:01:35,780 --> 00:01:31,920
from last month are in a biological

28
00:01:39,140 --> 00:01:35,790
reserve in Mexico called cuatro Sienna

29
00:01:41,210 --> 00:01:39,150
guess if I pronounced it right and some

30
00:01:43,429 --> 00:01:41,220
of the oldest ones we have found in the

31
00:01:46,520 --> 00:01:43,439
fossil record are over three and a half

32
00:01:48,889 --> 00:01:46,530
billion and that's was a be years old so

33
00:01:51,350 --> 00:01:48,899
really really ancient forms of life that

34
00:01:53,569 --> 00:01:51,360
are found today in analog environments

35
00:01:55,190 --> 00:01:53,579
so speaking of analog environments what

36
00:01:57,920 --> 00:01:55,200
is my background this month

37
00:02:00,530 --> 00:01:57,930
you can see this cold ice desert it's a

38
00:02:02,840 --> 00:02:00,540

location where scientists have gone to

39
00:02:04,459 --> 00:02:02,850
test instruments that are destined for

40
00:02:07,520 --> 00:02:04,469
Mars excavation so if you know the

41
00:02:09,740 --> 00:02:07,530
answer put it on a hashtag ask Astro bio

42
00:02:11,390 --> 00:02:09,750
on Twitter or on the Ziggy Network chat

43
00:02:12,260 --> 00:02:11,400
and we'll give you a shout out next

44
00:02:14,300 --> 00:02:12,270
month

45
00:02:16,460 --> 00:02:14,310
you get it right so speaking of very old

46
00:02:20,060 --> 00:02:16,470
stuff this month we're gonna talk about

47
00:02:22,670 --> 00:02:20,070
even older material meteorites and for

48
00:02:25,760 --> 00:02:22,680
that we are very lucky to welcome to the

49
00:02:27,710 --> 00:02:25,770
program dr. George Cooper who is a

50
00:02:30,110 --> 00:02:27,720
senior scientist in the exobiology

51
00:02:33,710 --> 00:02:30,120
branch at NASA Ames Research Center in

52
00:02:37,010 --> 00:02:33,720
California welcome George how are you Oh

53
00:02:39,230 --> 00:02:37,020
fine so enjoy Thanks and so like we like

54
00:02:41,420 --> 00:02:39,240
to do in this show we first rewind the

55
00:02:43,700 --> 00:02:41,430
wheels of time a little bit and now like

56
00:02:46,670 --> 00:02:43,710
to we are curious about how did young

57
00:02:51,970 --> 00:02:46,680
George emerge to being the scientist he

58
00:02:54,590 --> 00:02:51,980
is today well I you know hadn't really

59
00:02:59,720 --> 00:02:54,600
discovered scientists the science until

60
00:03:02,600 --> 00:02:59,730
basically you know college and just sort

61
00:03:05,270 --> 00:03:02,610
of fell in love with chemistry instead

62
00:03:07,970 --> 00:03:05,280
of you know other subjects an

63
00:03:12,050 --> 00:03:07,980

undergraduate and from what they are one

64
00:03:14,030 --> 00:03:12,060
thing led to another and so why choose

65
00:03:16,280 --> 00:03:14,040
meteorites chemistry is a very very

66
00:03:17,960 --> 00:03:16,290
broad discipline right so what got you

67
00:03:20,290 --> 00:03:17,970
interested in meteorites under their

68
00:03:23,540 --> 00:03:20,300
potential clues to the origin of life

69
00:03:28,010 --> 00:03:23,550
well in graduate school at Arizona State

70
00:03:30,290 --> 00:03:28,020
University my professor well my eventual

71
00:03:32,900 --> 00:03:30,300
professor major professor was John

72
00:03:37,430 --> 00:03:32,910
Cronin who maybe some people in the

73
00:03:40,520 --> 00:03:37,440
audience have heard of and the reason I

74
00:03:43,520 --> 00:03:40,530
ended up with him is that I always liked

75
00:03:46,790 --> 00:03:43,530
astronomy you know having the telescope

76
00:03:49,040 --> 00:03:46,800
and and you know things like that and

77
00:03:52,250 --> 00:03:49,050
like I said an undergraduate I like

78
00:03:54,650 --> 00:03:52,260
chemistry so it was trying to find an

79
00:03:57,590 --> 00:03:54,660
area of study in a graduate school that

80
00:04:00,500 --> 00:03:57,600
that sort of melded those two things

81
00:04:03,949 --> 00:04:00,510
together and you know he was the the

82
00:04:06,890 --> 00:04:03,959
perfect person because you know

83
00:04:09,500 --> 00:04:06,900
meteorites undoubtedly you cannot talk

84
00:04:12,590 --> 00:04:09,510
meteorites without talking astronomy and

85
00:04:14,060 --> 00:04:12,600
the solar system and at the same time is

86
00:04:19,640 --> 00:04:14,070
you know the work is basically

87
00:04:22,700 --> 00:04:19,650
analytical chemistry so you know I would

88
00:04:24,830 --> 00:04:22,710

say you know John Cronin and and then

89
00:04:25,670 --> 00:04:24,840
there's the Arizona State University me

90
00:04:28,180 --> 00:04:25,680
right center

91
00:04:31,370 --> 00:04:28,190
I think the world's largest university

92
00:04:34,610 --> 00:04:31,380
meteorite center so it sort of came

93
00:04:36,560 --> 00:04:34,620
together from there it's very exciting

94
00:04:38,450 --> 00:04:36,570
you're it's clear that your natural

95
00:04:41,540 --> 00:04:38,460
biology is of interests from astronomy

96
00:04:44,390 --> 00:04:41,550
and chemistry merging to guide your

97
00:04:46,129 --> 00:04:44,400
field of research today so let's let's

98
00:04:47,930 --> 00:04:46,139
let's talk about first about meteorites

99
00:04:49,219 --> 00:04:47,940
could you describe to us what they are

100
00:04:50,450 --> 00:04:49,229
how different they are you know they're

101
00:04:52,070 --> 00:04:50,460
iron meteorites they're chondritic

102
00:04:54,650 --> 00:04:52,080
meteorites what are the two differences

103
00:04:55,850 --> 00:04:54,660
and what they form and why is one of

104
00:04:56,770 --> 00:04:55,860
those important to study in the first

105
00:05:00,439 --> 00:04:56,780
place

106
00:05:03,740 --> 00:05:00,449
well the astronomers would take you back

107
00:05:06,890 --> 00:05:03,750
to the beginning of the solar system and

108
00:05:10,730 --> 00:05:06,900
now they have photos actual photos of

109
00:05:14,589 --> 00:05:10,740
other forming planetary systems that you

110
00:05:17,839 --> 00:05:14,599
know form out of rock dust gas and

111
00:05:22,670 --> 00:05:17,849
coalesce into larger bodies planets

112
00:05:24,650 --> 00:05:22,680
comets asteroids saw the the meteorites

113
00:05:27,710 --> 00:05:24,660

that I study or when when most people

114
00:05:30,490 --> 00:05:27,720
say the word meteorite they're usually

115
00:05:34,250 --> 00:05:30,500
thinking of asteroid old meteorites so

116
00:05:37,790 --> 00:05:34,260
asteroids like comets are leftover bits

117
00:05:42,230 --> 00:05:37,800
of planet toys that didn't inform the

118
00:05:44,719 --> 00:05:42,240
larger planets like Earth so comets

119
00:05:48,950 --> 00:05:44,729
you could have meteorites from comets

120
00:05:50,659 --> 00:05:48,960
also but I think the historical problem

121
00:05:52,820 --> 00:05:50,669
is if he picked one up you wouldn't know

122
00:05:55,730 --> 00:05:52,830
whether it was a comet meteorite or an

123
00:06:00,080 --> 00:05:55,740
asteroid meteorite but the meteorites we

124
00:06:06,680 --> 00:06:00,090
do have appear to match the spectra of

125
00:06:09,370 --> 00:06:06,690
of asteroids so right now carbonaceous

126
00:06:12,620 --> 00:06:09,380
meteorites in particular are pretty much

127
00:06:16,339 --> 00:06:12,630
almost all that scientists know how

128
00:06:18,170 --> 00:06:16,349
probably came from the asteroid belt you

129
00:06:22,310 --> 00:06:18,180
know from the initial formation of the

130
00:06:24,620 --> 00:06:22,320
solar system so the the organic

131
00:06:27,830 --> 00:06:24,630
chemistry that's happening in meteorites

132
00:06:29,570 --> 00:06:27,840
is not something that happens once the

133
00:06:30,980 --> 00:06:29,580
meteorites have arrived on earth right

134
00:06:34,010 --> 00:06:30,990
there's organic chemistry that can

135
00:06:35,870 --> 00:06:34,020
happen if the meteorites have ice when

136
00:06:38,980 --> 00:06:35,880
they are in the far away solar system

137
00:06:43,360 --> 00:06:38,990
right and Eve

138
00:06:45,130 --> 00:06:43,370

before the the bodies of the asteroid

139
00:06:49,510 --> 00:06:45,140
the parent bodies of the meteorites

140
00:06:51,970 --> 00:06:49,520
formed people here for example here but

141
00:06:54,550 --> 00:06:51,980
you know over the years and enlightened

142
00:06:56,560 --> 00:06:54,560
have shown that on the interstellar

143
00:07:00,100 --> 00:06:56,570
grains the grains that eventually

144
00:07:02,890 --> 00:07:00,110
coalesced to become asteroids and comets

145
00:07:04,900 --> 00:07:02,900
even there you have chemistry taking

146
00:07:08,710 --> 00:07:04,910
place you have carbon oxygen nitrogen

147
00:07:13,720 --> 00:07:08,720
and a source of energy photons radiation

148
00:07:16,900 --> 00:07:13,730
so organics are even made before then

149
00:07:18,760 --> 00:07:16,910
there's a big group here at Ames the

150
00:07:21,940 --> 00:07:18,770
Scott Sanford Lou El Mundo LaMichael

151
00:07:26,110 --> 00:07:21,950
nuevo who do this you know all the time

152
00:07:28,180 --> 00:07:26,120
they they form organics simulating the

153
00:07:30,790 --> 00:07:28,190
conditions of interstellar greenies 50

154
00:07:33,940 --> 00:07:30,800
degrees above absolute zero things like

155
00:07:36,780 --> 00:07:33,950
that so that's probably I would say

156
00:07:40,270 --> 00:07:36,790
where the the initial organics are

157
00:07:43,390 --> 00:07:40,280
formed eventually to be in the rocks we

158
00:07:45,610 --> 00:07:43,400
have in the lab but after that you know

159
00:07:47,710 --> 00:07:45,620
the grains as I say they coalesce and

160
00:07:50,620 --> 00:07:47,720
there's further chemistry once that

161
00:07:52,450 --> 00:07:50,630
water warms up more if you have

162
00:07:55,420 --> 00:07:52,460
chemicals in water you're going to get

163
00:07:58,330 --> 00:07:55,430

more chemistry so for example glycine

164
00:08:03,340 --> 00:07:58,340
the smallest amino acid easily formed

165
00:08:06,250 --> 00:08:03,350
from from aldehyde suck night you know a

166
00:08:08,620 --> 00:08:06,260
few other couple other things they're

167
00:08:11,500 --> 00:08:08,630
all seen in interstellar space all the

168
00:08:15,490 --> 00:08:11,510
chemicals that amino acids and therefore

169
00:08:18,010 --> 00:08:15,500
us we're made of are out there so once

170
00:08:20,410 --> 00:08:18,020
they land on freeze out on these grains

171
00:08:24,190 --> 00:08:20,420
from aldehyde cyanide aldehydes and

172
00:08:26,410 --> 00:08:24,200
ketones once they form on the grains as

173
00:08:28,750 --> 00:08:26,420
I said before there's chemistry when

174
00:08:30,760 --> 00:08:28,760
they warm up incorporate into larger

175
00:08:34,630 --> 00:08:30,770
