
AbSciCon
2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:11,240 --> 00:00:09,160
[Applause]

3
00:00:12,530 --> 00:00:11,250
one of the things that's also happened

4
00:00:13,730 --> 00:00:12,540
in the last couple of years which I

5
00:00:16,100 --> 00:00:13,740
think is the sort of a final evolution

6
00:00:17,030 --> 00:00:16,110
of what we've done is changing the

7
00:00:18,950 --> 00:00:17,040
framework of how we think about

8
00:00:20,480 --> 00:00:18,960
biosignatures to understand that

9
00:00:22,340 --> 00:00:20,490
biosignatures must be interpreted in

10
00:00:24,230 --> 00:00:22,350
context of their environment and that

11
00:00:25,999 --> 00:00:24,240
that environment might suppress that by

12
00:00:27,440 --> 00:00:26,009
a signature false negative it might

13
00:00:29,600 --> 00:00:27,450

mimic that by a signature a false

14
00:00:32,480 --> 00:00:29,610
positive and it might change it in other

15
00:00:34,160 --> 00:00:32,490
ways and so we have sort of looked at

16
00:00:35,780 --> 00:00:34,170
oxygen to start with because that's our

17
00:00:37,310 --> 00:00:35,790
that's our golden child right we want to

18
00:00:39,260 --> 00:00:37,320
look for oxygen in the atmosphere and

19
00:00:43,549 --> 00:00:39,270
pioneered ways to understand how oxygen

20
00:00:44,990 --> 00:00:43,559
might be generated abiotic ly and that's

21
00:00:46,790 --> 00:00:45,000
the depressing thing but the promising

22
00:00:48,619 --> 00:00:46,800
thing is to then understand what are the

23
00:00:50,299 --> 00:00:48,629
observational discriminants of those

24
00:00:53,869 --> 00:00:50,309
processes in the atmosphere can we tell

25
00:00:55,369 --> 00:00:53,879
when a planet is trying to fool us and

26
00:00:56,840 --> 00:00:55,379
in doing all of this I think one of our

27
00:00:58,130 --> 00:00:56,850
other major goals is not just the

28
00:00:59,660 --> 00:00:58,140
science and the way we've changed the

29
00:01:02,299 --> 00:00:59,670
way we think about habitability and

30
00:01:03,889 --> 00:01:02,309
biosignatures but the amazing next

31
00:01:05,270 --> 00:01:03,899
generation of astrobiologists and

32
00:01:07,310 --> 00:01:05,280
mission scientists people who've you

33
00:01:10,490 --> 00:01:07,320
tied in to the missions who have come

34
00:01:12,679 --> 00:01:10,500
from this and so yeah big shout out to

35
00:01:15,230 --> 00:01:12,689
all of our early career people who are

36
00:01:16,460 --> 00:01:15,240
now moving and shaking and interfacing

37
00:01:18,350 --> 00:01:16,470
with mission development and getting

38
00:01:19,850 --> 00:01:18,360

astrobiology into those missions you

39
00:01:21,710 --> 00:01:19,860
heard in the plenary this morning how

40
00:01:24,350 --> 00:01:21,720
astrobiology focused our future missions

41
00:01:26,899 --> 00:01:24,360
are becoming we have strong mission

42
00:01:28,520 --> 00:01:26,909
relevance again we've done a whole bunch

43
00:01:30,800 --> 00:01:28,530
of things enhanced the small planet yo

44
00:01:32,600 --> 00:01:30,810
from Kepler simulated spectra to try and

45
00:01:34,730 --> 00:01:32,610
interpret HST and Spitzer data Travis

46
00:01:36,590 --> 00:01:34,740
one we've looked at environment spectra

47
00:01:38,660 --> 00:01:36,600
and detectability for JWST and you saw

48
00:01:40,969 --> 00:01:38,670
that this morning but we also are

49
00:01:43,490 --> 00:01:40,979
embedded in pretty much all of the study

50
00:01:45,920 --> 00:01:43,500
teams except links we have VPL people in

51
00:01:47,300 --> 00:01:45,930
OST Havoc's and before so we are doing

52
00:01:49,010 --> 00:01:47,310
our best to make sure that message of

53
00:01:51,649 --> 00:01:49,020
astrobiology is getting into the designs

54
00:01:53,660 --> 00:01:51,659
of these missions so I'm finishing up

55
00:01:57,679 --> 00:01:53,670
here I'm the VP L would not be here

56
00:01:59,990 --> 00:01:57,689
without the NAI and I mean the thing we

57
00:02:02,690 --> 00:02:00,000
really needed was that to have that

58
00:02:04,190 --> 00:02:02,700
funding over a very long period which

59
00:02:05,450 --> 00:02:04,200
allowed us to ultimately connect the

60
00:02:07,130 --> 00:02:05,460
microscope to the telescope there's

61
00:02:09,260 --> 00:02:07,140
Nikki paronto likes to say so that's

62
00:02:10,609 --> 00:02:09,270
what we've really done here with the

63
00:02:11,930 --> 00:02:10,619

research that crosses multiple divisions

64
00:02:13,550 --> 00:02:11,940
there's no way I could have put together

65
00:02:16,280 --> 00:02:13,560
this theme and had the individual

66
00:02:17,869 --> 00:02:16,290
programs actually pay for it so that was

67
00:02:18,400 --> 00:02:17,879
just absolutely instrumental in getting

68
00:02:20,050 --> 00:02:18,410
this done

69
00:02:21,610 --> 00:02:20,060
allowing us the time and the effort and

70
00:02:24,580 --> 00:02:21,620
the support from any i central and so on

71
00:02:26,020 --> 00:02:24,590
to help build those teams so the virtual

72
00:02:27,370 --> 00:02:26,030
collaboration is well we leptin with

73
00:02:28,840 --> 00:02:27,380
both boots on as well I understand that

74
00:02:32,050 --> 00:02:28,850
wasn't you know a big thing for some

75
00:02:33,760 --> 00:02:32,060
other teams yes but we loved it because

76
00:02:35,500 --> 00:02:33,770
for me it meant I could pick my team

77
00:02:37,090 --> 00:02:35,510
from anywhere I didn't have to stick to

78
00:02:38,950 --> 00:02:37,100
my host institution I could go out and

79
00:02:40,840 --> 00:02:38,960
have you you you you you I could go

80
00:02:42,520 --> 00:02:40,850
across national boundaries I could pick

81
00:02:43,720 --> 00:02:42,530
anybody I wanted and have them

82
00:02:45,490 --> 00:02:43,730
participate in that virtual

83
00:02:47,110 --> 00:02:45,500
collaboration and we've continued to do

84
00:02:48,310 --> 00:02:47,120
that we've evolved our tools you know

85
00:02:49,960 --> 00:02:48,320
we're now kind of in the zoom and the

86
00:02:51,670 --> 00:02:49,970
slack era when we started off with Adobe

87
00:02:54,070 --> 00:02:51,680
Connect and other things but we're still

88
00:02:56,530 --> 00:02:54,080

very much in that virtual space

89
00:02:57,640 --> 00:02:56,540
collaborating so I think the VPL

90
00:03:00,280 --> 00:02:57,650
experiment was a massive

91
00:03:02,350 --> 00:03:00,290
interdisciplinary basic massively

92
00:03:04,180 --> 00:03:02,360
interdisciplinary research topic and

93
00:03:05,440 --> 00:03:04,190
then the team that came with it and I

94
00:03:07,180 --> 00:03:05,450
think it's been successful and I think

95
00:03:08,860 --> 00:03:07,190
it's also scalable so things like the

96
00:03:11,650 --> 00:03:08,870
nexus research coordination network for

97
00:03:13,750 --> 00:03:11,660
example are sort of examples of where we

98
00:03:15,160 --> 00:03:13,760
as the VPLS can come in and make you

99
00:03:16,960 --> 00:03:15,170
four more connections and keep going and

100
00:03:19,060 --> 00:03:16,970
just interacting with the rest of the

101
00:03:21,700 --> 00:03:19,070
community there so things I've learned

102
00:03:23,800 --> 00:03:21,710
running the VPL so this is my experience

103
00:03:25,420 --> 00:03:23,810
in 18 years is that you have to have a

104
00:03:27,250 --> 00:03:25,430
vision and a focus question to get

105
00:03:28,540 --> 00:03:27,260
people to stick together and so it to

106
00:03:30,699 --> 00:03:28,550
work together and to and to do their

107
00:03:32,170 --> 00:03:30,709
signs proximity just putting people next

108
00:03:34,060 --> 00:03:32,180
to each other really doesn't spawn

109
00:03:35,530 --> 00:03:34,070
interdisciplinarity a common goal does

110
00:03:37,390 --> 00:03:35,540
and so you need a vision and a common

111
00:03:38,740 --> 00:03:37,400
goal for what you're gonna do I also

112
00:03:41,260 --> 00:03:38,750
like to think of interdisciplinarity as

113
00:03:42,820 --> 00:03:41,270

a pyramid everyone contributes you could

114
00:03:44,380 --> 00:03:42,830
have single discipline contribute it

115
00:03:45,640 --> 00:03:44,390
contributors at the bottom you know they

116
00:03:47,350 --> 00:03:45,650
might measure the flux of something in

117
00:03:49,090 --> 00:03:47,360
the fields but they feed up into a model

118
00:03:50,380 --> 00:03:49,100
that then uses that flux which is then

119
00:03:52,270 --> 00:03:50,390
working with the stellar atmospheric

120
00:03:54,220 --> 00:03:52,280
model or interaction model or whatever

121
00:03:56,560 --> 00:03:54,230
so there's this pyramid from single

122
00:03:58,270 --> 00:03:56,570
things that build up into a couple

123
00:03:59,320 --> 00:03:58,280
disciplines then ultimately to five or

124
00:04:00,880 --> 00:03:59,330
six disciplines at the top of that

125
00:04:02,229 --> 00:04:00,890
pyramid but even the single discipline

126
00:04:04,720 --> 00:04:02,239
people working towards that common goal

127
00:04:06,520 --> 00:04:04,730
at the top can be interdisciplinary pick

128
00:04:08,979 --> 00:04:06,530
your team members well that is so

129
00:04:10,240 --> 00:04:08,989
important I have a saying I can't repeat

130
00:04:12,070 --> 00:04:10,250
here because it's a family show but

131
00:04:13,510 --> 00:04:12,080
basically Vicki's first rule of team

132
00:04:16,270 --> 00:04:13,520
building is get rid of let's say the

133
00:04:17,380 --> 00:04:16,280
jerks okay so I'm it's really really

134
00:04:19,060 --> 00:04:17,390
important that you have people who are

135
00:04:21,340 --> 00:04:19,070
willing to work with each other and

136
00:04:23,710 --> 00:04:21,350
willing to interact willing to encourage

137
00:04:25,570 --> 00:04:23,720
a culture of scientific rigor and

138
00:04:26,200 --> 00:04:25,580

cooperation and not have competition get

139
00:04:28,180 --> 00:04:26,210
in the way of

140
00:04:29,350 --> 00:04:28,190
and of course there's nothing more

141
00:04:31,719 --> 00:04:29,360
rewarding than training your future

142
00:04:33,430 --> 00:04:31,729
colleagues and we've made a point in the

143
00:04:34,960 --> 00:04:33,440
VPL to train our colleagues not just in

144
00:04:36,700 --> 00:04:34,970
research but also in science management

145
00:04:39,520 --> 00:04:36,710
as well and we found that to be very

146
00:04:41,529 --> 00:04:39,530
very important and finally the point of

147
00:04:43,510 --> 00:04:41,539
our team was to have fun we are getting

148
00:04:45,310 --> 00:04:43,520
paid to get up each morning and search

149
00:04:58,450 --> 00:04:45,320
for life elsewhere and that is so cool

150
00:05:02,279 --> 00:04:58,460
and so with that I will finish and I'm

151
00:05:06,400 --> 00:05:02,289
so proud of everybody for going so fast

152
00:05:09,480 --> 00:05:06,410
our next speaker is Bruce jakosky come

153
00:05:11,710 --> 00:05:09,490
on up Bruce I met Bruce when I was a

154
00:05:13,990 --> 00:05:11,720
beginning graduate student at the

155
00:05:17,950 --> 00:05:14,000
University of Colorado and Bruce was a

156
00:05:19,540 --> 00:05:17,960
baby professor just come on board so we

157
00:05:23,800 --> 00:05:19,550
have known each other for an outrageous

158
00:05:25,659 --> 00:05:23,810
number of decades so Bruce is going to

159
00:05:27,010 --> 00:05:25,669
talk about the potential for life in the

160
00:05:29,379 --> 00:05:27,020
universe and the role of the NASA

161
00:05:35,129 --> 00:05:29,389
Astrobiology Institute and he was one of

162
00:05:44,260 --> 00:05:38,070
year there we go on that very first

163
00:05:49,629 --> 00:05:44,270

round of Nai funding after how many

164
00:05:54,159 --> 00:05:49,639
minutes thank you it's really a delight

165
00:05:57,249 --> 00:05:54,169
to be here although this is a different

166
00:06:00,370 --> 00:05:57,259
kind of talk for me for two reasons one

167
00:06:03,520 --> 00:06:00,380
is I don't want to just get up here and

168
00:06:05,409 --> 00:06:03,530
extol how wonderful the NAI was instead

169
00:06:10,210 --> 00:06:05,419
I want to take an historical perspective

170
00:06:14,649 --> 00:06:10,220
and talk about why B nai evolved sort of

171
00:06:17,439 --> 00:06:14,659
the life and times of life back in the

172
00:06:19,240 --> 00:06:17,449
90s when the NAI was forming and that's

173
00:06:21,370 --> 00:06:19,250
the second reason why this is a

174
00:06:24,040 --> 00:06:21,380
different talk I was telling Carl

175
00:06:27,730 --> 00:06:24,050
Pilcher yesterday morning that with this

176
00:06:30,100 --> 00:06:27,740
talk I've officially transitioned into

177
00:06:33,070 --> 00:06:30,110
being an old fart because I'm talking

178
00:06:34,600 --> 00:06:33,080
into historical session and Carl puts

179
00:06:42,189 --> 00:06:34,610
his hand on my shoulder and goes Bruce

180
00:06:48,460 --> 00:06:43,990
you know I think we're all here because

181
00:06:51,219 --> 00:06:48,470
of the excitement about life on earth

182
00:06:53,409 --> 00:06:51,229
and life in extreme environments the

183
00:06:56,050 --> 00:06:53,419
potential for life in our solar system

184
00:06:58,960 --> 00:06:56,060
the discovery of planets around other

185
00:07:00,610 --> 00:06:58,970
stars and as Viki put it the search for

186
00:07:02,710 --> 00:07:00,620
life elsewhere

187
00:07:04,270 --> 00:07:02,720
by the way Viki I presume it's because

188
00:07:11,230 --> 00:07:04,280

of your rule number one that I'm not on

189
00:07:13,149 --> 00:07:11,240
your team but I wanted to talk about the

190
00:07:15,610 --> 00:07:13,159
the evolution of thought because back

191
00:07:19,180 --> 00:07:15,620
when I got into this field in the

192
00:07:21,459 --> 00:07:19,190
Paleolithic era back in the 1970s the

193
00:07:23,469 --> 00:07:21,469
search for life elsewhere even though it

194
00:07:27,119 --> 00:07:23,479
was a fundamental part of the Viking

195
00:07:30,219 --> 00:07:27,129
mission to Mars was really separate from

196
00:07:32,709 --> 00:07:30,229
planetary science if you look at the

197
00:07:35,110 --> 00:07:32,719
missions that were flying Viking was the

198
00:07:37,570 --> 00:07:35,120
only one that really had any life

199
00:07:39,219 --> 00:07:37,580
connection the other missions I've

200
00:07:41,890 --> 00:07:39,229
listed some of them here we're all about

201
00:07:44,529 --> 00:07:41,900
exploring the solar system for the first

202
00:07:46,629 --> 00:07:44,539
time by the way everything I say is my

203
00:07:48,100 --> 00:07:46,639
own opinion and you're gonna find people

204
00:07:53,339 --> 00:07:48,110
in this room that disagree with

205
00:07:55,689 --> 00:07:53,349
everything I say even the words and and

206
00:07:57,640 --> 00:07:55,699
but everybody's got their own

207
00:08:00,010 --> 00:07:57,650
perspective and the reality of some

208
00:08:01,659 --> 00:08:00,020
combination of all of them but my last

209
00:08:03,010 --> 00:08:01,669
bullet here I thought there was at the

210
00:08:06,070 --> 00:08:03,020
time I thought there was a fundamental

211
00:08:09,790 --> 00:08:06,080
disconnect between mainstream planetary

212
00:08:11,619 --> 00:08:09,800
science and exobiology the the

213
00:08:13,600 --> 00:08:11,629

mainstream planetary scientists which

214
00:08:15,999 --> 00:08:13,610
was the path I came up through really

215
00:08:18,369 --> 00:08:16,009
didn't pay attention to exobiology other

216
00:08:22,269 --> 00:08:18,379
than watching what was happening on the

217
00:08:25,510 --> 00:08:22,279
Viking mission and as a result of the

218
00:08:28,149 --> 00:08:25,520
Viking mission life was pretty much dead

219
00:08:30,339 --> 00:08:28,159
there was no life on Mars there was no

220
00:08:35,529 --> 00:08:30,349
water on Mars it was a cold dry planet

221
00:08:37,269 --> 00:08:35,539
and any evidence for life was ancient so

222
00:08:40,959 --> 00:08:37,279
why were we searching for life on Mars

223
00:08:45,130 --> 00:08:40,969
anyways and one of the things that that

224
00:08:47,350 --> 00:08:45,140
I think marked the change at least with

225
00:08:50,180 --> 00:08:47,360
regard to the public was the Allen Hills

226
00:08:52,730 --> 00:08:50,190
meteorite in 1996

227
00:08:54,920 --> 00:08:52,740
that really brought out not not that

228
00:08:57,650 --> 00:08:54,930
people think today that there was

229
00:08:59,689 --> 00:08:57,660
evidence for life in that meteorite but

230
00:09:01,430 --> 00:08:59,699
it brought out the idea that there could

231
00:09:04,999 --> 00:09:01,440
be life on Mars there could be evidence

232
00:09:07,670 --> 00:09:05,009
for ancient life on Mars but that wasn't

233
00:09:09,980 --> 00:09:07,680
the only thing going on at the time and

234
00:09:12,410 --> 00:09:09,990
I've tried to put my perspective here on

235
00:09:14,319 --> 00:09:12,420
what was happening in the 1990s that

236
00:09:17,139 --> 00:09:14,329
really changed the intellectual

237
00:09:20,569 --> 00:09:17,149
environment around the search for life

238
00:09:22,550 --> 00:09:20,579

prior to the 90s we saw a real explosion

239
00:09:25,040 --> 00:09:22,560
in our understanding of life on Earth

240
00:09:28,069 --> 00:09:25,050
the potential for life in extreme

241
00:09:29,809 --> 00:09:28,079