asteroids as evidence for aqueous

176
00:08:39,430 --> 00:08:34,640
alteration there - so - I would say

177
00:08:41,860 --> 00:08:39,440
primary sites for organic formation so

178
00:08:44,380 --> 00:08:41,870
we are really a legal structure of

179
00:08:46,480 --> 00:08:44,390
organic chemistry and it if some of

180
00:08:49,030 --> 00:08:46,490
those fundamental organic compounds came

181
00:08:50,470 --> 00:08:49,040
from meteorites which are not formed on

182
00:08:51,800 --> 00:08:50,480
earth but formed in the early solar

183
00:08:53,570 --> 00:08:51,810
system that really

184
00:08:57,620 --> 00:08:53,580
means that we are Stardust which is

185
00:09:01,670 --> 00:08:57,630
quite humbling I think right so that's

186
00:09:04,940 --> 00:09:01,680
this oh no go ahead sorry yeah that

187
00:09:07,760 --> 00:09:04,950
that's you know the same chemicals or

188
00:09:11,450 --> 00:09:07,770

strana mercy wherever they look in the

189
00:09:14,840 --> 00:09:11,460
universe so you know which which is a

190
00:09:20,030 --> 00:09:14,850
good sign for potential life in other

191
00:09:23,510 --> 00:09:20,040
places us so so life could have been if

192
00:09:24,920 --> 00:09:23,520
life exists on on Mars and elsewhere of

193
00:09:28,210 --> 00:09:24,930
course you have no confirmation of that

194
00:09:30,980 --> 00:09:28,220
but those early those planets were also

195
00:09:33,050 --> 00:09:30,990
subjected to the same early bombardment

196
00:09:35,930 --> 00:09:33,060
as Earth and therefore they also or

197
00:09:37,430 --> 00:09:35,940
contributed organic material so in your

198
00:09:40,400 --> 00:09:37,440
view it's possible given the right

199
00:09:42,800 --> 00:09:40,410
circumstances and it's a big if that

200
00:09:44,920 --> 00:09:42,810
that life could have emerged on other

201
00:09:48,410 --> 00:09:44,930
bodies other than Earth of course oh

202
00:09:52,790 --> 00:09:48,420
yeah yeah of course even Mars last year

203
00:09:55,820 --> 00:09:52,800
I think 2015 maybe it was the finding of

204
00:09:59,060 --> 00:09:55,830
organics on the surface by the Rovers

205
00:10:03,470 --> 00:09:59,070
and the paper I think it was journal

206
00:10:07,120 --> 00:10:03,480
Geophysical Research a big group said

207
00:10:11,840 --> 00:10:07,130
that well the organics that were finding

208
00:10:17,720 --> 00:10:11,850
could probably either meteoritic or from

209
00:10:20,300 --> 00:10:17,730
some indigenous Mars process um so sings

210
00:10:22,910 --> 00:10:20,310
as I say at how the astronomers see

211
00:10:25,370 --> 00:10:22,920
these compounds every place they look

212
00:10:27,200 --> 00:10:25,380
and now obviously land on Earth every

213
00:10:32,030 --> 00:10:27,210

day or we wouldn't have them in the

214
00:10:34,550 --> 00:10:32,040
rocks in our labs but now on Mars years

215
00:10:38,180 --> 00:10:34,560
ago we saw a comet crashing into Jupiter

216
00:10:40,940 --> 00:10:38,190
so yes the potential in addition to the

217
00:10:43,550 --> 00:10:40,950
meteorite organics you know the further

218
00:10:46,730 --> 00:10:43,560
chemistry on earth or maybe some also

219
00:10:50,000 --> 00:10:46,740
indigenous earth compounds so yeah I

220
00:10:53,150 --> 00:10:50,010
think that's a great potential you know

221
00:10:55,010 --> 00:10:53,160
all their life so all life potential

222
00:10:57,410 --> 00:10:55,020
life in the solar system is shopping for

223
00:11:03,980 --> 00:10:57,420
organic matter at the same grocery store

224
00:11:05,910 --> 00:11:03,990
right so how does one find meteorites on

225
00:11:10,620 --> 00:11:05,920
earth and how do you differentiate

226
00:11:15,180 --> 00:11:10,630
from other rocks well the there are big

227
00:11:19,639 --> 00:11:15,190
groups for example that go to the Arctic

228
00:11:22,110 --> 00:11:19,649
and an ice-covered you know snow-covered

229
00:11:25,139 --> 00:11:22,120
backgrounds like the one behind you

230
00:11:27,199 --> 00:11:25,149
exactly I've seen some of the pictures

231
00:11:30,180 --> 00:11:27,209
and they're pretty easy to spot most

232
00:11:33,389 --> 00:11:30,190
meteorites are you know darkish and it

233
00:11:36,210 --> 00:11:33,399
gets the snow you know you could rather

234
00:11:39,449 --> 00:11:36,220
readily pick them out but also you know

235
00:11:42,030 --> 00:11:39,459
they're seen to fall and a lot of places

236
00:11:43,949 --> 00:11:42,040
and if you're careful and follow the

237
00:11:46,889 --> 00:11:43,959
trajectory you can find them yourself

238
00:11:49,079 --> 00:11:46,899

for example the Murchison meteorite the

239
00:11:52,920 --> 00:11:49,089
most famous was found in Murchison

240
00:11:57,900 --> 00:11:52,930
Australia in 1969 and people saw it fall

241
00:12:01,590 --> 00:11:57,910
and saw a big debris field so that's the

242
00:12:05,850 --> 00:12:01,600
the major you know type of discoveries

243
00:12:08,579 --> 00:12:05,860
Antarctic lucky fine they're transported

244
00:12:11,150 --> 00:12:08,589
to museums most of them you know ones

245
00:12:15,350 --> 00:12:11,160
that aren't privately found and

246
00:12:18,689 --> 00:12:15,360
scientists me and others can request

247
00:12:20,970 --> 00:12:18,699
from museums or Antarctic meteorites

248
00:12:24,180 --> 00:12:20,980
again from say to Johnson Space Center

249
00:12:27,720 --> 00:12:24,190
you know which has a huge collection so

250
00:12:32,220 --> 00:12:27,730
those are the major ways to to get them

251
00:12:34,590 --> 00:12:32,230
for scientific research so you have

252
00:12:36,329 --> 00:12:34,600
actively worked on the Murchison

253
00:12:37,710 --> 00:12:36,339
meteorite itself which is just really

254
00:12:39,509 --> 00:12:37,720
cool could you tell us a little bit

255
00:12:42,240 --> 00:12:39,519
about how you feel when you receive a

256
00:12:43,710 --> 00:12:42,250
sample that's as famous as the Murchison

257
00:12:45,300 --> 00:12:43,720
perhaps you can describe to us also why

258
00:12:47,910 --> 00:12:45,310
famous and like what goes through your

259
00:12:51,780 --> 00:12:47,920
mind when you hold this rock that's 4.6

260
00:12:54,269 --> 00:12:51,790
billion years old well we had an

261
00:12:57,809 --> 00:12:54,279
outreach the other day with students

262
00:13:00,240 --> 00:12:57,819
from one of the high schools local some

263
00:13:03,180 --> 00:13:00,250

were sort of local high schools and I

264
00:13:05,129 --> 00:13:03,190
had powder that you know it's no longer

265
00:13:08,040 --> 00:13:05,139
useful research meteorite powder that we

266
00:13:12,439 --> 00:13:08,050
grind up and extract out the organics

267
00:13:15,569 --> 00:13:12,449
but what I did was let them smell it

268
00:13:17,160 --> 00:13:15,579
because if you shake it the particles

269
00:13:19,379 --> 00:13:17,170
are still breaking down too

270
00:13:23,460 --> 00:13:19,389
des and the original gases from the

271
00:13:25,590 --> 00:13:23,470
solar system come out and and most

272
00:13:27,960 --> 00:13:25,600
students says sort of smells like dirt

273
00:13:31,949 --> 00:13:27,970
and maybe wet dirt in the country when

274
00:13:35,269 --> 00:13:31,959
you walk walk along the road but the

275
00:13:37,620 --> 00:13:35,279
feeling you mentioned you know is still

276
00:13:40,949 --> 00:13:37,630
something else too to think that you're

277
00:13:43,379 --> 00:13:40,959
actually looking at smelling things that

278
00:13:47,790 --> 00:13:43,389
are for point they're actually closer to

279
00:13:49,500 --> 00:13:47,800
four point six years old so and then

280
00:13:52,500 --> 00:13:49,510
it's a process of extracting out

281
00:13:56,189 --> 00:13:52,510
organics and with normal analytical

282
00:13:59,819 --> 00:13:56,199
chemistry means and now it's ours

283
00:14:03,480 --> 00:13:59,829
Murchison the reason is I would say more

284
00:14:06,389 --> 00:14:03,490
famous is because when it fell in 69

285
00:14:08,579 --> 00:14:06,399
there have been meteorites of course a

286
00:14:11,879 --> 00:14:08,589
long time before that and there had been

287
00:14:18,000 --> 00:14:11,889
analysis before that but mostly they

288
00:14:19,800 --> 00:14:18,010

were very contaminated so of course the

289
00:14:22,560 --> 00:14:19,810
earlier people had found some indigenous

290
00:14:25,620 --> 00:14:22,570
compounds but a lot were just earthly

291
00:14:28,019 --> 00:14:25,630
contaminants Murchison as I said a few

292
00:14:32,490 --> 00:14:28,029
minutes ago it was actually seen to fall

293
00:14:35,069 --> 00:14:32,500
and picked up very quickly and on top of

294
00:14:41,400 --> 00:14:35,079
that it had many many organic compounds

295
00:14:45,509 --> 00:14:41,410
so it sort of stood out right away and

296
00:14:47,970 --> 00:14:45,519
and and the analysis began and you know

297
00:14:50,069 --> 00:14:47,980
people discovered amino acids in it and

298
00:14:52,319 --> 00:14:50,079
you know the older meteorites were

299
00:14:54,600 --> 00:14:52,329
thought also to have amino acids but

300
00:14:57,360 --> 00:14:54,610
again that contamination problem so

301
00:14:59,910 --> 00:14:57,370
Murchison sort of settled that you know

302
00:15:03,660 --> 00:14:59,920
that question wasn't for all and that's

303
00:15:05,340 --> 00:15:03,670
why is the more famous so you bring up a

304
00:15:07,439 --> 00:15:05,350
good point in a sense that earth is

305
00:15:10,920 --> 00:15:07,449
covered with biology right so if a rock

306
00:15:12,480 --> 00:15:10,930
from space falls on the planet then the

307
00:15:15,030 --> 00:15:12,490
biology does near it could contaminate

308
00:15:17,129 --> 00:15:15,040
it and so how are we sure that these

309
00:15:18,990 --> 00:15:17,139
organic matter that we find in

310
00:15:22,110 --> 00:15:19,000
meteorites are not actually just earth

311
00:15:24,629 --> 00:15:22,120
contaminating the rock right right and

312
00:15:25,710 --> 00:15:24,639
there there's in almost every meteorite

313
00:15:28,079 --> 00:15:25,720

I've looked at there's earth

314
00:15:30,809 --> 00:15:28,089
contamination at least you know some

315
00:15:34,650 --> 00:15:30,819
there's one that's you know very clean

316
00:15:37,110 --> 00:15:34,660
but most right life loves to any carbon

317
00:15:39,660 --> 00:15:37,120
source so the way people have

318
00:15:44,850 --> 00:15:39,670
discriminated against indigenous versus

319
00:15:47,819 --> 00:15:44,860
you know contamination one of the

320
00:15:50,040 --> 00:15:47,829
principal methods was isotopes and

321
00:15:52,620 --> 00:15:50,050
people watching probably you know

322
00:15:54,990 --> 00:15:52,630
loosely heard of isotopes different

323
00:15:56,819 --> 00:15:55,000
weights of the same compounds so for

324
00:15:59,309 --> 00:15:56,829
example carbon most carbon in nature's

325
00:16:02,370 --> 00:15:59,319
twelve ways twelve on the periodic table

326
00:16:05,400 --> 00:16:02,380
there's a little bit of carbon 13 I

327
00:16:09,090 --> 00:16:05,410
think around 1% or you know forget the

328
00:16:10,920 --> 00:16:09,100
exact number so with mass spectrometer

329
00:16:14,340 --> 00:16:10,930
is very sensitive mass spectrometers

330
00:16:18,030 --> 00:16:14,350
it's quite easy to tell if let's say the

331
00:16:21,540 --> 00:16:18,040
the carbon and glycine has the earth

332
00:16:26,400 --> 00:16:21,550
ratio of carbon-13 to carbon-12

333
00:16:31,340 --> 00:16:26,410
or if it's higher relatively in carbon

334
00:16:34,769 --> 00:16:31,350
13 then 12 to 12 and that tells you

335
00:16:38,069 --> 00:16:34,779
right away that is not from earth

336
00:16:41,579 --> 00:16:38,079
geochemist are very good even with only

337
00:16:43,590 --> 00:16:41,589
earthly samples they can take isotope

338
00:16:46,410 --> 00:16:43,600

measurements let's say of a rock in

339
00:16:48,929 --> 00:16:46,420
California or a rock in India and in

340
00:16:51,329 --> 00:16:48,939
some cases tell you what countries from

341
00:16:53,130 --> 00:16:51,339
or what region rather is from simply by

342
00:16:57,449 --> 00:16:53,140
the isotopes and how it was made

343
00:17:00,449 --> 00:16:57,459
so the astronomers see that in space

344
00:17:02,870 --> 00:17:00,459
many compounds are fractionated that is

345
00:17:05,909 --> 00:17:02,880
these organics I mentioned a while ago

346
00:17:08,880 --> 00:17:05,919
many are higher in the heavier isotopes

347
00:17:10,799 --> 00:17:08,890
of carbon hydrogen nitrogen so when

348
00:17:12,689 --> 00:17:10,809
they're corporated again into the parent

349
00:17:16,020 --> 00:17:12,699
bodies of the asteroids fall to earth as

350
00:17:18,120 --> 00:17:16,030
meteorites that signature a good deal of

351
00:17:21,299 --> 00:17:18,130
it is still there so that's that's

352
00:17:23,760 --> 00:17:21,309
number one the the the second best ways

353
00:17:26,960 --> 00:17:23,770
in some cases just as good is to look

354
00:17:31,470 --> 00:17:26,970
for organics that aren't used in biology

355
00:17:34,980 --> 00:17:31,480
and that's what people have done a lot

356
00:17:37,560 --> 00:17:34,990
since since Murchison look for strange

357
00:17:39,420 --> 00:17:37,570
amino acids because you know asteroids

358
00:17:43,140 --> 00:17:39,430
wasn't a biological process

359
00:17:46,620 --> 00:17:43,150
it would make glycine with two carbons

360
00:17:49,110 --> 00:17:46,630
all the way up to the the space

361
00:17:52,290 --> 00:17:49,120
processes a biotic non-biological

362
00:17:55,950 --> 00:17:52,300
process would make from carbon number

363
00:17:58,350 --> 00:17:55,960

two to carbon 15 four amino acids it's

364
00:18:02,210 --> 00:17:58,360
just thermodynamics whereas life on

365
00:18:06,120 --> 00:18:02,220
earth uses very specific amino acids

366
00:18:08,610 --> 00:18:06,130
very specific weights life your body

367
00:18:11,880 --> 00:18:08,620
bacteria doesn't want to make you know

368
00:18:14,760 --> 00:18:11,890
every possible isomer of a compound up

369
00:18:15,180 --> 00:18:14,770
to c10 there's simply that's a waste of

370
00:18:17,520 --> 00:18:15,190
energy

371
00:18:20,310 --> 00:18:17,530
but again the ape and the non-biological

372
00:18:24,930 --> 00:18:20,320
abiotic processing asteroids probably

373
00:18:27,720 --> 00:18:24,940
comments make all including weird ones

374
00:18:30,840 --> 00:18:27,730
not used so that's how you tell if it's

375
00:18:34,260 --> 00:18:30,850
really from spaces non-biological

376
00:18:36,090 --> 00:18:34,270
compounds that's so cool so meteorites

377
00:18:38,610 --> 00:18:36,100
are really the history book of the solar

378
00:18:40,020 --> 00:18:38,620
system and you and your colleagues learn

379
00:18:42,030 --> 00:18:40,030
the language of the rocks to really

380
00:18:43,290 --> 00:18:42,040
extract the story of that means of that

381
00:18:45,750 --> 00:18:43,300
means of what that means for the

382
00:18:47,820 --> 00:18:45,760
formation of planets but also for the

383
00:18:50,010 --> 00:18:47,830
origin of life which it's just a

384
00:18:52,020 --> 00:18:50,020
fascinating field many years ago I was

385
00:18:53,970 --> 00:18:52,030
lucky enough to be in Washington DC and

386
00:18:56,160 --> 00:18:53,980
was visiting the meteorite collection

387
00:18:59,670 --> 00:18:56,170
you were talking about and I held in my

388
00:19:01,890 --> 00:18:59,680

hand a alh84001 which is like them the

389
00:19:04,680 --> 00:19:01,900
meteorite that we know came from Mars

390
00:19:06,150 --> 00:19:04,690
and so there's not only meteorites that

391
00:19:07,860 --> 00:19:06,160
come from far beyond in terms of

392
00:19:09,480 --> 00:19:07,870
asteroids that feed the earth but also

393
00:19:12,390 --> 00:19:09,490
the different planets are exchanging

394
00:19:14,340 --> 00:19:12,400
rocks with with each other and have you

395
00:19:19,680 --> 00:19:14,350
worked with a Martian or even lunar

396
00:19:23,220 --> 00:19:19,690
samples no not what the alh you

397
00:19:26,040 --> 00:19:23,230
mentioned or nor moon rocks

398
00:19:31,260 --> 00:19:26,050
my research is problem primarily the

399
00:19:34,410 --> 00:19:31,270
asteroid 'el meteorites okay yeah and

400
00:19:35,760 --> 00:19:34,420
the fact that the rocks can transfer

401
00:19:37,650 --> 00:19:35,770
between planets is also I found

402
00:19:39,330 --> 00:19:37,660
mesmerizing because he can tell some

403
00:19:41,280 --> 00:19:39,340
some stories about the Martian

404
00:19:43,830 --> 00:19:41,290
atmosphere is from the atmosphere that's

405
00:19:45,360 --> 00:19:43,840
trapped in bubbles in that form on Mars

406
00:19:46,680 --> 00:19:45,370
and that rock was transported to earth

407
00:19:49,140 --> 00:19:46,690
from which you can analyze using the

408
00:19:51,180 --> 00:19:49,150
tools if such used you're mentioned so

409
00:19:52,580 --> 00:19:51,190
just really cool analytical techniques

410
00:19:54,620 --> 00:19:52,590
and the precision you need to make

411
00:19:55,789 --> 00:19:54,630
conclusion is incredible I was also

412
00:19:57,799 --> 00:19:55,799
quite amazed to hear about your

413
00:20:01,190 --> 00:19:57,809

colleagues that simulates the radiation

414
00:20:02,960 --> 00:20:01,200
the solar radiation inside the

415
00:20:04,610 --> 00:20:02,970
laboratory to create the conditions that

416
00:20:06,529 --> 00:20:04,620
leads to the development of organic

417
00:20:10,039 --> 00:20:06,539
matter that then you can take in the

418
00:20:11,659 --> 00:20:10,049
laboratory using your techniques to see

419
00:20:14,360 --> 00:20:11,669
what's there and then does that conform

420
00:20:16,190 --> 00:20:14,370
with what we can expect so Wow it's a

421
00:20:19,010 --> 00:20:16,200
really cool stuff when you were a

422
00:20:20,210 --> 00:20:19,020
student I'm sure is it's like all of us

423
00:20:21,740 --> 00:20:20,220
have been through college it's kind of

424
00:20:24,289 --> 00:20:21,750
it's not an easy path to navigate

425
00:20:25,730 --> 00:20:24,299
especially when you're after a PhD I was

426
00:20:27,830 --> 00:20:25,740
wondering if you benefited from from

427
00:20:29,930 --> 00:20:27,840
mentors in that process and any people

428
00:20:33,380 --> 00:20:29,940
that contributed that helped you out to

429
00:20:36,740 --> 00:20:33,390
become the scientist you are today

430
00:20:40,100 --> 00:20:36,750
well again graduate school you're your

431
00:20:44,810 --> 00:20:40,110
best mentor is going to be your

432
00:20:49,700 --> 00:20:44,820
professor undergraduate you know you you

433
00:20:51,560 --> 00:20:49,710
do have of course you know professors

434
00:20:54,560 --> 00:20:51,570
that you're some you're closer to than

435
00:20:57,380 --> 00:20:54,570
others and of course you know there's

436
00:21:00,980 --> 00:20:57,390
there's always help along the way but

437
00:21:03,799 --> 00:21:00,990
for getting settled in your particular

438
00:21:05,120 --> 00:21:03,809

field and for example the organic

439
00:21:07,730 --> 00:21:05,130
analysis of meteorites were talking

440
00:21:10,730 --> 00:21:07,740
about now the major professor graduate

441
00:21:15,380 --> 00:21:10,740
school is I would say the chief mentor

442
00:21:18,950 --> 00:21:15,390
and so I I was lucky I had the what I

443
00:21:21,470 --> 00:21:18,960
call a professor's professor and John

444
00:21:23,899 --> 00:21:21,480
Cronin who you know took his work very

445
00:21:25,990 --> 00:21:23,909
seriously and he you know it's sit there

446
00:21:28,789 --> 00:21:26,000
all day and get every I dotted

447
00:21:33,889 --> 00:21:28,799
everything would be correct when he got

448
00:21:36,409 --> 00:21:33,899
up so I would you know say that you know

449
00:21:39,260 --> 00:21:36,419
mentor wise but you know it's the host

450
00:21:42,649 --> 00:21:39,270
at ASU them the Stars being in

451
00:21:45,889 --> 00:21:42,659
meteorites you know you had his postdoc

452
00:21:48,080 --> 00:21:45,899
there Santa Pizza reloj you had the the

453
00:21:52,100 --> 00:21:48,090
ASU meteorite Center with you know

454
00:21:54,380 --> 00:21:52,110
Carlton Moore and other people there who

455
00:21:58,010 --> 00:21:54,390
this was serious business for them you

456
00:22:01,370 --> 00:21:58,020
know so that that always affects you

457
00:22:03,620 --> 00:22:01,380
know as a student as you probably as as

458
00:22:05,169 --> 00:22:03,630
you probably know you know so it's the

459
00:22:07,690 --> 00:22:05,179
whole

460
00:22:10,000 --> 00:22:07,700
community of meteorite people in my case

461
00:22:14,020 --> 00:22:10,010
organic you know analysis of meteorite

462
00:22:16,180 --> 00:22:14,030
group so what did you do after you

463
00:22:20,860 --> 00:22:16,190

finished your PhD who is this expertise

464
00:22:23,440 --> 00:22:20,870
in meteorite studies well I was came to

465
00:22:26,980 --> 00:22:23,450
Ames as a postdoc for sure what change

466
00:22:30,100 --> 00:22:26,990
and it was one of the founders of you

467
00:22:33,370 --> 00:22:30,110
know astrobiology he really worked for

468
00:22:36,820 --> 00:22:33,380
years to to focus research get funding

469
00:22:39,130 --> 00:22:36,830
for research and he was the branch chief

470