environments environments where we

242
00:09:31,430 --> 00:09:29,819
didn't think life could have existed by

243
00:09:33,740 --> 00:09:31,440
the way I've put a few references up

244
00:09:37,189 --> 00:09:33,750
here just to have a few names purely an

245
00:09:38,480 --> 00:09:37,199
idiosyncratic list and again everybody

246
00:09:41,720 --> 00:09:38,490
in the room is going to disagree with

247
00:09:45,040 --> 00:09:41,730
who I might have listed but the key

248
00:09:50,980 --> 00:09:45,050
things in the the 80s and into the 90s

249
00:09:54,410 --> 00:09:50,990
were life in hydrothermal systems and in

250
00:09:57,170 --> 00:09:54,420
the events of the mid-ocean spreading

251
00:10:00,740 --> 00:09:57,180
centers the potential for life inside of

252
00:10:04,009 --> 00:10:00,750
rocks living off of chemical energy and

253
00:10:07,129 --> 00:10:04,019
then what happened and then the 90s I

254
00:10:11,960 --> 00:10:07,139
think was the the application of this to

255
00:10:13,579 --> 00:10:11,970
the planetary world and the first first

256
00:10:16,069 --> 00:10:13,589
time I became aware of this as a

257
00:10:18,740 --> 00:10:16,079
planetary scientist was the Boston at

258
00:10:20,900 --> 00:10:18,750
all 92 paper which when I became aware

259
00:10:23,410 --> 00:10:20,910
of it and realized the significance

260
00:10:25,579 --> 00:10:23,420
marked a turning point in my thought

261
00:10:27,559 --> 00:10:25,589
saying hey all those extreme

262
00:10:29,990 --> 00:10:27,569
environments on the earth they occur on

263
00:10:33,910 --> 00:10:30,000

Mars - so why can't there be life on

264
00:10:37,189 --> 00:10:33,920
Mars present or past we saw Mars

265
00:10:40,100 --> 00:10:37,199
evolving as a very water rich

266
00:10:42,710 --> 00:10:40,110
environment there is evidence for water

267
00:10:45,230 --> 00:10:42,720
now we we look at it evidence for liquid

268
00:10:47,689 --> 00:10:45,240
water throughout history in different

269
00:10:51,079 --> 00:10:47,699
places and even potential for liquid

270
00:10:53,660 --> 00:10:51,089
water at the surface today in in some

271
00:10:55,429 --> 00:10:53,670
environments or with the presence of

272
00:10:58,160 --> 00:10:55,439
perchlorates and deliquescent minerals

273
00:11:00,829 --> 00:10:58,170
maybe in all environments and then of

274
00:11:03,230 --> 00:11:00,839
course the Allen Hills meteorite also in

275
00:11:07,429 --> 00:11:03,240
the 90s was the recognition that Europa

276
00:11:10,280 --> 00:11:07,439
was an interesting world we saw the the

277
00:11:14,359 --> 00:11:10,290
recognition of the the geology that

278
00:11:17,470 --> 00:11:14,369
looked like icebergs the induced

279
00:11:23,030 --> 00:11:17,480
magnetic field that indicated a sub ice

280
00:11:24,739 --> 00:11:23,040
ocean and then my own little plug here

281
00:11:28,069 --> 00:11:24,749
the recognition of sources of energy

282
00:11:37,609 --> 00:11:28,079
that could support life on Mars or

283
00:11:41,119 --> 00:11:37,619
Europa finally in the 90s was the the

284
00:11:42,949 --> 00:11:41,129
first real discovery of planets orbiting

285
00:11:44,449 --> 00:11:42,959
other stars we always knew that they

286
00:11:46,639 --> 00:11:44,459
were going to be there we expected them

287
00:11:50,389 --> 00:11:46,649
to be there but actually finding them I

288
00:11:55,389 --> 00:11:50,399

think was a big deal with in the 90s we

289
00:11:57,079 --> 00:11:55,399
went from not having any really to

290
00:12:00,530 --> 00:11:57,089
believing that they were going to be

291
00:12:04,480 --> 00:12:00,540
very widespread so I see the the 90s as

292
00:12:07,509 --> 00:12:04,490
a fundamental time of shifting

293
00:12:11,179 --> 00:12:07,519
intellectual thought within this

294
00:12:13,189 --> 00:12:11,189
recognize that the NAI you know this was

295
00:12:16,509 --> 00:12:13,199
the whole period of the 90s the the

296
00:12:18,980 --> 00:12:16,519
Allen Hills meteorite was in 96 the NAI

297
00:12:22,419 --> 00:12:18,990
proposals were due for the first call in

298
00:12:25,160 --> 00:12:22,429
98 so the NAI wasn't the formation of

299
00:12:27,319 --> 00:12:25,170
astrobiology but it was a response to

300
00:12:29,960 --> 00:12:27,329
the changing intellectual environment

301
00:12:32,480 --> 00:12:29,970
and since then you know we went from one

302
00:12:34,129 --> 00:12:32,490
planet that could have life the earth to

303
00:12:36,259 --> 00:12:34,139
a whole slew here that were of

304
00:12:40,910 --> 00:12:36,269
astrobiological relevance or the could

305
00:12:44,809 --> 00:12:40,920
have life today and we see the search

306
00:12:47,090 --> 00:12:44,819
for life is really central to what was

307
00:12:48,410 --> 00:12:47,100
going on and I've got two charts left

308
00:12:50,239 --> 00:12:48,420
and I'm going to spend one minute on

309
00:12:52,489 --> 00:12:50,249
each since I have a minute each the

310
00:12:54,259 --> 00:12:52,499
first was what really highlighted to me

311
00:12:57,019 --> 00:12:54,269
the changing intellectual environment

312
00:13:00,379 --> 00:12:57,029
the first thing was the the carriage

313
00:13:03,590 --> 00:13:00,389

report on exobiology strategy and I have

314
00:13:08,299 --> 00:13:03,600
a quote here from it this was effective

315
00:13:10,160 --> 00:13:08,309
in 1908 in 1994 finally NASA's mission

316
00:13:11,960 --> 00:13:10,170
from Planet Earth study office has

317
00:13:14,119 --> 00:13:11,970
formally decided to make the search for

318
00:13:16,309 --> 00:13:14,129
life on Mars one of the overarching

319
00:13:17,270 --> 00:13:16,319
goals of long-term solar system

320
00:13:20,330 --> 00:13:17,280
exploration

321
00:13:22,790 --> 00:13:20,340
that's a really major shift the second

322
00:13:26,470 --> 00:13:22,800
thing is my third bullet whoops my third

323
00:13:29,540 --> 00:13:26,480
bullet there you can't tap the screen

324
00:13:35,480 --> 00:13:29,550
there was a Mars sample return workshop

325
00:13:36,950 --> 00:13:35,490
held in 2005 I'm sorry in in 1996 and at

326
00:13:39,770 --> 00:13:36,960
the end of that Mike Drake who is

327
00:13:43,070 --> 00:13:39,780
moderating the discussion session took a

328
00:13:44,870 --> 00:13:43,080
poll of the participants and that was

329
00:13:47,900 --> 00:13:44,880
the first time I saw a majority of

330
00:13:49,910 --> 00:13:47,910
planetary scientists agree with the idea

331
00:13:54,170 --> 00:13:49,920
that the search for life was the central

332
00:13:57,800 --> 00:13:54,180
theme of of planetary science and of

333
00:14:00,980 --> 00:13:57,810
Mars sample return so the 1990s was a

334
00:14:02,030 --> 00:14:00,990
time of changing environment so within

335
00:14:05,450 --> 00:14:02,040
that the NAI

336
00:14:08,180 --> 00:14:05,460
my take on what the NAI is looking back

337
00:14:08,990 --> 00:14:08,190
with 20 years hindsight the science was

338
00:14:12,560 --> 00:14:09,000

fundamental

339
00:14:15,380 --> 00:14:12,570
but the real role of the NAI was to

340
00:14:17,600 --> 00:14:15,390
create from scratch a community that had

341
00:14:20,000 --> 00:14:17,610
scientific interest fokin focused on

342
00:14:21,560 --> 00:14:20,010
questions about life to enhance these

343
00:14:23,960 --> 00:14:21,570
connections between earth science

344
00:14:27,070 --> 00:14:23,970
planetary science and astrophysics and

345
00:14:29,090 --> 00:14:27,080
to give legitimacy and credibility to

346
00:14:34,760 --> 00:14:29,100
science around the search for life

347
00:14:37,930 --> 00:14:34,770
elsewhere and within this the NAI what's

348
00:14:40,790 --> 00:14:37,940
what's most important is the NA I was

349
00:14:42,860 --> 00:14:40,800
not the instigator of the field of

350
00:14:45,500 --> 00:14:42,870
astrobiology it was the changing

351
00:14:47,510 --> 00:14:45,510
environment intellectual environment

352
00:14:49,310 --> 00:14:47,520
that did that the fundamental

353
00:14:51,830 --> 00:14:49,320
discoveries that were being made that

354
00:14:56,960 --> 00:14:51,840
changed intellectual thought the NAI was

355
00:14:59,570 --> 00:14:56,970
a mechanism of implementing a program so

356
00:15:01,910 --> 00:14:59,580
it wasn't that astrobiology was created

357
00:15:04,940 --> 00:15:01,920
programmatically or politically it was

358
00:15:07,130 --> 00:15:04,950
created scientifically and NASA was able

359
00:15:10,070 --> 00:15:07,140
to take advantage of this and really

360
00:15:13,850 --> 00:15:10,080
create a program in astrobiology and I

361
00:15:13,860 --> 00:15:20,069
[Applause]