00:22:42,760 --> 00:22:39,140
at that time of the exobiology branch

471
00:22:47,169 --> 00:22:42,770
here and he retired years ago so I was

472
00:22:52,180 --> 00:22:47,179
his postdoc and so a few years postdoc

473
00:22:54,580 --> 00:22:52,190
and then a position came open I was

474
00:22:58,930 --> 00:22:54,590
lucky to get the the research scientist

475
00:23:05,710 --> 00:22:58,940
position here so that was pretty much to

476
00:23:11,350 --> 00:23:05,720
the trail from graduate school and let's

477
00:23:13,810 --> 00:23:11,360
see so the environment the academic

478
00:23:16,350 --> 00:23:13,820
environment is one that is changing and

479
00:23:19,750 --> 00:23:16,360
I was wondering if you have any

480
00:23:23,110 --> 00:23:19,760
recommendations for minorities who are

481
00:23:24,850 --> 00:23:23,120
interested in in science and want to

482
00:23:29,890 --> 00:23:24,860
become scientists and get PhDs in

483
00:23:32,830 --> 00:23:29,900
science well I guess if you start you

484
00:23:35,919 --> 00:23:32,840
know an undergraduate the the advice a

485
00:23:40,440 --> 00:23:35,929
lot of the advice is the same for

486
00:23:44,490 --> 00:23:40,450
everyone you know find opportunities ask

487
00:23:47,409 --> 00:23:44,500
professors counselors you know about

488
00:23:54,070 --> 00:23:47,419

internships that of things you might be

489
00:23:58,890 --> 00:23:54,080
interested in let's see and now there's

490
00:24:06,580 --> 00:24:02,440
minority field for example I knew people

491
00:24:10,000 --> 00:24:06,590
at you know Howard University and Texas

492
00:24:13,510 --> 00:24:10,010
Southern you know and it's always good

493
00:24:16,600 --> 00:24:13,520
to try to to reach out to people like

494
00:24:17,740 --> 00:24:16,610
that who you know can tell you how they

495
00:24:19,660 --> 00:24:17,750
operate it

496
00:24:25,810 --> 00:24:19,670
the system you know what made life a lot

497
00:24:29,200 --> 00:24:25,820
easier so that and I always have joke

498
00:24:32,800 --> 00:24:29,210
that and get lots of sleep but health

499
00:24:35,740 --> 00:24:32,810
and you know but I I would say if you

500
00:24:38,310 --> 00:24:35,750
have an idea about what you want then

501
00:24:41,320 --> 00:24:38,320
there's nothing like getting internships

502
00:24:43,840 --> 00:24:41,330
finding the information you know and

503
00:24:47,170 --> 00:24:43,850
most professors at you at their school

504
00:24:50,280 --> 00:24:47,180
should have an idea of internships and

505
00:24:53,350 --> 00:24:50,290
opportunities I think that's huge

506
00:24:55,960 --> 00:24:53,360
yeah the students have really nothing to

507
00:24:57,670 --> 00:24:55,970
lose for reaching out and contacting an

508
00:25:00,490 --> 00:24:57,680
expert and hey I'm really interested in

509
00:25:02,200 --> 00:25:00,500
this what can I do to you know advance

510
00:25:03,820 --> 00:25:02,210
my career and most of the time you

511
00:25:05,320 --> 00:25:03,830
you'll get a response so all of you who

512
00:25:07,810 --> 00:25:05,330
are students who are watching this like

513
00:25:09,550 --> 00:25:07,820

don't feel shy about connecting whether

514
00:25:14,530 --> 00:25:09,560
it was a scientist most likely dogs are

515
00:25:16,840 --> 00:25:14,540
delighted to reply so yeah what what do

516
00:25:20,830 --> 00:25:16,850
you find most exciting about being an

517
00:25:23,500 --> 00:25:20,840
astrobiologist well again it goes back

518
00:25:26,590 --> 00:25:23,510
to what you mention is you know looking

519
00:25:30,040 --> 00:25:26,600
at these four point five seven eleven

520
00:25:34,690 --> 00:25:30,050
billion here holding rocks you know that

521
00:25:37,000 --> 00:25:34,700
is still to me amazing so that is number

522
00:25:41,110 --> 00:25:37,010
one you know the fact that you can look

523
00:25:44,860 --> 00:25:41,120
at something that formed before anyone

524
00:25:46,660 --> 00:25:44,870
thought you know about humans before

525
00:25:49,900 --> 00:25:46,670
there was any thought about humans

526
00:25:53,460 --> 00:25:49,910
before the earth actually formed and now

527
00:25:56,770 --> 00:25:53,470
with again with these space telescopes

528
00:26:00,250 --> 00:25:56,780
it's just not some delusion you actually

529
00:26:02,680 --> 00:26:00,260
see the same process happening all over

530
00:26:04,720 --> 00:26:02,690
the place over and over again so it

531
00:26:09,750 --> 00:26:04,730
really drives home the point that you

532
00:26:13,090 --> 00:26:09,760
are looking at you know formations of

533
00:26:15,670 --> 00:26:13,100
planets eventually to be you know people

534
00:26:18,880 --> 00:26:15,680
and bacteria and crocodile you know it's

535
00:26:21,360 --> 00:26:18,890
just amazing so that that I would say is

536
00:26:24,190 --> 00:26:21,370
still number one

537
00:26:26,260 --> 00:26:24,200
so can you paint in your mind and and

538
00:26:30,040 --> 00:26:26,270

share that with us perhaps how you think

539
00:26:30,909 --> 00:26:30,050
life arose on our planet what kind of

540
00:26:33,369 --> 00:26:30,919
environments

541
00:26:37,239 --> 00:26:33,379
or yeah boy that's a nobel-prize

542
00:26:39,849 --> 00:26:37,249
question right yeah maybe in three years

543
00:26:43,840 --> 00:26:39,859
I'll give you an answer but but that

544
00:26:46,960 --> 00:26:43,850
that's that's the golden question you

545
00:26:49,840 --> 00:26:46,970
know I we see the compounds in organic

546
00:26:52,869 --> 00:26:49,850
compounds and meteorites but it's

547
00:26:55,509 --> 00:26:52,879
obvious that it took from there some

548
00:27:00,129 --> 00:26:55,519
more some additional chemistry on the

549
00:27:03,609 --> 00:27:00,139
earth for example right now we don't see

550
00:27:06,909 --> 00:27:03,619
long polymers of proteins you know made

551
00:27:09,669 --> 00:27:06,919
of amino acids which is in everything

552
00:27:13,930 --> 00:27:09,679
you know everything that's life

553
00:27:17,139 --> 00:27:13,940
there's a very small - amino acid

554
00:27:19,840 --> 00:27:17,149
peptide or you know very small piece of

555
00:27:23,080 --> 00:27:19,850
a protein but that's very trace amounts

556
00:27:25,330 --> 00:27:23,090
so it had to take more chemistry from

557
00:27:29,049 --> 00:27:25,340
the Earth's and probably you know

558
00:27:32,190 --> 00:27:29,059
additional chemistry in hot regions

559
00:27:34,539 --> 00:27:32,200
people are doing hydrothermal vent

560
00:27:40,119 --> 00:27:34,549
simulations people like you know George

561
00:27:43,180 --> 00:27:40,129
Cody at Carnegie years ago researchers

562
00:27:45,789 --> 00:27:43,190
took amino acids and simply put them on

563
00:27:47,950 --> 00:27:45,799

what they simulate it to be hot islands

564
00:27:50,710 --> 00:27:47,960
ancient volcanic islands on the ancient

565
00:27:53,529 --> 00:27:50,720
earth using just heat you can form

566
00:27:56,499 --> 00:27:53,539
linkages you can join compounds together

567
00:27:58,359 --> 00:27:56,509
which is necessary before you get life

568
00:28:00,369 --> 00:27:58,369
you have to join individual small

569
00:28:03,249 --> 00:28:00,379
compounds together and they could do

570
00:28:05,950 --> 00:28:03,259
that was simply heat by mimicking the

571
00:28:10,599 --> 00:28:05,960
many what had to be the many volcanic

572
00:28:12,879 --> 00:28:10,609
hot areas own agent earth so I and heat

573
00:28:15,249 --> 00:28:12,889
is just the simplest thing to do I don't

574
00:28:17,320 --> 00:28:15,259
know of a complicated scenario for life

575
00:28:19,419 --> 00:28:17,330
people are working on it but you know I

576
00:28:22,659 --> 00:28:19,429
would start with something like that you

577
00:28:25,539 --> 00:28:22,669
know but well you know as time go on

578
00:28:27,789 --> 00:28:25,549
ideas will get better and better yeah

579
00:28:30,879 --> 00:28:27,799
it's an active area of research so if I

580
00:28:32,919 --> 00:28:30,889
understand you well the the seeds you

581
00:28:36,519 --> 00:28:32,929
need to get life started on a planet

582
00:28:39,159 --> 00:28:36,529
requires not only solar system chemistry

583
00:28:40,479 --> 00:28:39,169
where you have cosmic radiation that's

584
00:28:42,310 --> 00:28:40,489
interacting with eyes that are

585
00:28:44,080 --> 00:28:42,320
meteorites who create as organic matter

586
00:28:46,000 --> 00:28:44,090
but also the

587
00:28:47,470 --> 00:28:46,010
the geochemistry the chemistry that's

588
00:28:49,840 --> 00:28:47,480

happening at the interaction of a

589
00:28:51,610 --> 00:28:49,850
terrestrial or planetary surface

590
00:28:53,290 --> 00:28:51,620
interacting with rocks and water and the

591
00:28:56,020 --> 00:28:53,300
chemistry is happening then putting

592
00:28:58,920 --> 00:28:56,030
those two together and you know with the

593
00:29:00,970 --> 00:28:58,930
proper conditions could then arise

594
00:29:03,850 --> 00:29:00,980
biology right so it's not only a

595
00:29:05,950 --> 00:29:03,860
planetary a closed planetary ecosystem

596
00:29:08,590 --> 00:29:05,960
that leads to life it's this interaction

597
00:29:12,370 --> 00:29:08,600
of the planet with with its outer solar

598
00:29:13,960 --> 00:29:12,380
system environments exactly even though

599
00:29:16,450 --> 00:29:13,970
I'm you know I'm fascinated with

600
00:29:19,600 --> 00:29:16,460
meteorite organics this this big Earth's

601
00:29:22,510 --> 00:29:19,610
not wasn't sitting here for nothing

602
00:29:24,940 --> 00:29:22,520
billions of years ago so like said

603
00:29:28,750 --> 00:29:24,950
undoubtedly there was further chemistry

604
00:29:30,970 --> 00:29:28,760
maybe different chemistry the the

605
00:29:34,030 --> 00:29:30,980
organics and meteorites you could have

606
00:29:36,310 --> 00:29:34,040
you can make very fragile compounds that

607
00:29:38,770 --> 00:29:36,320
you need it probably need it for life

608
00:29:41,410 --> 00:29:38,780
for example pyruvic acid oxalic acid

609
00:29:43,720 --> 00:29:41,420
things like that because you're forming

610
00:29:47,440 --> 00:29:43,730
them out there as I said it you know 50

611
00:29:49,900 --> 00:29:47,450
Kelvin you know very cold so there are

612
00:29:53,830 --> 00:29:49,910
radical compounds that are very stable

613
00:29:57,040 --> 00:29:53,840

and in interstellar space when they fall

614
00:29:58,870 --> 00:29:57,050
to earth they're very reactive so right

615
00:30:01,740 --> 00:29:58,880
away on Earth's surface they could have

616
00:30:05,170 --> 00:30:01,750
done more chemistry but again also

617
00:30:07,600 --> 00:30:05,180
linking monomers linking amino acids

618
00:30:10,720 --> 00:30:07,610
together sugar or sugar derivatives

619
00:30:14,500 --> 00:30:10,730
together to make our larger the larger

620
00:30:18,040 --> 00:30:14,510
polymers were made of right now it looks

621
00:30:23,170 --> 00:30:18,050
like that had to be an earth process you

622
00:30:26,130 --> 00:30:23,180
know whatever the the mechanism and like

623
00:30:27,970 --> 00:30:26,140
I said I sort of favor you know warm

624
00:30:31,570 --> 00:30:27,980
maybe even hot

625
00:30:33,520 --> 00:30:31,580
at least localized now the ancient earth

626
00:30:35,260 --> 00:30:33,530
for organics couldn't have obviously

627
00:30:37,480 --> 00:30:35,270
couldn't have been terribly hot or you

628
00:30:39,370 --> 00:30:37,490
wouldn't have had organics but localized

629
00:30:42,070 --> 00:30:39,380
to just the right temperatures and they

630
00:30:46,000 --> 00:30:42,080
must have been a very huge amount of

631
00:30:48,250 --> 00:30:46,010
different temperature regimes for

632
00:30:50,920 --> 00:30:48,260
linking compounds together I think that

633
00:30:52,570 --> 00:30:50,930
would be the right compounds and there

634
00:30:54,520 --> 00:30:52,580
are many in the meteorites and who knows

635
00:30:55,779 --> 00:30:54,530
what it made on earth there are the

636
00:30:58,739 --> 00:30:55,789
right compounds that

637
00:31:02,759 --> 00:30:58,749
you did have a warm hot or hot

638
00:31:04,450 --> 00:31:02,769

environment that easily could link

639
00:31:07,169 --> 00:31:04,460
compounds could have been linked

640
00:31:10,299 --> 00:31:07,179
together to form larger polymers

641
00:31:12,909 --> 00:31:10,309
fascinating so could you take us to your

642
00:31:14,499 --> 00:31:12,919
lab and describe to us what you do in

643
00:31:19,299 --> 00:31:14,509
the lab what kind of instruments do you

644
00:31:22,119 --> 00:31:19,309
use to make such detailed measurements a

645
00:31:26,229 --> 00:31:22,129
few different types of instruments and

646
00:31:28,509 --> 00:31:26,239
techniques the first is really boring

647
00:31:30,519 --> 00:31:28,519
analytical chemistry stuff you have no

648
00:31:33,580 --> 00:31:30,529
don't tear your sample you have to

649
00:31:36,009 --> 00:31:33,590
extract with solvent it could be water

650
00:31:38,589 --> 00:31:36,019
or it could be a you know more nonpolar

651
00:31:40,389 --> 00:31:38,599
solvent you first you have to extract a

652
00:31:45,519 --> 00:31:40,399
compound Lau but there are a lot of

653
00:31:49,239 --> 00:31:45,529
salts and and meteorites so that's for a

654
00:31:51,369 --> 00:31:49,249
long you know keep the story short you

655
00:31:53,379 --> 00:31:51,379
couldn't do the type of analysis I do

656
00:31:55,359 --> 00:31:53,389
and the mixed of all the sauce for

657
00:31:57,519 --> 00:31:55,369
example in Murchison a lot of meat our

658
00:32:02,320 --> 00:31:57,529
carbonation meteorites there's lots of

659
00:32:07,180 --> 00:32:02,330
sulfate so4 - - mer send a lot of it is

660
00:32:10,029 --> 00:32:07,190
magnesium calcium you have to - what we

661
00:32:12,690 --> 00:32:10,039
call d salt you have to remove those to

662
00:32:15,190 --> 00:32:12,700
the side to get at the organics and

663
00:32:17,139 --> 00:32:15,200

here's where the boring analytical

664
00:32:20,649 --> 00:32:17,149
preparation techniques come in you know

665
00:32:23,349 --> 00:32:20,659
use resins to D salt and you go on and

666
00:32:26,830 --> 00:32:23,359
on and it can take forever for one

667
00:32:30,070 --> 00:32:26,840
sample and the instrument that finally

668
00:32:34,570 --> 00:32:30,080
tells you what the organic is in my case

669
00:32:39,339 --> 00:32:34,580
this mostly gas chromatography - mass

670
00:32:43,629 --> 00:32:39,349
spectrometry GCMs and a little bit of

671
00:32:48,009 --> 00:32:43,639
liquid chromatography but that is my has

672
00:32:50,619 --> 00:32:48,019
been my major analytical estimate that I

673
00:32:53,440 --> 00:32:50,629
actually identifies compounds I use

674
00:32:57,310 --> 00:32:53,450
others for other reasons so can you

675
00:32:59,499 --> 00:32:57,320
describe what a GCM is is and does in in

676
00:33:04,089 --> 00:32:59,509
just a few minutes okay a gas

677
00:33:06,220 --> 00:33:04,099
chromatograph the GC part you injectors

678
00:33:07,990 --> 00:33:06,230
after you've done all the preparation

679
00:33:11,170 --> 00:33:08,000
you inject the sample

680
00:33:15,010 --> 00:33:11,180
and the word gas implies of course a gas

681
00:33:20,950 --> 00:33:15,020
phase it vaporizes a sample puts it onto

682
00:33:23,740 --> 00:33:20,960
a GC column a column is a long glass

683
00:33:26,650 --> 00:33:23,750
capillary tube coated inside with

684
00:33:29,230 --> 00:33:26,660
organic with an organic phase your

685
00:33:32,410 --> 00:33:29,240
compounds after you inject land and that

686
00:33:35,800 --> 00:33:32,420
long column make these columns can be 25

687
00:33:40,000 --> 00:33:35,810
meters 50 meters and often I've used

688
00:33:43,150 --> 00:33:40,010

even longer GC columns they land in that

689
00:33:46,150 --> 00:33:43,160
phase again back to the gas part you

690
00:33:47,710 --> 00:33:46,160
start heating your gas chromatograph so

691
00:33:49,720 --> 00:33:47,720
your column is inside the gas

692
00:33:52,780 --> 00:33:49,730
chromatograph the organics are now

693
00:33:56,800 --> 00:33:52,790
they've landed on that column so now you

694
00:33:59,890 --> 00:33:56,810
start heating that column and eventually

695
00:34:04,360 --> 00:33:59,900
things boil off they boil off at

696
00:34:06,400 --> 00:34:04,370
different temperatures because most of

697
00:34:08,650 --> 00:34:06,410
the audience knows about a boiling point

698
00:34:11,350 --> 00:34:08,660
water boiling points 100 degrees Celsius

699
00:34:14,140 --> 00:34:11,360
so the organics on this column they as

700
00:34:16,120 --> 00:34:14,150
you slowly heat up your column they come

701
00:34:19,210 --> 00:34:16,130
off at their own particular boiling

702
00:34:24,070 --> 00:34:19,220
point in that particular organic phase

703
00:34:27,040 --> 00:34:24,080
of the column and that's the major a way

704
00:34:29,260 --> 00:34:27,050
to separate organics they boil off their

705
00:34:33,160 --> 00:34:29,270
swept out of the column you you're

706
00:34:35,890 --> 00:34:33,170
always running a gas through it an inert

707
00:34:37,330 --> 00:34:35,900
nonreactive gas that doesn't react with

708
00:34:40,630 --> 00:34:37,340
your compounds for example helium or

709
00:34:43,600 --> 00:34:40,640
hydrogen so because the each compound

710
00:34:46,180 --> 00:34:43,610
has a different boiling point you can

711
00:34:48,220 --> 00:34:46,190
imagine when these compounds are leaving

712
00:34:52,330 --> 00:34:48,230
the column going to the detector or the

713
00:34:54,760 --> 00:34:52,340

mass spectrometer you'll see each

714
00:34:58,420 --> 00:34:54,770
compound come off at a different time in

715
00:35:01,090 --> 00:34:58,430
other words this gas chromatograph is

716
00:35:03,820 --> 00:35:01,100
taking this big group of a mass of

717
00:35:07,510 --> 00:35:03,830
organics and a meteorite and separating

718
00:35:09,850 --> 00:35:07,520
it so you can identify one by one the

719
00:35:12,790 --> 00:35:09,860
compounds you couldn't do it

720
00:35:15,840 --> 00:35:12,800
if you we had all the organics just

721
00:35:18,550 --> 00:35:15,850
sitting there and one one big mixture

722
00:35:19,630 --> 00:35:18,560
after they go to the mass spectrometer

723
00:35:22,170 --> 00:35:19,640
and a mass spectrometer

724
00:35:25,780 --> 00:35:22,180
can tell you the molecular weights of

725
00:35:27,400 --> 00:35:25,790
the organics and it also fragments the

726
00:35:30,250 --> 00:35:27,410
compounds it shoots a beam of electrons

727
00:35:33,730 --> 00:35:30,260
at each compound they break apart

728
00:35:37,660 --> 00:35:33,740
fragment but they do it in different

729
00:35:43,450 --> 00:35:37,670
ways so that's called a fragmentation

730
00:35:46,150 --> 00:35:43,460
pattern so the fragments are an ID you

731
00:35:48,970 --> 00:35:46,160
know fingerprint of each organic so you

732
00:35:51,520 --> 00:35:48,980
had so that's two ways to identify the

733
00:35:54,280 --> 00:35:51,530
retention time or the time it takes each

734
00:35:57,160 --> 00:35:54,290
compound to boil up and come out and

735
00:36:00,550 --> 00:35:57,170
it's fragmentation pattern how it breaks

736
00:36:03,730 --> 00:36:00,560
apart and you know that because you run

737
00:36:05,890 --> 00:36:03,740
several standards either before or after

738
00:36:09,160 --> 00:36:05,900

you can analyze your sample and if that

739
00:36:11,500 --> 00:36:09,170
standard matches then you can go back to

740
00:36:12,730 --> 00:36:11,510
your sample and say AHA this one had the

741
00:36:16,690 --> 00:36:12,740
same wintertime in the same

742
00:36:18,970 --> 00:36:16,700
fragmentation pattern the GCMs the gas

743
00:36:21,970 --> 00:36:18,980
chromatography mass spec is what was

744
00:36:26,200 --> 00:36:21,980
used for I think the first big Olympic

745
00:36:28,090 --> 00:36:26,210
cheating scandal I think that was 1990

746
00:36:31,540 --> 00:36:28,100
maybe son joy well you probably went

747
00:36:33,630 --> 00:36:31,550
boring warning but I think it was the 90

748
00:36:37,000 --> 00:36:33,640
or 92 Olympics and there was a big

749
00:36:39,700 --> 00:36:37,010
doping scandal and a gas chromatograph

750
00:36:43,840 --> 00:36:39,710
mass spec did exactly what I just

751
00:36:47,560 --> 00:36:43,850
described it identified the the

752
00:36:51,640 --> 00:36:47,570
compounds and so if you are caught you

753
00:36:53,860 --> 00:36:51,650
couldn't say no no no the GCMs was wrong

754
00:36:55,930 --> 00:36:53,870
because it's really tough to be wrong

755
00:36:59,650 --> 00:36:55,940
when you have a standard and all the

756
00:37:02,380 --> 00:36:59,660
properties are identical so it's pretty

757
00:37:04,780 --> 00:37:02,390
useful not for me for example the water

758
00:37:07,330 --> 00:37:04,790
in the background of a Sun joy there

759
00:37:11,110 --> 00:37:07,340
when you melt it you could analyze it by

760
00:37:13,420 --> 00:37:11,120
GCMs to tell what compounds are there so

761
00:37:15,580 --> 00:37:13,430
it's pretty useful technique that's so

762
00:37:17,320 --> 00:37:15,590
cool I could talk to you forever about

763
00:37:18,910 --> 00:37:17,330

meteorites and organic matter but I

764
00:37:20,620 --> 00:37:18,920