362
00:15:29,319 --> 00:15:24,610
our next I'm short our next speaker is

363
00:15:31,960 --> 00:15:29,329

Jason Morgan and he is substituting for

364
00:15:34,660 --> 00:15:31,970
Michael Mumma who really wanted to be

365
00:15:36,429 --> 00:15:34,670
here and sent his profound regrets and

366
00:15:39,460 --> 00:15:36,439
not being able to be here but he's

367
00:15:51,489 --> 00:15:39,470
dealing with a family crisis and so we

368
00:15:53,230 --> 00:15:51,499
have you yes hi so Mike moba sends his

369
00:15:54,150 --> 00:15:53,240
regards and apologizes for not being

370
00:15:59,679 --> 00:15:54,160
able to be here

371
00:16:00,999 --> 00:15:59,689
so since I'm not the not a PI I'm just a

372
00:16:04,749 --> 00:16:01,009
co I let me tell you a little bit about

373
00:16:07,629 --> 00:16:04,759
my background I started off interest in

374
00:16:10,720 --> 00:16:07,639
the origins of life as an intern and

375
00:16:12,360 --> 00:16:10,730
then in 1985 and then I turned into an

376
00:16:15,009 --> 00:16:12,370
exobiologist

377
00:16:18,160 --> 00:16:15,019
doing very similar work but a different

378
00:16:19,509 --> 00:16:18,170
name I was a member of the N skorts the

379
00:16:21,460 --> 00:16:19,519
NASA specialize standard for resource

380
00:16:23,530 --> 00:16:21,470
and training in microbiology I actually

381
00:16:26,530 --> 00:16:23,540
have the privilege of being the first in

382
00:16:28,660 --> 00:16:26,540
skort students because my letter was

383
00:16:30,490 --> 00:16:28,670
hand-delivered because my office was

384
00:16:32,049 --> 00:16:30,500
right across the hall from the office

385
00:16:37,569 --> 00:16:32,059
where they were being written so I'm the

386
00:16:40,509 --> 00:16:37,579
first then I was fortunate to be in a

387
00:16:44,769 --> 00:16:40,519
postdoc at NASA Ames say Institute where

388
00:16:47,040 --> 00:16:44,779

I became a postdoc under can one doing

389
00:16:51,490 --> 00:16:47,050
I've suddenly became an astrobiologist

390
00:16:54,490 --> 00:16:51,500
and then I was hired by NASA Goddard to

391
00:16:56,230 --> 00:16:54,500
start off their astrobiology effort and

392
00:16:57,790 --> 00:16:56,240
then I discovered I was actually a

393
00:17:01,480 --> 00:16:57,800
planetary scientist I didn't know that

394
00:17:02,980 --> 00:17:01,490
at the time and then was lucky fortunate

395
00:17:03,579 --> 00:17:02,990
to be a member of can three five and

396
00:17:09,399 --> 00:17:03,589
seven

397
00:17:12,760 --> 00:17:09,409
and so Goddard had proposed for the fork

398
00:17:15,100 --> 00:17:12,770
and two and been profoundly unsuccessful

399
00:17:18,819 --> 00:17:15,110
and they did some soul-searching about

400
00:17:21,939 --> 00:17:18,829
what happens and they came up with a

401
00:17:25,780 --> 00:17:21,949
strategy in April 2002 to try and figure

402
00:17:29,160 --> 00:17:25,790
out how to be a more successful proposer

403
00:17:35,200 --> 00:17:29,170
and so the ideas were overly diffuse and

404
00:17:37,690 --> 00:17:35,210
in this case overly decentralized and an

405
00:17:44,410 --> 00:17:37,700
effort was made to make it institutional

406
00:17:46,500 --> 00:17:44,420
commitments to have three very

407
00:17:50,500 --> 00:17:46,510
significant pre-proposal commitments to

408
00:17:53,410 --> 00:17:50,510
investing in personnel and so micah de

409
00:17:56,980 --> 00:17:53,420
Santi and I were hired to help with this

410
00:17:59,050 --> 00:17:56,990
effort an example I like to give is if

411
00:18:01,350 --> 00:17:59,060
you look at the Wayback Machine of the

412
00:18:04,090 --> 00:18:01,360
website of the astrochemistry laboratory

413
00:18:07,180 --> 00:18:04,100

the department that I was hired into

414
00:18:08,950 --> 00:18:07,190
right before I was hired you can see in

415
00:18:14,160 --> 00:18:08,960
the tiny print that there are some

416
00:18:19,840 --> 00:18:14,170
things that are plausible astrobiology

417
00:18:21,310 --> 00:18:19,850
this is the our poster today and there's

418
00:18:23,980 --> 00:18:21,320
been a profound change not only it

419
00:18:28,530 --> 00:18:23,990
changed from eleven percent female to

420
00:18:30,670 --> 00:18:28,540
fifty-five percent female but also a

421
00:18:32,740 --> 00:18:30,680
proliferation of things that are

422
00:18:35,770 --> 00:18:32,750
plausibly astrobiology there's been a

423
00:18:40,960 --> 00:18:35,780
profound transformation of my

424
00:18:42,820 --> 00:18:40,970
departments because of of Nai and my

425
00:18:46,060 --> 00:18:42,830
department only consists of these four

426
00:18:49,750 --> 00:18:46,070
elements of the Goddard Center for

427
00:18:51,310 --> 00:18:49,760
astrobiology also consists of of other

428
00:18:53,310 --> 00:18:51,320
things in other departments at Goddard

429
00:18:57,360 --> 00:18:53,320
and of course the distributed network

430
00:19:02,500 --> 00:19:00,880
and so the impacts in addition to gains

431
00:19:05,110 --> 00:19:02,510
and personnel and a fundamental

432
00:19:08,440 --> 00:19:05,120
institutional shift in focus has been

433
00:19:10,210 --> 00:19:08,450
the stability brought by predictable

434
00:19:13,870 --> 00:19:10,220
five years of funding base

435
00:19:15,460 --> 00:19:13,880
predictability is not a common thing in

436
00:19:17,320 --> 00:19:15,470
governments and not a common thing in

437
00:19:20,110 --> 00:19:17,330
research and having being blessed by

438
00:19:24,120 --> 00:19:20,120

this ability you can make long-term

439
00:19:27,670 --> 00:19:24,130
plans we allocated most of the funding

440
00:19:31,500 --> 00:19:27,680
to early career members so that was me

441
00:19:33,790 --> 00:19:31,510
for a while and then not so much and

442
00:19:36,010 --> 00:19:33,800
providing matching funds to build

443
00:19:38,230 --> 00:19:36,020
laboratory equipment so this is part of

444
00:19:39,970 --> 00:19:38,240
my laboratory studying organics in

445
00:19:42,970 --> 00:19:39,980
meteorites in extra

446
00:19:45,639 --> 00:19:42,980
simply turn materials and analogs and as

447
00:19:48,070 --> 00:19:45,649
you can imagine or as you know from

448
00:19:49,720 --> 00:19:48,080
personal experience purchasing expensive

449
00:19:54,159 --> 00:19:49,730
laboratory equipment and maintaining it

450
00:19:56,230 --> 00:19:54,169
is very difficult even with polenta very

451
00:19:58,950 --> 00:19:56,240
major equipments and other programs so

452
00:20:01,119 --> 00:19:58,960
having matching funding provided by nai

453
00:20:04,480 --> 00:20:01,129
by the Goddard Center for astrobiology

454
00:20:06,700 --> 00:20:04,490
to help with these large capital

455
00:20:10,330 --> 00:20:06,710
investments has allowed this laboratory

456
00:20:13,080 --> 00:20:10,340
to flourish as well as the investment of

457
00:20:17,080 --> 00:20:13,090
the Center for further matching funds

458
00:20:19,330 --> 00:20:17,090
so the strategy in kanthri and beyond

459
00:20:27,509 --> 00:20:19,340
has been to have a coupled relationship

460
00:20:32,769 --> 00:20:27,519
between Oh between mission concepts

461
00:20:37,119 --> 00:20:32,779
initially things like the discovery

462
00:20:40,889 --> 00:20:37,129
ideas that that never bear fruits two

463
00:20:45,249 --> 00:20:40,899

things later on like Mars sandwich like

464
00:20:50,039 --> 00:20:45,259
sam zeff analysis at mars concepts MoMA

465
00:20:52,749 --> 00:20:50,049
concepts of Sowers Rex Caesar

466
00:20:55,869 --> 00:20:52,759
observations from ground and space-based

467
00:21:00,279 --> 00:20:55,879
telescopes to to bring the Astro int

468
00:21:02,639 --> 00:21:00,289
astrobiology modeling done in on

469
00:21:05,440 --> 00:21:02,649
computers and on old-fashioned paper

470
00:21:07,629 --> 00:21:05,450
simulations of laboratory environments

471
00:21:10,810 --> 00:21:07,639
of space environments in the laboratory

472
00:21:12,730 --> 00:21:10,820
and sample analysis of either those same

473
00:21:17,350 --> 00:21:12,740
simulations or authentic temperature

474
00:21:21,430 --> 00:21:17,360
material and so at some of the advances

475
00:21:24,759 --> 00:21:21,440
done since 2003 have naturally been on

476
00:21:27,369 --> 00:21:24,769
looking at the taxonomy of of comets and

477
00:21:30,610 --> 00:21:27,379
how they are indicative of their of

478
00:21:31,860 --> 00:21:30,620
their origins of their parents in the

479
00:21:36,639 --> 00:21:31,870
solar system

480
00:21:40,990 --> 00:21:36,649
looking at the plumes of of methane on

481
00:21:44,230 --> 00:21:41,000
Mars both from ground-based observations

482
00:21:49,240 --> 00:21:44,240
and in support of the Sam observations

483
00:21:52,180 --> 00:21:49,250
on Mars that happened recently the

484
00:21:52,989 --> 00:21:52,190
laboratory studies of surface mediated

485
00:21:56,219 --> 00:21:52,999
reactions

486
00:21:59,529 --> 00:21:56,229
looking at formation of complex organic

487
00:22:04,509 --> 00:21:59,539
polymers in early solar system

488
00:22:06,930 --> 00:22:04,519

environments to studying a variety of

489
00:22:09,460 --> 00:22:06,940
ice reactions and how they relate to

490
00:22:15,810 --> 00:22:09,470
observations seen immediate rights and

491
00:22:18,700 --> 00:22:15,820
in spectra to my own work looking at

492
00:22:20,289 --> 00:22:18,710