think it's time that we open the floor

765
00:37:22,480 --> 00:37:20,630
up to questions I'm gonna turn to my

766
00:37:27,000 --> 00:37:22,490
question screen which is right here and

767
00:37:33,070 --> 00:37:29,920
what is responsible for choosing the

768
00:37:39,670 --> 00:37:33,080
chiral handedness of organic molecules

769
00:37:41,860 --> 00:37:39,680
in life that's another good question

770
00:37:44,380 --> 00:37:41,870
no one knows it

771
00:37:47,770 --> 00:37:44,390
scientists know why it works so well why

772
00:37:49,810 --> 00:37:47,780
and what what he's talking about is if I

773
00:37:51,790 --> 00:37:49,820
don't you know know how diverse the

774
00:37:53,560 --> 00:37:51,800
audience is but if you put up your two

775
00:37:55,390 --> 00:37:53,570
hands you could imagine pretend that's

776
00:37:56,830 --> 00:37:55,400
an organic compound you have a left

777
00:38:00,970 --> 00:37:56,840
mirror image and a right mirror image

778
00:38:04,330 --> 00:38:00,980
well for example in RNA and DNA only one

779
00:38:06,490 --> 00:38:04,340
of those mirror images of the compound

780
00:38:09,910 --> 00:38:06,500
in this case I'll say ribose and Ernie

781
00:38:13,150 --> 00:38:09,920
only one is used in those long strands

782
00:38:15,970 --> 00:38:13,160
of RNA and DNA so most people from

783
00:38:18,340 --> 00:38:15,980
school high school have seen the long

784
00:38:21,250 --> 00:38:18,350
strands you have an RNA a base and

785
00:38:24,490 --> 00:38:21,260
phosphate and it repeats RNA you know

786
00:38:27,880 --> 00:38:24,500
ribose phosphate base and it goes on and

787
00:38:32,410 --> 00:38:27,890
on and on but only one of those ribose

788
00:38:36,280 --> 00:38:32,420

is only the D mirror image is used so

789
00:38:39,100 --> 00:38:36,290
that's what caller Mr Wong is asking

790
00:38:41,500 --> 00:38:39,110
about how in the world can you get just

791
00:38:45,760 --> 00:38:41,510
one because if you go in a lab to make

792
00:38:48,010 --> 00:38:45,770
let's say rivals non-biologically like

793
00:38:50,350 --> 00:38:48,020
what happened before life it was it

794
00:38:52,060 --> 00:38:50,360
wasn't a biased process you go in the

795
00:38:54,610 --> 00:38:52,070
lab now and do the same thing you'll get

796
00:38:56,410 --> 00:38:54,620
both you'll get two hands just like

797
00:38:59,170 --> 00:38:56,420
flipping a coin a thousand times you

798
00:39:03,520 --> 00:38:59,180
can't get one coin one hour here only

799
00:39:08,350 --> 00:39:03,530
hits so that is a good question you know

800
00:39:11,620 --> 00:39:08,360
how did one get picked out from what

801
00:39:15,070 --> 00:39:11,630
we're seeing now with compounds close to

802
00:39:17,560 --> 00:39:15,080
sugars and what my old professor and

803
00:39:19,660 --> 00:39:17,570
Senator Pitt Cirillo saw back you know

804
00:39:22,900 --> 00:39:19,670
years ago a paper published in science

805
00:39:27,760 --> 00:39:22,910
in 1997 was that some of the amino acids

806
00:39:30,190 --> 00:39:27,770
have a slight bias of one of the mirror

807
00:39:33,040 --> 00:39:30,200
images you know sometimes it you know

808
00:39:35,950 --> 00:39:33,050
the the amount the excess of one of

809
00:39:38,150 --> 00:39:35,960
those mere inches very it's the l-amino

810
00:39:41,480 --> 00:39:38,160
acid which just by cause an assistant

811
00:39:44,120 --> 00:39:41,490
on your proteins beta so lately we see

812
00:39:48,650 --> 00:39:44,130
sugar derivatives you know cousins of

813
00:39:51,040 --> 00:39:48,660

ribose that has a lot more of one mirror

814
00:39:54,710 --> 00:39:51,050
image and that's 2d mirror image and

815
00:39:58,190 --> 00:39:54,720
maybe it's questionable now but the D of

816
00:40:03,650 --> 00:39:58,200
the sugars are what is what life uses

817
00:40:06,380 --> 00:40:03,660
mostly oh is that a hint to you know the

818
00:40:08,030 --> 00:40:06,390
answer to that question you know what

819
00:40:10,430 --> 00:40:08,040
else happened on the ancient earth you

820
00:40:13,070 --> 00:40:10,440
know so that what I described came from

821
00:40:15,320 --> 00:40:13,080
space comes from space what else

822
00:40:20,360 --> 00:40:15,330
happened on earth and people are looking

823
00:40:22,610 --> 00:40:20,370
at that so maybe if this work is you

824
00:40:25,100 --> 00:40:22,620
know we could do more of it and see the

825
00:40:29,000 --> 00:40:25,110
same thing over and over I saw that

826
00:40:31,160 --> 00:40:29,010
phenomenon since 2001 but we just

827
00:40:32,840 --> 00:40:31,170
published it but I've seen the same

828
00:40:35,870 --> 00:40:32,850
phenomenon in these sugar derivatives

829
00:40:39,410 --> 00:40:35,880
for 15 years and people wondering why

830
00:40:41,630 --> 00:40:39,420
the heck aren't you focusing it but you

831
00:40:47,240 --> 00:40:41,640
still I still you know you should still

832
00:40:50,300 --> 00:40:47,250
look at it in different ways so now the

833
00:40:52,970 --> 00:40:50,310
reason it works I said at first

834
00:40:55,940 --> 00:40:52,980
scientists weren't sure about how it

835
00:40:59,570 --> 00:40:55,950
happened but they know that you can only

836
00:41:02,750 --> 00:40:59,580
form let's say RNA and DNA if you have

837
00:41:05,300 --> 00:41:02,760
one mirror image so that's why it works

838
00:41:07,310 --> 00:41:05,310

well you can't have both what's called a

839
00:41:10,340 --> 00:41:07,320
racemic mixture you can't have left-hand

840
00:41:12,050 --> 00:41:10,350
and right-hand ribose and go and try to

841
00:41:15,530 --> 00:41:12,060
make your DNA

842
00:41:19,610 --> 00:41:15,540
Jerry Joyce at Scripps showed years ago

843
00:41:22,490 --> 00:41:19,620
I think is 84 paper in 84 that you don't

844
00:41:25,970 --> 00:41:22,500
get very far if you mix both of those

845
00:41:29,210 --> 00:41:25,980
mirror images so we know why it works

846
00:41:32,360 --> 00:41:29,220
well but the initial spark is still a

847
00:41:34,730 --> 00:41:32,370
question cool thanks for that George our

848
00:41:36,230 --> 00:41:34,740
next question comes from Janet Ashley

849
00:41:38,990 --> 00:41:36,240
Pollock hello Janet thank you for your

850
00:41:41,300 --> 00:41:39,000
question and she asks whether comets

851
00:41:48,260 --> 00:41:41,310
could also deliver organic material on

852
00:41:51,620 --> 00:41:48,270
earth yes we just you know don't have

853
00:41:54,410 --> 00:41:51,630
what we can actually say is

854
00:41:57,650 --> 00:41:54,420
a comet a bonafide comet like I said

855
00:42:01,220 --> 00:41:57,660
some asteroids or probably comets you

856
00:42:03,230 --> 00:42:01,230
know who knows what the the organically

857
00:42:08,120 --> 00:42:03,240
wise what the difference is we just

858
00:42:10,220 --> 00:42:08,130
can't say the there was a paper company

859
00:42:13,040 --> 00:42:10,230
last year a few years ago last year I

860
00:42:16,900 --> 00:42:13,050
think where they identified glycine on

861
00:42:22,220 --> 00:42:16,910
the famous comet now 67p where the

862
00:42:26,140 --> 00:42:22,230
European spacecraft is landed on so

863
00:42:29,750 --> 00:42:26,150

glycine is the smallest amino acid so

864
00:42:34,190 --> 00:42:29,760
and they identify small organic molecule

865
00:42:36,590 --> 00:42:34,200
CN cyanide a few others but the larger

866
00:42:39,740 --> 00:42:36,600
more what we think of is biologically

867
00:42:42,740 --> 00:42:39,750
relevant I don't think it's known about

868
00:42:45,200 --> 00:42:42,750
comets yet but even if there were only

869
00:42:47,480 --> 00:42:45,210
those small molecules from aldehyde is

870
00:42:52,610 --> 00:42:47,490
one of them you know this formaldehyde

871
00:42:55,460 --> 00:42:52,620
as ch2oh CN cyanide another couple even

872
00:42:58,700 --> 00:42:55,470
if this only they are the only ones on

873
00:43:02,510 --> 00:42:58,710
comets if they land it on the ancient

874
00:43:04,430 --> 00:43:02,520
earth the chemistry you could get the

875
00:43:06,830 --> 00:43:04,440
further chemistry the the building of

876
00:43:10,220 --> 00:43:06,840
larger compounds from that I think would

877
00:43:14,330 --> 00:43:10,230
be pretty significant again if you have

878
00:43:16,700 --> 00:43:14,340
formaldehyde CN which are in comets

879
00:43:18,800 --> 00:43:16,710
right or what not right away but pretty

880
00:43:23,360 --> 00:43:18,810
much you're going to get glycine and

881
00:43:25,970 --> 00:43:23,370
other amino acids so just the small

882
00:43:28,670 --> 00:43:25,980
molecules would would have been I think

883
00:43:32,390 --> 00:43:28,680
huge as far as further chemistry from

884
00:43:34,700 --> 00:43:32,400
comets thank you the next question is

885
00:43:37,790 --> 00:43:34,710
from Gina regio hi Gina thanks for your

886
00:43:40,850 --> 00:43:37,800
question and she asks what is an example

887
00:43:44,290 --> 00:43:40,860
of an unexpected organic compound that

888
00:43:48,320 --> 00:43:44,300

you have recovered from a meteorite oh

889
00:43:53,740 --> 00:43:48,330
the most unexpected I I would say it was

890
00:43:56,060 --> 00:43:53,750
a an organic phosphorous compound that

891
00:43:59,330 --> 00:43:56,070
fairly unusual

892
00:44:02,750 --> 00:43:59,340
she got bond for example DNA and RNA

893
00:44:05,190 --> 00:44:02,760
organic phosphorus but that's not you

894
00:44:07,349 --> 00:44:05,200
know as far as we know not in meteorites

895
00:44:11,309 --> 00:44:07,359
and that's phosphorus with four oxygen

896
00:44:13,650 --> 00:44:11,319
around it and the RNA each phosphate is

897
00:44:15,779 --> 00:44:13,660
bonded to arrivals and then another

898
00:44:18,960 --> 00:44:15,789
phosphate and another ribose oh no no no

899
00:44:19,650 --> 00:44:18,970
that's po4 phosphorus with the four

900
00:44:21,960 --> 00:44:19,660
oxygen

901
00:44:24,809 --> 00:44:21,970
the most surprising that I could

902
00:44:28,680 --> 00:44:24,819
remember is of the the organic

903
00:44:32,730 --> 00:44:28,690
phosphorus we saw years ago bond

904
00:44:34,710 --> 00:44:32,740
directly to a carbon and it had has

905
00:44:37,700 --> 00:44:34,720
different organic groups attached to the

906
00:44:41,789 --> 00:44:37,710
carbon so they're called phosphonates

907
00:44:46,710 --> 00:44:41,799
not phosphates but phosphonates so I

908
00:44:50,309 --> 00:44:46,720
think that compound was not phenomenal

909
00:44:55,680 --> 00:44:50,319
eyes but compound wise is probably the

910
00:44:57,210 --> 00:44:55,690
more surprising cool Janet asked a

911
00:45:00,059 --> 00:44:57,220
question again about whether you have