amino acids nucleobases it means

493
00:22:24,430 --> 00:22:20,299
carboxylic acids out ahaituki tones

494
00:22:25,869 --> 00:22:24,440
alcohols and PHS in a range of 50 or so

495
00:22:30,639 --> 00:22:25,879
meteorites and trying to understand how

496
00:22:32,379 --> 00:22:30,649
that fits in with the observations and

497
00:22:38,589 --> 00:22:32,389
making predictions on what should be

498
00:22:42,149 --> 00:22:38,599
studied in future missions and also

499
00:22:45,489 --> 00:22:42,159
helping develop protocols both for

500
00:22:48,460 --> 00:22:45,499
ExoMars and Sam Salvatore ex Caesar and

501
00:22:51,609 --> 00:22:48,470
even helping get some of the men iron

502
00:22:57,129 --> 00:22:51,619
work going that is then since taken off

503
00:22:58,299 --> 00:22:57,139
at JSC and so finally the goddess dinner

504
00:23:00,399 --> 00:22:58,309
for astrobiology had a principal

505
00:23:02,710 --> 00:23:00,409
question of why is Earth wet and alive

506
00:23:06,729 --> 00:23:02,720
and to answer these questions we've

507
00:23:08,820 --> 00:23:06,739
looked at naval regions follow the

508
00:23:11,830 --> 00:23:08,830
messengers looked at four modern worlds

509
00:23:17,109 --> 00:23:11,840
by searching the skies and searching our

510
00:23:20,769 --> 00:23:17,119
laboratories and nei has created a

511
00:23:23,859 --> 00:23:20,779
fundamental shift in the the research

512
00:23:25,930 --> 00:23:23,869
focus of the planetary science and the

513
00:23:28,359 --> 00:23:25,940

asteroid and some of the astrophysics at

514
00:23:29,560 --> 00:23:28,369
NASA Goddard and I thank you for your

515
00:23:31,760 --> 00:23:29,570
attention and thank you for your

516
00:23:37,369 --> 00:23:31,770
continued support

517
00:23:43,769 --> 00:23:41,700
our next speaker is Ariel and bark and I

518
00:23:46,440 --> 00:23:43,779
hope you're here Ariel I'm oh yeah there

519
00:23:48,180 --> 00:23:46,450
you are and Ariel is a special friend

520
00:23:50,489 --> 00:23:48,190
because he has the same name as my

521
00:23:53,639 --> 00:23:50,499
daughter who is an Ariel as well and

522
00:23:56,279 --> 00:23:53,649
does a lot of amazing work and has a

523
00:23:57,509 --> 00:23:56,289
very tantalizing title which I'm even

524
00:24:00,359 --> 00:23:57,519
going to read even though I'm not

525
00:24:02,039 --> 00:24:00,369
reading most of them let's see the

526
00:24:04,169 --> 00:24:02,049
mission to early Earth the 20 year

527
00:24:09,899 --> 00:24:04,179
legacy of NASA's first astrobiology

528
00:24:11,999 --> 00:24:09,909
sample return great thank you

529
00:24:13,320 --> 00:24:12,009
yes so in 10 minutes I'm gonna try to go

530
00:24:19,379 --> 00:24:13,330
through 20 slides that very quickly

531
00:24:21,089 --> 00:24:19,389
summarize yeah I am the legacy of of

532
00:24:22,560 --> 00:24:21,099
astrobiology investing in getting

533
00:24:24,060 --> 00:24:22,570
pristine samples from the early Earth

534
00:24:26,969 --> 00:24:24,070
and how that is important for

535
00:24:29,609 --> 00:24:26,979
astrobiology the punchline is kind of

536
00:24:33,539 --> 00:24:29,619
this this is the conventional wisdom now

537
00:24:36,479 --> 00:24:33,549
about how the has this laser work there

538
00:24:38,759 --> 00:24:36,489

we go about oxygen over through time in

539
00:24:41,099 --> 00:24:38,769
Earth history oxygen on the y-axis time

540
00:24:42,719 --> 00:24:41,109
here great oxidation event here about

541
00:24:44,639 --> 00:24:42,729
2.3 billion years ago and before that

542
00:24:45,989 --> 00:24:44,649
this notion has become conventional

543
00:24:48,359 --> 00:24:45,999
wisdom that there were small amounts of

544
00:24:50,009 --> 00:24:48,369
oxygen in the environments in in shallow

545
00:24:52,589 --> 00:24:50,019
marine environments but not accumulating

546
00:24:53,729 --> 00:24:52,599
in the atmosphere whiffs of oxygen and

547
00:24:55,440 --> 00:24:53,739
depicted here in this in a kind of

548
00:24:57,239 --> 00:24:55,450
cartoon fashion of a mildly oxygenated

549
00:24:59,940 --> 00:24:57,249
surface ocean but an an toxic atmosphere

550
00:25:01,979 --> 00:24:59,950
some very yook cynic sulfide rich parts

551
00:25:04,469 --> 00:25:01,989
of the ocean and at bulk ocean that was

552
00:25:06,690 --> 00:25:04,479
an toxic so this worldview kind of

553
00:25:09,269 --> 00:25:06,700
existed already 20 years ago but it was

554
00:25:10,680 --> 00:25:09,279
very fluid and and controversial and it

555
00:25:12,839 --> 00:25:10,690
really became cemented as conventional

556
00:25:14,700 --> 00:25:12,849
wisdom as a consequence of investments

557
00:25:17,039 --> 00:25:14,710
by the nei and in this sample sample

558
00:25:18,869 --> 00:25:17,049
return Everage and really we owe a lot

559
00:25:22,109 --> 00:25:18,879
of debt to Barry Bloomberg the founding

560
00:25:25,919 --> 00:25:22,119
director of the NAI so that's a little

561
00:25:28,349 --> 00:25:25,929
personal history here so Barry in 1999

562
00:25:31,469 --> 00:25:28,359
just FDA I've formed convened the first

563
00:25:33,839 --> 00:25:31,479

PI's meeting of the nei of the can one

564
00:25:36,180 --> 00:25:33,849
teams and I was part of the Harvard team

565
00:25:37,769 --> 00:25:36,190
led by Andy Noll who for some reason I

566
00:25:39,899 --> 00:25:37,779
think sending a not-so-subtle message

567
00:25:42,629 --> 00:25:39,909
about his thinking about the value of

568
00:25:44,999 --> 00:25:42,639
such meetings sent me in his place i I a

569
00:25:47,219 --> 00:25:45,009
baby professor at the time three years

570
00:25:47,850 --> 00:25:47,229
into a faculty job untenured so I was

571
00:25:50,370 --> 00:25:47,860
sent to represent

572
00:25:55,500 --> 00:25:50,380
the Harvard team and Barry had put out a

573
00:25:57,510 --> 00:25:55,510
call it spurred by Dan Goldin that the

574
00:25:59,490 --> 00:25:57,520
success the nei will be measured by its

575
00:26:02,160 --> 00:25:59,500
ability to mount astrobiology missions

576
00:26:04,500 --> 00:26:02,170
of course space missions was the the the

577
00:26:05,820 --> 00:26:04,510
focus but I said to Andy well if I'm

578
00:26:07,230 --> 00:26:05,830
gonna be there and their topic his

579
00:26:08,280 --> 00:26:07,240
missions and our team has nothing to do

580
00:26:10,140 --> 00:26:08,290
with missions how about I propose a

581
00:26:12,060 --> 00:26:10,150
mission to early Earth and he said yeah

582
00:26:13,260 --> 00:26:12,070
okay fine you know sacrificial baby

583
00:26:16,820 --> 00:26:13,270
professor II go ahead and do it say what

584
00:26:19,080 --> 00:26:16,830
you want to say so so I did that and and

585
00:26:20,400 --> 00:26:19,090
number the other PI's who are also had

586
00:26:22,049 --> 00:26:20,410
Geoscience backgrounds like this idea

587
00:26:23,640 --> 00:26:22,059
and buried like this idea he appreciated

588
00:26:25,230 --> 00:26:23,650

it and the basic concept was and this is

589
00:26:27,450 --> 00:26:25,240
a concept that there was a little more

590
00:26:28,919 --> 00:26:27,460
radical than that it is now that you

591
00:26:30,510 --> 00:26:28,929
know Earth's history encompasses

592
00:26:31,830 --> 00:26:30,520
embodies all sorts of alternative

593
00:26:32,820 --> 00:26:31,840
versions of Earth and that if we want to

594
00:26:34,710 --> 00:26:32,830
think about looking for life on other

595
00:26:36,930 --> 00:26:34,720
worlds it behooves us to understand the

596
00:26:38,310 --> 00:26:36,940
alternative earths of Earth's past now

597
00:26:39,690 --> 00:26:38,320
we actually have a team an AI team

598
00:26:40,860 --> 00:26:39,700
called the alternative Earth's team but

599
00:26:42,360 --> 00:26:40,870
at the time this was a little radical

600
00:26:43,799 --> 00:26:42,370
because the focus of astrobiology was

601
00:26:45,960 --> 00:26:43,809
not so much on exoplanets it was very

602
00:26:47,700 --> 00:26:45,970
much Mars in the solar system and the

603
00:26:49,289 --> 00:26:47,710
relating early Earth to Mars that was

604
00:26:51,150 --> 00:26:49,299
kind of a stretch so this wasn't nearly

605
00:26:54,900 --> 00:26:51,160
as clear thing to do but but Barry got

606
00:26:56,370 --> 00:26:54,910
it and others got it and so the context

607
00:26:58,110 --> 00:26:56,380
also in which this was going on was that

608
00:26:59,760 --> 00:26:58,120
there was a lot of arguments about the

609
00:27:01,890 --> 00:26:59,770
environment of the early Earth embodied

610
00:27:03,600 --> 00:27:01,900
very much by my undergraduate mentor

611
00:27:05,400 --> 00:27:03,610
dick Holland and one of his former

612
00:27:07,140 --> 00:27:05,410
mentees Hiroshi Emoto who were going at

613
00:27:08,970 --> 00:27:07,150

it like cats and dogs through the 1990s

614
00:27:10,289 --> 00:27:08,980
they were old friends they were old

615
00:27:11,760 --> 00:27:10,299
colleagues mentor and mentee but they

616
00:27:13,760 --> 00:27:11,770
disagreed vehemently about the amount of

617
00:27:15,840 --> 00:27:13,770
oxygen in Earth's ancient environment

618
00:27:17,760 --> 00:27:15,850
and this is the only photo I have of

619
00:27:19,919 --> 00:27:17,770
them together this is an astrobiology

620
00:27:23,669 --> 00:27:19,929
sponsored field trip around 2007-2008 in

621