912
00:45:02,069 --> 00:45:00,069
any she's Canadian and she's asking if

913
00:45:03,930 --> 00:45:02,079

you have any Canadian colleagues who do

914
00:45:09,059 --> 00:45:03,940
some of these early life early Earth

915
00:45:14,730 --> 00:45:09,069
type studies not myself I I do not but

916
00:45:17,660 --> 00:45:14,740
there are people in Canada who like

917
00:45:21,299 --> 00:45:17,670
meteorites also and analyzed organics

918
00:45:23,759 --> 00:45:21,309
but not not personally Janet you should

919
00:45:25,890 --> 00:45:23,769
check out the Center for planetary

920
00:45:28,319 --> 00:45:25,900
science and exploration which is in in

921
00:45:30,059 --> 00:45:28,329
London London Ontario I think they might

922
00:45:32,009 --> 00:45:30,069
have it's at Western they might have

923
00:45:36,809 --> 00:45:32,019
some department there that you might

924
00:45:40,609 --> 00:45:36,819
find some collaborators the next

925
00:45:46,490 --> 00:45:40,619
question is by Abhishek Sony he asks

926
00:45:49,589 --> 00:45:46,500
what can what can an environmentalist do

927
00:45:51,509 --> 00:45:49,599
with astrobiology if you are modern

928
00:45:53,490 --> 00:45:51,519
ecologists environmentalists how can

929
00:45:58,470 --> 00:45:53,500
that give you insights into astrobiology

930
00:46:02,089 --> 00:45:58,480
I think so that question is going well I

931
00:46:07,410 --> 00:46:02,099
haven't thought of the environmental

932
00:46:11,430 --> 00:46:07,420
connection before as far as astrobiology

933
00:46:15,539 --> 00:46:11,440
you said the between in the environment

934
00:46:18,599 --> 00:46:15,549
and astrobiology and yeah what's that

935
00:46:22,880 --> 00:46:18,609
that was been you yeah

936
00:46:25,440 --> 00:46:22,890
I think of a it when I think of an

937
00:46:29,190 --> 00:46:25,450
environmentalism I'm thinking of trying

938
00:46:33,359 --> 00:46:29,200

to save the planet from its current you

939
00:46:37,650 --> 00:46:33,369
know it towards destruction like climate

940
00:46:41,069 --> 00:46:37,660
change and the rest but I'm sure there

941
00:46:43,859 --> 00:46:41,079
must be some some connection the the

942
00:46:46,319 --> 00:46:43,869
astrobiologist that I spoke up before

943
00:46:49,140 --> 00:46:46,329
they go you know all around the earth

944
00:46:52,229 --> 00:46:49,150
searching for meteorites and they

945
00:46:54,569 --> 00:46:52,239
obviously the ice melting and where they

946
00:46:58,650 --> 00:46:54,579
go collect meteorites so I'm sure they

947
00:47:01,529 --> 00:46:58,660
would have a really strong bent on on

948
00:47:03,599 --> 00:47:01,539
that particular question it's true and

949
00:47:06,660 --> 00:47:03,609
analog studies that we check are a

950
00:47:08,940 --> 00:47:06,670
modern way of studying astrobiology look

951
00:47:10,079 --> 00:47:08,950
at analog sites that are similar to some

952
00:47:12,299 --> 00:47:10,089
conditions you're exploring in other

953
00:47:15,359 --> 00:47:12,309
worlds and if you have some expertise in

954
00:47:16,710 --> 00:47:15,369
the ecology or the local bio geology

955
00:47:18,839 --> 00:47:16,720
that's going in there then you can make

956
00:47:20,579 --> 00:47:18,849
some educated conclusions about the

957
00:47:22,589 --> 00:47:20,589
plausibility of that environment to be

958
00:47:24,180 --> 00:47:22,599
similar to one elsewhere so there's so

959
00:47:25,650 --> 00:47:24,190
many questions that are pouring in right

960
00:47:27,660 --> 00:47:25,660
now thank you all for for all these

961
00:47:29,130 --> 00:47:27,670
great questions I'm probably not gonna

962
00:47:31,650 --> 00:47:29,140
have time to get through all of them but

963
00:47:35,670 --> 00:47:31,660

we'll do the best we can what is the

964
00:47:38,069 --> 00:47:35,680
next question here it's oh it's by

965
00:47:40,289 --> 00:47:38,079
question by Jacob hack mezra hello Jacob

966
00:47:42,269 --> 00:47:40,299
thank you for your questions and he asks

967
00:47:44,519 --> 00:47:42,279
what are the main geochemical

968
00:47:46,950 --> 00:47:44,529
differences between meteorites that

969
00:47:49,880 --> 00:47:46,960
originated from earth compared to from

970
00:47:58,710 --> 00:47:52,319
you mean the meteorites to fall to earth

971
00:48:01,410 --> 00:47:58,720
yes in Martian meteorites that I know of

972
00:48:05,160 --> 00:48:01,420
again I haven't studied but I think the

973
00:48:08,670 --> 00:48:05,170
majority are more rock like one or two

974
00:48:12,269 --> 00:48:08,680
have they have found traces of organic

975
00:48:14,220 --> 00:48:12,279
compounds but they look like they come

976
00:48:20,130 --> 00:48:14,230
from a heated process and igneous

977
00:48:22,170 --> 00:48:20,140
process certainly the big complex true

978
00:48:24,299 --> 00:48:22,180
organics that we see an asteroid of

979
00:48:27,509 --> 00:48:24,309
meteorites that falter

980
00:48:29,370 --> 00:48:27,519
you cannot you've been seen in Martian

981
00:48:31,800 --> 00:48:29,380
meteorites so I would say they're more

982
00:48:35,160 --> 00:48:31,810
rock like more planetary like

983
00:48:37,290 --> 00:48:35,170
less organics yes meteorites from Mars

984
00:48:39,330 --> 00:48:37,300
are essentially like lava flows that

985
00:48:41,160 --> 00:48:39,340
then cooled off and became rock that

986
00:48:42,720 --> 00:48:41,170
they were then ejected by some sort of

987
00:48:45,030 --> 00:48:42,730
impact and landed on earth whereas

988
00:48:47,430 --> 00:48:45,040

meteorites a more primitive silicon

989
00:48:49,800 --> 00:48:47,440
material that are what the planets are

990
00:48:51,270 --> 00:48:49,810
made of in the first place I think

991
00:48:52,340 --> 00:48:51,280
that's what you're after Jacob yeah more

992
00:48:55,350 --> 00:48:52,350
Christian more

993
00:48:57,240 --> 00:48:55,360
well pristine that's it yeah the next

994
00:48:59,400 --> 00:48:57,250
question is by Graham Lau hello Graham

995
00:49:02,040 --> 00:48:59,410
thank you for your question what do you

996
00:49:04,320 --> 00:49:02,050
think the odds are that we have Venusian

997
00:49:09,180 --> 00:49:04,330
meteorites already in our collections

998
00:49:11,610 --> 00:49:09,190
but just don't know about them oh well

999
00:49:15,930 --> 00:49:11,620
the the ones in the collections they're

1000
00:49:18,830 --> 00:49:15,940
pretty well characterized every now and

1001
00:49:23,120 --> 00:49:18,840
then I will hear something about a

1002
00:49:27,960 --> 00:49:23,130
meteorite possible rock from Venus but I

1003
00:49:30,720 --> 00:49:27,970
don't know the the people who think the

1004
00:49:32,430 --> 00:49:30,730
geochemist a geologist actually who

1005
00:49:37,800 --> 00:49:32,440
think about that type of thing I don't

1006
00:49:41,790 --> 00:49:37,810
know what the latest count is but yeah I

1007
00:49:44,010 --> 00:49:41,800
do hear about that now and then I just

1008
00:49:45,720 --> 00:49:44,020
couldn't give a good answer it's a good

1009
00:49:47,850 --> 00:49:45,730
question I don't know either

1010
00:49:50,910 --> 00:49:47,860
Venus meteorites are they cool there's

1011
00:49:52,970 --> 00:49:50,920
probably some rocks from a lot of places

1012
00:49:56,850 --> 00:49:52,980
on earth we just wouldn't recognize it

1013
00:49:58,290 --> 00:49:56,860

if we stepped on it yeah because you

1014
00:50:00,150 --> 00:49:58,300
have to find them in specific conditions

1015
00:50:01,050 --> 00:50:00,160
you recognize them as meteorites it's

1016
00:50:03,810 --> 00:50:01,060
not always obvious

1017
00:50:05,850 --> 00:50:03,820
the next question is Gina again she

1018
00:50:08,010 --> 00:50:05,860
asked a very good one in terms of you're

1019
00:50:11,130 --> 00:50:08,020
talking about the column in in your lab

1020
00:50:13,920 --> 00:50:11,140
or in your lab that's like 25 50 feet or

1021
00:50:16,110 --> 00:50:13,930
meters or even longer I'm sure she asks

1022
00:50:17,790 --> 00:50:16,120
how does that fit in your life in the

1023
00:50:18,930 --> 00:50:17,800
first place and and how many compounds

1024
00:50:23,550 --> 00:50:18,940
people separate

1025
00:50:28,140 --> 00:50:23,560
using that technique well I'm to ask the

1026
00:50:31,590 --> 00:50:28,150
center management for a nice long lap no

1027
00:50:36,150 --> 00:50:31,600
the columns we're talking the ID is a

1028
00:50:38,820 --> 00:50:36,160
millet less the internal diameter so

1029
00:50:42,030 --> 00:50:38,830
they're tightly coiled they're made of

1030
00:50:43,990 --> 00:50:42,040
flexible polyamide material so you can

1031
00:50:47,830 --> 00:50:44,000
imagine take 50 meters

1032
00:50:51,220 --> 00:50:47,840
coil it up into a circle of about let's

1033
00:50:55,300 --> 00:50:51,230
say a foot across and that fits in your

1034
00:50:57,010 --> 00:50:55,310
gas chromatograph oven gotcha and how

1035
00:51:00,520 --> 00:50:57,020
many compounds can you separates like

1036
00:51:03,850 --> 00:51:00,530
like a hundred or more than hundreds

1037
00:51:05,800 --> 00:51:03,860
more than hundreds yeah yeah in a single

1038
00:51:08,050 --> 00:51:05,810

run you could have you know I you you

1039
00:51:11,560 --> 00:51:08,060
can't even count the number in the

1040
00:51:14,380 --> 00:51:11,570
meteorite it's just you know strange

1041
00:51:20,920 --> 00:51:17,940
Sukanya singh asks if you've ever

1042
00:51:22,690 --> 00:51:20,930
detected a compound that that is not

1043
00:51:24,280 --> 00:51:22,700
organic and now you're like wow that's a

1044
00:51:25,900 --> 00:51:24,290
really weird one that should not belong

1045
00:51:28,210 --> 00:51:25,910
here or is everything that you've

1046
00:51:29,620 --> 00:51:28,220
discovered kind of expected from the

1047
00:51:34,510 --> 00:51:29,630
cosmic chemistry

1048
00:51:37,870 --> 00:51:34,520
I do see non organic compounds now and

1049
00:51:40,540 --> 00:51:37,880
then as you know just simply you don't

1050
00:51:42,190 --> 00:51:40,550
get all you don't get all of the

1051
00:51:46,630 --> 00:51:42,200
inorganic compounds out for example

1052
00:51:49,120 --> 00:51:46,640
sulfate so4 2 - i mentioned i try to get

1053
00:51:52,330 --> 00:51:49,130
you try to get out most as i say it but

1054
00:51:54,850 --> 00:51:52,340
you see sulfate phosphate you know

1055
00:52:00,220 --> 00:51:54,860
traces of it sometimes in your analysis

1056
00:52:02,830 --> 00:52:00,230
so I'll fight you know three and there's

1057
00:52:05,380 --> 00:52:02,840
probably one or two others but those are

1058
00:52:11,110 --> 00:52:05,390
the principal non organics that I'll see