00:27:25,650 --> 00:27:23,679
Canada and so there was this big debate

622
00:27:27,180 --> 00:27:25,660
and and it was clear that more samples

623
00:27:28,140 --> 00:27:27,190
were needed to sort of get to get

624
00:27:31,049 --> 00:27:28,150
through and resolve this argument

625
00:27:34,590 --> 00:27:31,059
between the two of them there was also

626
00:27:36,990 --> 00:27:34,600
this paper in 1999 which which raised a

627
00:27:39,299 --> 00:27:37,000
lot of interest in ruckus and and and a

628
00:27:41,630 --> 00:27:39,309
lot of consternation and arguments

629
00:27:45,539 --> 00:27:41,640
following that this was the discovery of

630
00:27:46,919 --> 00:27:45,549
molecular fossils of molecules that that

631
00:27:48,659 --> 00:27:46,929
at the time were argued to be evidence

632
00:27:50,700 --> 00:27:48,669
of santé bacteria and eukaryotes

633
00:27:52,680 --> 00:27:50,710
producing and requiring oxygen from

634
00:27:54,690 --> 00:27:52,690
rocks 2.7 billion years old

635
00:27:56,640 --> 00:27:54,700
this was landmark work led by Jochen

636
00:27:58,530 --> 00:27:56,650
brock's and Roger Buick and and Rogers

637
00:27:59,549 --> 00:27:58,540
summons and there was a lot of interest

638
00:28:00,900 --> 00:27:59,559

and there was an understanding of

639
00:28:01,200 --> 00:28:00,910
concern about contamination and all

640
00:28:02,909 --> 00:28:01,210
sorts of

641
00:28:04,230 --> 00:28:02,919
there was the notion that well if we had

642
00:28:05,159 --> 00:28:04,240
better samples we could really settle

643
00:28:07,680 --> 00:28:05,169
some of the debates that were emerging

644
00:28:10,049 --> 00:28:07,690
starting in 1999 so this whole notion

645
00:28:11,580 --> 00:28:10,059
that samples would really help was it

646
00:28:13,740 --> 00:28:11,590
was starting to emerge and Barry said ok

647
00:28:15,720 --> 00:28:13,750
mission earlier--the that sounds fine so

648
00:28:17,250 --> 00:28:15,730
once you do if somebody suggests I don't

649
00:28:18,930 --> 00:28:17,260
know who want you do a field trip so we

650
00:28:21,720 --> 00:28:18,940
ended up doing a field trip he naps a

651
00:28:24,720 --> 00:28:21,730
mission to early Earth this was in 2001

652
00:28:26,250 --> 00:28:24,730
this is a nice family photo taken at

653
00:28:28,080 --> 00:28:26,260
marble bar you may recognize some of

654
00:28:30,000 --> 00:28:28,090
these folks some of you may not because

655
00:28:34,409 --> 00:28:30,010
they they look don't look quite the same

656
00:28:36,480 --> 00:28:34,419
then as they do now and the leader of

657
00:28:38,430 --> 00:28:36,490
this trip was was Roger Buick here who

658
00:28:40,860 --> 00:28:38,440
does look remarkably today like he did

659
00:28:42,269 --> 00:28:40,870
in 1999 and pretty much like he did when

660
00:28:43,710 --> 00:28:42,279
I first met him 10 years before that

661
00:28:46,740 --> 00:28:43,720
when he was a postdoc at Harvard he has

662
00:28:48,930 --> 00:28:46,750
not aged he's like a vampire and and

663
00:28:50,460 --> 00:28:48,940

over here Tim Lyons who some of you may

664
00:28:52,320 --> 00:28:50,470
recognize he's a little grayer now but

665
00:28:54,240 --> 00:28:52,330
very recognizable this was actually

666
00:28:56,250 --> 00:28:54,250
Tim's first engagement with NASA and

667
00:28:57,539 --> 00:28:56,260
astrobiology was this field trip we knew

668
00:28:59,039 --> 00:28:57,549
we were going to look at old rocks and

669
00:29:00,870 --> 00:28:59,049
we wanted wide in the community and so

670
00:29:02,070 --> 00:29:00,880
so I and some others pulled Tim into

671
00:29:03,510 --> 00:29:02,080
this I was just getting to notes him at

672
00:29:04,860 --> 00:29:03,520
the time and so this was kind of this

673
00:29:07,860 --> 00:29:04,870
kind of landmark photo right again these

674
00:29:09,480 --> 00:29:07,870
these two people together and so Roger

675
00:29:10,919 --> 00:29:09,490
Lee led us through this this trip we

676
00:29:12,870 --> 00:29:10,929
were because of interest in organic

677
00:29:14,190 --> 00:29:12,880
molecules and ancient rocks and also

678
00:29:16,529 --> 00:29:14,200
what Tim brought to us which was

679
00:29:18,000 --> 00:29:16,539
interest in pilla redox proxies and I

680
00:29:19,710 --> 00:29:18,010
had interest there too as well as well

681
00:29:21,659 --> 00:29:19,720
as others we became very interested in

682
00:29:24,960 --> 00:29:21,669
black shales how can we get pristine

683
00:29:26,940 --> 00:29:24,970
black shales from from before the great

684
00:29:28,680 --> 00:29:26,950
oxidation event this is what those kind

685
00:29:29,940 --> 00:29:28,690
of rocks look like an outcrop there

686
00:29:31,529 --> 00:29:29,950
whether it's a pieces they don't look

687
00:29:33,450 --> 00:29:31,539
black at all and so this is why drilling

688
00:29:36,840 --> 00:29:33,460

is necessary hence the notion of sample

689
00:29:38,310 --> 00:29:36,850
return and also the existing archives of

690
00:29:41,039 --> 00:29:38,320
these samples are not always all that

691
00:29:42,240 --> 00:29:41,049
well preserved this is actually a we

692
00:29:43,740 --> 00:29:42,250
found this was actually a core

693
00:29:45,720 --> 00:29:43,750
repository that we encountered during

694
00:29:47,700 --> 00:29:45,730
that 2001 trip in the field I'm not very

695
00:29:49,049 --> 00:29:47,710
useful so the idea of doing science

696
00:29:51,389 --> 00:29:49,059
heavily targeted drilling preserve the

697
00:29:53,100 --> 00:29:51,399
samples do them well was was was it was

698
00:29:54,120 --> 00:29:53,110
a good idea we were the only ones I had

699
00:29:55,740 --> 00:29:54,130
this idea there were a bunch of other

700
00:29:57,720 --> 00:29:55,750
projects emerging about the same time

701
00:30:01,409 --> 00:29:57,730
how am i doing on time all right

702
00:30:03,029 --> 00:30:01,419
Hiroshi had mounted arguments for doing

703
00:30:03,990 --> 00:30:03,039
drilling as well so this is this is

704
00:30:05,250 --> 00:30:04,000
complicated I'm not going to walk

705
00:30:07,649 --> 00:30:05,260
through it the point is that it's

706
00:30:09,210 --> 00:30:07,659
complicated and the astrobiologist who

707
00:30:10,980 --> 00:30:09,220
played a key role not only in catalyzing

708
00:30:12,090 --> 00:30:10,990
us all to be thinking about this but

709
00:30:14,340 --> 00:30:12,100
then

710
00:30:16,739 --> 00:30:14,350
by 2003 Bruce reinecker was a director

711
00:30:18,090 --> 00:30:16,749
of Nai Bruce had a geology background he

712
00:30:19,769 --> 00:30:18,100
understood the value of this and he also

713
00:30:21,450 --> 00:30:19,779

understood the complexities and he

714
00:30:23,279 --> 00:30:21,460
helped really help the community really

715
00:30:26,070 --> 00:30:23,289
sort through the possible conflicts and

716
00:30:27,599 --> 00:30:26,080
competitions of that of that chart to

717
00:30:30,119 --> 00:30:27,609
make sure we actually would do this and

718
00:30:32,009 --> 00:30:30,129
do it well and then he was helped quite

719
00:30:33,180 --> 00:30:32,019
a bit by rose Grimes was the executive

720
00:30:34,950 --> 00:30:33,190
director of the NI at the time who also

721
00:30:36,930 --> 00:30:34,960
got it and was incredibly helpful behind

722
00:30:39,479 --> 00:30:36,940
the scenes and keeping funding moving

723
00:30:41,639 --> 00:30:39,489
and projects going and Karl also at the

724
00:30:44,129 --> 00:30:41,649
time before he was an a director and he

725
00:30:45,599 --> 00:30:44,139
became a director was also a great

726
00:30:47,669 --> 00:30:45,609
custodian and champion of this sort of

727
00:30:49,259 --> 00:30:47,679
work so Danny I played a very vital role

728
00:30:50,129 --> 00:30:49,269
in not just getting us out there

729
00:30:51,359 --> 00:30:50,139
thinking about this but then in

730
00:30:53,999 --> 00:30:51,369
shepherding this and turning into an

731
00:30:55,619 --> 00:30:54,009
actual something so one part of this

732
00:30:57,599 --> 00:30:55,629
I'll talk about one of these drill cores

733
00:30:59,759 --> 00:30:57,609
this is the famous abd p9 core that

734
00:31:01,019 --> 00:30:59,769
Roger is pointing to down here in

735
00:31:02,999 --> 00:31:01,029
Western Australia so this was the

736
00:31:05,580 --> 00:31:03,009
flagship of ten drill cores that were

737
00:31:09,570 --> 00:31:05,590
that were obtained over the course of

738
00:31:11,339 --> 00:31:09,580

this field campaign of sample return the

739
00:31:15,060 --> 00:31:11,349
intent of this was to be a kilometre

740
00:31:16,409 --> 00:31:15,070
long continuous core going from just

741
00:31:17,849 --> 00:31:16,419
before the great oxidation of actually

742
00:31:20,849 --> 00:31:17,859
from just before the great oxidation

743
00:31:23,519 --> 00:31:20,859
events back a couple hundred million

744
00:31:25,289 --> 00:31:23,529
years the the flagship target was to get

745
00:31:27,180 --> 00:31:25,299
to the the sediments down here the Roy

746
00:31:29,489 --> 00:31:27,190
Hill member this black shale down here

747
00:31:31,529 --> 00:31:29,499
which would be a pristine drilling of

748
00:31:34,950 --> 00:31:31,539
the drill of this of the sediments

749
00:31:36,719 --> 00:31:34,960
cemetry rocks from which summons and and

750
00:31:38,460 --> 00:31:36,729
brock's and view it could extract these

751
00:31:40,259 --> 00:31:38,470
biomarkers that was the the flagship

752
00:31:42,690 --> 00:31:40,269
goal of this but there was lots of other

753
00:31:44,070 --> 00:31:42,700
interesting rocks along the way like so

754
00:31:45,239 --> 00:31:44,080
many exploration missions like the

755
00:31:47,549 --> 00:31:45,249
drilling that's going on right now by

756
00:31:50,190 --> 00:31:47,559
insight we ran into problems it was

757
00:31:53,129 --> 00:31:50,200
actually kind of a disaster in that we

758
00:31:54,599 --> 00:31:53,139
never got any of this stuff because this

759
00:31:56,339 --> 00:31:54,609
the sections in the middle here where we

760
00:31:58,019 --> 00:31:56,349
drilled worth worth fault thickens so

761
00:31:59,820 --> 00:31:58,029
that you'd never never got through these

762
00:32:01,469 --> 00:31:59,830
carbonates we drilled a kilometer but we

763
00:32:04,320 --> 00:32:01,479

never got through the carbonates so

764
00:32:05,759 --> 00:32:04,330
ostensibly a disaster but like all such

765
00:32:09,570 --> 00:32:05,769
things you make the most of what you

766
00:32:11,700 --> 00:32:09,580
what you can do and we had a beautiful

767
00:32:13,139 --> 00:32:11,710
samples of this upper black shale here

768
00:32:16,109 --> 00:32:13,149
and so we threw all our energies into

769
00:32:19,799 --> 00:32:16,119
that so you can see we got these

770
00:32:21,479 --> 00:32:19,809
beautiful samples you can you know long

771
00:32:23,050 --> 00:32:21,489
long stretches of exquisitely preserved

772
00:32:25,570 --> 00:32:23,060
materials

773
00:32:27,580 --> 00:32:25,580
and what we threw at it were a whole lot

774
00:32:29,620 --> 00:32:27,590
of students and young who became quickly

775
00:32:32,260 --> 00:32:29,630
young postdocs and faculty in many of

776
00:32:34,180 --> 00:32:32,270
these phases we recognize now who are

777
00:32:35,290 --> 00:32:34,190
established faculty elsewhere some of

778
00:32:37,060 --> 00:32:35,300
these are still students now because

779
00:32:38,260 --> 00:32:37,070
this is these drill cores like any

780
00:32:40,690 --> 00:32:38,270
sample turn these are gifts that keep on

781
00:32:41,950 --> 00:32:40,700
giving I literally just got an abstract

782
00:32:44,050 --> 00:32:41,960
a draft abstract I was totally not

783
00:32:45,700 --> 00:32:44,060
expecting for GSA like two hours ago

784
00:32:47,560 --> 00:32:45,710
from a former undergraduate of mine

785
00:32:49,030 --> 00:32:47,570
who's now at Wits whole who's looking at

786
00:32:50,590 --> 00:32:49,040
cadmium isotopes these cores I didn't

787
00:32:52,540 --> 00:32:50,600
even know she was doing this so she

788
00:32:54,790 --> 00:32:52,550

wants to do abstract on this so 20 years

789
00:32:57,340 --> 00:32:54,800
later they're still new stuff coming but

790
00:32:59,560 --> 00:32:57,350
this gang here produced of students at

791
00:33:01,090 --> 00:32:59,570
Washington at Riverside at Arizona State

792
00:33:03,280 --> 00:33:01,100
University in particular produced a

793
00:33:05,710 --> 00:33:03,290
treasure trove of papers that continue

794
00:33:08,500 --> 00:33:05,720
to emerge that impact of the field and

795
00:33:10,030 --> 00:33:08,510
that basically you know cemented this

796
00:33:12,060 --> 00:33:10,040
worldview discovered this notion of

797
00:33:14,620 --> 00:33:12,070
whiffs of oxygen and made that a thing

798
00:33:19,030 --> 00:33:14,630
and inspired a whole bunch of other work

799
00:33:21,040 --> 00:33:19,040
that that extended that concept beyond

800
00:33:22,570 --> 00:33:21,050
just 2.5 billion years ago where mine

801
00:33:24,580 --> 00:33:22,580
Oakland ASCII and others and so there's

802
00:33:25,990 --> 00:33:24,590
there is now this strong sense that

803
00:33:27,280 --> 00:33:26,000
oxygen was being produced before the

804
00:33:28,630 --> 00:33:27,290
great oxidation event but it wasn't

805
00:33:30,880 --> 00:33:28,640
accumulating in the atmosphere that this

806
00:33:32,620 --> 00:33:30,890
is this is just you know a what that was

807
00:33:34,330 --> 00:33:32,630
pins these organic bio markers that

808
00:33:37,000 --> 00:33:34,340
whole story was tested separately and

809
00:33:38,560 --> 00:33:37,010
and and that's a whole nother story but

810
00:33:40,390 --> 00:33:38,570
independent the organic bio markers all

811
00:33:41,680 --> 00:33:40,400
these these these proxies that emerge

812
00:33:43,240 --> 00:33:41,690
from these black shales which are trace

813
00:33:45,310 --> 00:33:43,250

metal proxies an isotope proxies there's

814
00:33:47,440 --> 00:33:45,320
no time to actually talk about made a

815
00:33:50,080 --> 00:33:47,450
huge difference in how we think about

816
00:33:52,660 --> 00:33:50,090
this and so now you know legacy for

817
00:33:55,210 --> 00:33:52,670
those who are not geo scientists or not

818
00:33:58,090 --> 00:33:55,220
ancient sediment oxygen people like I am

819
00:34:00,520 --> 00:33:58,100
is that we start to think now when in

820
00:34:01,780 --> 00:34:00,530
terms of of looking for evidence of life

821
00:34:03,190 --> 00:34:01,790
we're starting to worry more and more

822
00:34:04,270 --> 00:34:03,200
about false negatives they're the

823
00:34:06,610 --> 00:34:04,280
Archaean earth was a false negative

824
00:34:08,139 --> 00:34:06,620
there was life it was producing oxygen

825
00:34:09,580 --> 00:34:08,149
probably but it wasn't acutely in the

826
00:34:11,830 --> 00:34:09,590
atmosphere you wouldn't see it today and

827
00:34:13,480 --> 00:34:11,840
so instead of focusing just on sources

828
00:34:14,770 --> 00:34:13,490
which is where the obsession has been we

829
00:34:16,090 --> 00:34:14,780
need to think a lot about sinks what was

830
00:34:17,290 --> 00:34:16,100
consuming that auction what was keeping

831
00:34:19,270 --> 00:34:17,300
it from rising even as it was being

832
00:34:20,590 --> 00:34:19,280
produced and that's leading them to a

833
00:34:22,659 --> 00:34:20,600
lot of interesting ferment of

834
00:34:23,950 --> 00:34:22,669
conversation between surface dirty of

835
00:34:26,590 --> 00:34:23,960
scientists like me and Tim and others

836
00:34:28,480 --> 00:34:26,600
and deep earth geo scientists who think

837
00:34:29,980 --> 00:34:28,490
about the bulk of the planet and how it

838
00:34:31,510 --> 00:34:29,990

might interact with the surface that

839
00:34:33,310 --> 00:34:31,520
bulk of the planet is an infinite sink

840
00:34:34,510 --> 00:34:33,320
for oxygen so it stands to reason that

841
00:34:34,750 --> 00:34:34,520
understanding those interactions is

842
00:34:37,510 --> 00:34:34,760
going to

843
00:34:39,129 --> 00:34:37,520
key and so the notion of exoplanetary

844
00:34:40,600 --> 00:34:39,139
science Viki alluded to this thinking of

845
00:34:42,370 --> 00:34:40,610
planets has not simply you know

846
00:34:43,240 --> 00:34:42,380
blackbody emitters that oh you don't

847
00:34:45,070 --> 00:34:43,250
have to think about what's going on

848
00:34:46,960 --> 00:34:45,080
inside is very important that is all

849
00:34:50,200 --> 00:34:46,970
kind of legacy of this in a sense this

850
00:34:51,430 --> 00:34:50,210
mission to early Earth in part and is

851
00:35:02,050 --> 00:34:51,440
going to be shaping what we think about

852
00:35:05,190 --> 00:35:02,060
for years to come so thank you our next

853
00:35:09,100 --> 00:35:05,200
presentation is Bill shop and I want to

854
00:35:12,430 --> 00:35:09,110
thank him many years in arrears for

855
00:35:14,970 --> 00:35:12,440
being such a wonderful enabler and

856
00:35:17,710 --> 00:35:14,980
mentor for graduate students of my era

857
00:35:19,420 --> 00:35:17,720
at Gordon conferences and many other

858
00:35:21,820 --> 00:35:19,430
opportunities and now I'm an old lady

859
00:35:22,990 --> 00:35:21,830
and I'm trying to pass it on so he's

860
00:35:24,550 --> 00:35:23,000
going to talk about the birth and

861
00:35:27,310 --> 00:35:24,560
gestation of the astrobiology

862
00:35:39,120 --> 00:35:27,320
game-changing Nai from his own personal

863
00:35:47,640 --> 00:35:42,950

thank you thank you for that kind in

864
00:35:52,589 --> 00:35:47,650
introduction probably not warranted but

865
00:35:56,660 --> 00:35:52,599
it was kind indeed I'm gonna start at

866
00:36:02,279 --> 00:35:56,670
the beginning this is one of the few

867
00:36:09,779 --> 00:36:02,289
advantages of being an old guy because I

868
00:36:13,049 --> 00:36:09,789
was there the founder of astrobiology

869
00:36:15,960 --> 00:36:13,059
for as far as I'm concerned was Carl

870
00:36:18,509 --> 00:36:15,970
Sagan and I was a graduate student at

871
00:36:21,690 --> 00:36:18,519
Harvard at the time and Carl was an

872
00:36:23,870 --> 00:36:21,700
assistant professor and one way or

873
00:36:29,770 --> 00:36:23,880
another we started having lunch together

874
00:36:35,710 --> 00:36:33,760
this is a always really just look most

875
00:36:39,820 --> 00:36:35,720
of my life I've been exceedingly

876
00:36:44,500 --> 00:36:39,830
fortunate and I was really fortunate he

877
00:36:47,770 --> 00:36:44,510
said my job was to he said my job was to

878
00:36:51,760 --> 00:36:47,780
teach him geology and biology and he

879
00:36:57,040 --> 00:36:51,770