1059
00:52:13,270 --> 00:52:11,120
now and then cool heipiess Eric asks

1060
00:52:15,070 --> 00:52:13,280
about the enantiomeric excess of the

1061
00:52:16,110 --> 00:52:15,080
excess of one carrier molecule versus

1062
00:52:19,750 --> 00:52:16,120
another

1063
00:52:20,800 --> 00:52:19,760

how how excess what is the excess I

1064
00:52:23,320 --> 00:52:20,810
guess in meteorites

1065
00:52:25,030 --> 00:52:23,330
and and can you use that excess to say

1066
00:52:27,700 --> 00:52:25,040
something about biology or how big has

1067
00:52:29,970 --> 00:52:27,710
the excess need to be in order to make

1068
00:52:34,480 --> 00:52:29,980
conclusions about biology

1069
00:52:37,180 --> 00:52:34,490
okay well going back again to before I

1070
00:52:40,120 --> 00:52:37,190
started and I mentioned the 97 paper

1071
00:52:43,900 --> 00:52:40,130
chronica Sorella before that there was a

1072
00:52:47,440 --> 00:52:43,910
paper looking at a biological amino

1073
00:52:49,829 --> 00:52:47,450
acids Matt Cole Ingo and Matt Cole

1074
00:52:54,339 --> 00:52:49,839
and I forget the year around 1990 of

1075
00:52:57,099 --> 00:52:54,349
alanine biological amino acid and again

1076
00:52:59,140 --> 00:52:57,109
you know people are always leery of you

1077
00:53:01,839 --> 00:52:59,150
know biological if you say there's any

1078
00:53:06,460 --> 00:53:01,849
Nanta more excess but you know it was

1079
00:53:10,170 --> 00:53:06,470
good work and so we'll have to see about

1080
00:53:14,650 --> 00:53:10,180
more about the biological amino acids

1081
00:53:18,009 --> 00:53:14,660
when you get to the 97 paper

1082
00:53:20,319 --> 00:53:18,019
Crona and a pizza reloj they as I said

1083
00:53:22,720 --> 00:53:20,329
the some of the strange amino acids that

1084
00:53:25,480 --> 00:53:22,730
are not in biology that there's no

1085
00:53:29,259 --> 00:53:25,490
question that they came from space so if

1086
00:53:33,250 --> 00:53:29,269
you see in anatomy excess you can say

1087
00:53:35,799 --> 00:53:33,260
that's real s indigenous for for a fact

1088
00:53:38,170 --> 00:53:35,809

those enantiomer excesses or in other

1089
00:53:41,380 --> 00:53:38,180
words one hand more than the other the

1090
00:53:41,650 --> 00:53:41,390
excess of one mirror image of the amino

1091
00:53:43,690 --> 00:53:41,660
acid

1092
00:53:46,660 --> 00:53:43,700
back then they were in the range

1093
00:53:51,009 --> 00:53:46,670
anywhere from 1% I think up to 10% and

1094
00:53:54,690 --> 00:53:51,019
this was more than one amino acid they

1095
00:53:58,480 --> 00:53:54,700
concentrated again on the non biological

1096
00:54:00,849 --> 00:53:58,490
and non non protein amino acids that's

1097
00:54:03,640 --> 00:54:00,859
another thing you won't want that aren't

1098
00:54:05,259 --> 00:54:03,650
laying around everywhere in proteins so

1099
00:54:10,900 --> 00:54:05,269
they were in the range of one to ten

1100
00:54:15,180 --> 00:54:10,910
percent and other people have done done

1101
00:54:17,680 --> 00:54:15,190
looked at those compounds to the paper

1102
00:54:21,430 --> 00:54:17,690
voice early morning I forget the year of

1103
00:54:24,749 --> 00:54:21,440
the paper but Glavine and Dworkin and I

1104
00:54:30,460 --> 00:54:24,759
think Jamie is Allah to they they did a

1105
00:54:35,019 --> 00:54:30,470
big survey of meteorites and they found

1106
00:54:37,900 --> 00:54:35,029
large excesses and and some of the same

1107
00:54:45,220 --> 00:54:37,910
amino acids I think they they went up to

1108
00:54:49,089 --> 00:54:45,230
20% and so 20 percent excess you know of

1109
00:54:53,680 --> 00:54:49,099
one enantiomer one mirror image and then

1110
00:54:56,499 --> 00:54:53,690
pizza reloj Santa Patrol found 50 or 60

1111
00:54:59,930 --> 00:54:56,509
percent excess you know one over the

1112
00:55:01,370 --> 00:54:59,940
other and other larger

1113
00:55:05,269 --> 00:55:01,380

amino acids I think these were

1114
00:55:07,759 --> 00:55:05,279
isoleucine derivatives but mostly with

1115
00:55:10,900 --> 00:55:07,769
the amino acids though you're talking

1116
00:55:15,140 --> 00:55:10,910
about that range of five to ten percent

1117
00:55:18,200 --> 00:55:15,150
excess just generally the ones we saw

1118
00:55:20,539 --> 00:55:18,210
last the now switched to sugar

1119
00:55:23,890 --> 00:55:20,549
derivatives away from amino acids so

1120
00:55:28,009 --> 00:55:23,900
last year in June we published that and

1121
00:55:30,829 --> 00:55:28,019
we went compound by compound increasing

1122
00:55:33,200 --> 00:55:30,839
carbon number so we went from Glassell

1123
00:55:35,359 --> 00:55:33,210
rick acid so instead of the sugar

1124
00:55:38,299 --> 00:55:35,369
glyceraldehyde if you have your organic

1125
00:55:42,349 --> 00:55:38,309
chemistry book the oxidized form is to

1126
00:55:45,380 --> 00:55:42,359
say rick acid so you add an oxygen and

1127
00:55:47,240 --> 00:55:45,390
you get an asset from that sugar so we

1128
00:55:49,309 --> 00:55:47,250
started with dosirak acid which is three

1129
00:55:51,829 --> 00:55:49,319
carbons then we went to four carbons

1130
00:55:54,230 --> 00:55:51,839
that's wreaths Roenick three hundred

1131
00:55:56,779 --> 00:55:54,240
five carbons five carbons is where you

1132
00:55:59,539 --> 00:55:56,789
get to the relative of ribose the very

1133
00:56:03,109 --> 00:55:59,549
close structural analog of ribose and

1134
00:56:05,900 --> 00:56:03,119
then we went to six carbons where

1135
00:56:09,589 --> 00:56:05,910
instead of glucose you have gluconic

1136
00:56:13,370 --> 00:56:09,599
acid most of those six carbons are rare

1137
00:56:16,700 --> 00:56:13,380
on earth gluconic is not so back to the

1138
00:56:20,749 --> 00:56:16,710

question at the first carbon number if

1139
00:56:24,380 --> 00:56:20,759
they were the CEREC it was 50/50 no

1140
00:56:26,120 --> 00:56:24,390
matter what meteorite you looked at 5050

1141
00:56:28,190 --> 00:56:26,130
now if you got a very contaminated you

1142
00:56:32,720 --> 00:56:28,200
meter i new newest contaminated you know

1143
00:56:37,339 --> 00:56:32,730
you can see a lot more d desert but for

1144
00:56:40,039 --> 00:56:37,349
normal mildly you know clean or super

1145
00:56:42,710 --> 00:56:40,049
clean meteorites the three carbons hit

1146
00:56:46,880 --> 00:56:42,720
fifty as you actually went up in carbon

1147
00:56:48,829 --> 00:56:46,890
number that spread increased so we went

1148
00:56:53,450 --> 00:56:48,839
to see four it was three to one

1149
00:56:56,509 --> 00:56:53,460
d reads ranking three honor we went to

1150
00:56:58,999 --> 00:56:56,519
the five carbon the rai banach acid the

1151
00:57:03,680 --> 00:56:59,009
cousin of ribose that was eight or nine

1152
00:57:09,559 --> 00:57:03,690
to one d we went up to the relatives of

1153
00:57:13,059 --> 00:57:09,569
glucose and it was only d we didn't see

1154
00:57:15,279 --> 00:57:13,069
any of the other mirror image to ale

1155
00:57:17,439 --> 00:57:15,289
and you know i-i-i would still not

1156
00:57:20,229 --> 00:57:17,449
believe it except the weird non earthly

1157
00:57:21,909 --> 00:57:20,239
ones are the same way there's no strict

1158
00:57:26,049 --> 00:57:21,919
boundary right there's no strict

1159
00:57:27,519 --> 00:57:26,059
definition that above 50 it's it's it's

1160
00:57:29,199 --> 00:57:27,529
my logical and below that it's not

1161
00:57:31,269 --> 00:57:29,209
instance it really depends on what

1162
00:57:32,949 --> 00:57:31,279
compounds you're talking about and so on

1163
00:57:35,019 --> 00:57:32,959

oh right right we're talking on a

1164
00:57:37,029 --> 00:57:35,029
molecular basis was found in life and

1165
00:57:41,559 --> 00:57:37,039
therefore can contaminate your

1166
00:57:45,909 --> 00:57:41,569
experiment and was not found and there

1167
00:57:49,419 --> 00:57:45,919
they all show this increase in excess of

1168
00:57:51,130 --> 00:57:49,429
one mirror image now I see so why we

1169
00:57:52,299 --> 00:57:51,140
have we're running close on time so I

1170
00:57:54,640 --> 00:57:52,309
just want to give there for you of

1171
00:57:58,179 --> 00:57:54,650
having one last question before we end

1172
00:57:59,890 --> 00:57:58,189
and that is Damian sterling hi Damian

1173
00:58:01,269 --> 00:57:59,900
thanks for your question and he is

1174
00:58:03,759 --> 00:58:01,279
asking perhaps a more speculative

1175
00:58:06,309 --> 00:58:03,769
question because life on Earth and life

1176
00:58:08,620 --> 00:58:06,319
on another terrestrial planets probably

1177
00:58:10,239 --> 00:58:08,630
came from the same building blocks he

1178
00:58:13,150 --> 00:58:10,249
asked do you think and speculatively

1179
00:58:15,249 --> 00:58:13,160
would with alien organisms also use your

1180
00:58:19,269 --> 00:58:15,259
peptides and DNA and and similar stuff

1181
00:58:21,130 --> 00:58:19,279
that were made of that's another good

1182
00:58:22,689 --> 00:58:21,140
question but you know I've heard

1183
00:58:23,919 --> 00:58:22,699
astronomers say we've seen the same

1184
00:58:27,219 --> 00:58:23,929
stuff everywhere

1185
00:58:31,929 --> 00:58:27,229
they look in space oh I think there's a

1186
00:58:34,329 --> 00:58:31,939
very good chance yes they figure this

1187
00:58:36,969 --> 00:58:34,339
one out Damian and then let us know

1188
00:58:38,499 --> 00:58:36,979

that's Nobel Prize type of result yeah

1189
00:58:41,279 --> 00:58:38,509
they might feel a different mirror image

1190
00:58:43,449 --> 00:58:41,289
but same right same compounds right

1191
00:58:45,459 --> 00:58:43,459
George I know you're a very busy person

1192
00:58:47,319 --> 00:58:45,469
and I'm so grateful and thankful that

1193
00:58:48,759 --> 00:58:47,329
you took time to talk to us today on

1194
00:58:51,579 --> 00:58:48,769
Sagan that it's been wonderful having

1195
00:58:53,880 --> 00:58:51,589
you best of luck on your research and we

1196
00:58:56,469 --> 00:58:53,890
hope to talk to you again in the future

1197
00:58:59,049 --> 00:58:56,479
if you are watching thank you for for

1198
00:59:01,749 --> 00:58:59,059
your questions hashtag ask Astro bio I

1199
00:59:03,669 --> 00:59:01,759
don't try don't forget to let me know if

1200
00:59:06,069 --> 00:59:03,679
you know what's what's behind me where

1201
00:59:07,839 --> 00:59:06,079
is that picture taken from so until then

1202
00:59:09,699 --> 00:59:07,849
we'll talk to you all next month for a

1203
00:59:11,019 --> 00:59:09,709
new episode of ask an astrobiologist and

1204
00:59:12,250 --> 00:59:11,029
please stay curious