would teach me astronomy that's Carl

880
00:37:01,300 --> 00:36:57,050
Sagan that was in the 1960s and let me

881
00:37:04,690 --> 00:37:01,310
let me remind us all that the 1960s was

882
00:37:06,820 --> 00:37:04,700
a tumult as time for this country in a

883
00:37:09,370 --> 00:37:06,830
whole lot of ways Vietnam war and a lot

884
00:37:13,420 --> 00:37:09,380
of other stuff going on which I don't

885
00:37:17,530 --> 00:37:13,430
have time to mention but with regard to

886
00:37:22,210 --> 00:37:17,540
NASA and the space exploration remember

887
00:37:24,900 --> 00:37:22,220
1961 with Yuri Gagarin this is a great

888
00:37:29,080 --> 00:37:24,910

defeat for the United States and a great

889
00:37:33,520 --> 00:37:29,090
triumph for the Soviet Union they put

890
00:37:35,770 --> 00:37:33,530
him into orbit around the world and we

891
00:37:38,020 --> 00:37:35,780
hadn't ever done Knut before and nobody

892
00:37:41,070 --> 00:37:38,030
else had done that before

893
00:37:43,839 --> 00:37:41,080
that was in April and a month later

894
00:37:45,700 --> 00:37:43,849
President Kennedy said to the Congress

895
00:37:48,640 --> 00:37:45,710
the country should commit itself to

896
00:37:51,460 --> 00:37:48,650
achieving the goal before this decade is

897
00:37:54,240 --> 00:37:51,470
out of landing a man on the moon and

898
00:37:58,210 --> 00:37:54,250
returning him safely to earth

899
00:38:03,630 --> 00:37:58,220
what we in fact did that with Apollo 11

900
00:38:07,150 --> 00:38:03,640
in Apollo 12 in 1969 1971 by that time

901
00:38:12,220 --> 00:38:07,160
Sagan had gone off to Cornell and I had

902
00:38:14,200 --> 00:38:12,230
gone off to UCLA and in 1968 his

903
00:38:16,690 --> 00:38:14,210
fledgling

904
00:38:19,030 --> 00:38:16,700
professor I was invited to be a member

905
00:38:23,170 --> 00:38:19,040
of the six-person preliminary

906
00:38:25,330 --> 00:38:23,180
examination team that the first studies

907
00:38:29,380 --> 00:38:25,340
of the lunar rocks while they were still

908
00:38:32,890 --> 00:38:29,390
under quarantine at Johnson Space Craft

909
00:38:34,690 --> 00:38:32,900
Center I was very much the younger guy I

910
00:38:37,890 --> 00:38:34,700
mean I was the youngest the the other

911
00:38:41,380 --> 00:38:37,900
five guys on our team were really really

912
00:38:42,970 --> 00:38:41,390
established people and they let me on it

913
00:38:47,350 --> 00:38:42,980

because they figured I wouldn't find

914
00:38:49,420 --> 00:38:47,360
anything they were right I got a bunch

915
00:38:54,130 --> 00:38:49,430
of papers out of it anyway

916
00:38:57,880 --> 00:38:54,140
there I am and that was the 1960s but it

917
00:39:01,840 --> 00:38:57,890
didn't it established for me a long-term

918
00:39:05,230 --> 00:39:01,850
relationship with NASA well during the

919
00:39:08,350 --> 00:39:05,240
subsequent few years I did fieldwork in

920
00:39:11,170 --> 00:39:08,360
Australia and India and I spent six

921
00:39:13,360 --> 00:39:11,180
months in the Soviet Union as an

922
00:39:15,400 --> 00:39:13,370
exchange scientist for the you know for

923
00:39:16,720 --> 00:39:15,410
the National Academy of Sciences during

924
00:39:19,270 --> 00:39:16,730
the height of the Cold War which was

925
00:39:21,970 --> 00:39:19,280
pretty awful folks with the KGB around

926
00:39:26,650 --> 00:39:21,980
and all that in any case that got back

927
00:39:29,350 --> 00:39:26,660
in 1977 was anointed the outstanding

928
00:39:32,410 --> 00:39:29,360
young scientists in the United States I

929
00:39:34,270 --> 00:39:32,420
had no knowledge of that I didn't know

930
00:39:36,820 --> 00:39:34,280
what the out of the watermen Ward was

931
00:39:39,550 --> 00:39:36,830
I'd never heard of it it was established

932
00:39:42,870 --> 00:39:39,560
a year earlier to commemorate the 200th

933
00:39:44,020 --> 00:39:42,880
anniversary of the United States and in

934
00:39:48,400 --> 00:39:44,030
1976

935
00:39:49,820 --> 00:39:48,410
so I happen to be the second guy and it

936
00:39:53,000 --> 00:39:49,830
carried a

937
00:39:55,370 --> 00:39:53,010
a large prize a large monetary prize and

938
00:40:00,770 --> 00:39:55,380

I hadn't been expecting this I had no

939
00:40:02,750 --> 00:40:00,780
idea what to do with it I spent several

940
00:40:04,490 --> 00:40:02,760
weeks thinking about it

941
00:40:06,440 --> 00:40:04,500
and I decided to put together a

942
00:40:09,590 --> 00:40:06,450
pipedream team that I'd thought about

943
00:40:11,320 --> 00:40:09,600
years before that would be

944
00:40:13,670 --> 00:40:11,330
interdisciplinary that would be

945
00:40:15,590 --> 00:40:13,680
international that would be composed of

946
00:40:18,830 --> 00:40:15,600
young people so we wouldn't be fettered

947
00:40:21,890 --> 00:40:18,840
by previous ideas about the missing

948
00:40:24,560 --> 00:40:21,900
Precambrian fossil record we'd work

949
00:40:27,170 --> 00:40:24,570
together at UCLA I thought for a year it

950
00:40:29,660 --> 00:40:27,180
turned out to be for 14 months and we

951
00:40:32,150 --> 00:40:29,670
might set some precedents for the field

952
00:40:34,700 --> 00:40:32,160
and for interdisciplinary science which

953
00:40:37,760 --> 00:40:34,710
simply was not done at that time I

954
00:40:39,890 --> 00:40:37,770
realized I didn't have enough money from

955
00:40:43,280 --> 00:40:39,900
the watermen award to fund this so I

956
00:40:48,080 --> 00:40:43,290
turned to the exobiology program at NASA

957
00:40:50,660 --> 00:40:48,090
I put in a proposal after checking with

958
00:40:55,820 --> 00:40:50,670
John Hayes who had worked with Klaus

959
00:40:57,200 --> 00:40:55,830
Pema at MIT on the Viking project and it

960
00:40:59,090 --> 00:40:57,210
was a friend of mine from graduate

961
00:41:03,470 --> 00:40:59,100
school when I was at Harvard he was at

962
00:41:06,580 --> 00:41:03,480
MIT and Malcom Walter whom I'd met doing

963
00:41:12,650 --> 00:41:06,590

when I was doing fieldwork in Australia

964
00:41:14,810 --> 00:41:12,660
they both were very skeptical this was a

965
00:41:17,630 --> 00:41:14,820
risky project that nobody had ever tried

966
00:41:20,300 --> 00:41:17,640
but they agreed to come along and with

967
00:41:24,140 --> 00:41:20,310
that with them in the fold I then

968
00:41:26,000 --> 00:41:24,150
applied to NASA and the two luminaries

969
00:41:28,599 --> 00:41:26,010
in the United States reviewed the

970
00:41:31,430 --> 00:41:28,609
proposal both of them turned it down

971
00:41:34,280 --> 00:41:31,440
also Varg horn and my professor said

972
00:41:37,310 --> 00:41:34,290
look science is done by individuals not

973
00:41:39,740 --> 00:41:37,320
by groups the idea of an

974
00:41:42,620 --> 00:41:39,750
interdisciplinary group was unheard of

975
00:41:45,020 --> 00:41:42,630
at that time although now it is very

976
00:41:48,640 --> 00:41:45,030
common and Preston cloud said it will

977
00:41:51,440 --> 00:41:48,650
not work there are no senior scientists

978
00:41:52,580 --> 00:41:51,450
well he's right we were not senior

979
00:41:56,420 --> 00:41:52,590
scientists we were wet-behind-the-ears

980
00:42:01,530 --> 00:41:56,430
but that's the way it went folks that

981
00:42:04,589 --> 00:42:01,540
was my notion well it turned out that

982
00:42:09,480 --> 00:42:04,599
dick young who was heading up the NASA X

983
00:42:10,650 --> 00:42:09,490
biology program funded in any way so off

984
00:42:12,300 --> 00:42:10,660
we went

985
00:42:17,220 --> 00:42:12,310
they brought their families to Los

986
00:42:19,770 --> 00:42:17,230
Angeles we worked together 14 months we

987
00:42:22,020 --> 00:42:19,780
picked out the first two billion years

988
00:42:23,790 --> 00:42:22,030

of Earth history we pooled our rocks

989
00:42:27,210 --> 00:42:23,800
together and we work like the dickens

990
00:42:29,579 --> 00:42:27,220
and had a wonderful time learning from

991
00:42:33,230 --> 00:42:29,589
each other every Wednesday night

992
00:42:36,540 --> 00:42:33,240
drinking beer and eatin pizza and

993
00:42:38,339 --> 00:42:36,550
arguing and getting educated and that's

994
00:42:43,140 --> 00:42:38,349
the way science should be it was

995
00:42:45,030 --> 00:42:43,150
beautiful all right all right so off we

996
00:42:48,780 --> 00:42:45,040
go folks

997
00:42:51,480 --> 00:42:48,790
we then there were 22 of us from four

998
00:42:53,609 --> 00:42:51,490
countries we got a National Book Prize

999
00:42:55,440 --> 00:42:53,619
for that book but we'd only covered two

1000
00:42:59,040 --> 00:42:55,450
billion years so we had to do it again

1001
00:43:01,530 --> 00:42:59,050
so there we went off again and this time

1002
00:43:03,810 --> 00:43:01,540
with 41 members added a whole bunch of

1003
00:43:06,270 --> 00:43:03,820
more interdisciplinary science eight

1004
00:43:08,849 --> 00:43:06,280
countries folks Australia Canada Denmark

1005
00:43:11,280 --> 00:43:08,859
Germany South Africa Sweden the United

1006
00:43:13,319 --> 00:43:11,290
States and the Soviet Union off we went

1007
00:43:15,630 --> 00:43:13,329
again we got another National Book Prize

1008
00:43:18,359 --> 00:43:15,640
out of that one all right we're doing

1009
00:43:21,329 --> 00:43:18,369
really well okay things are right we've

1010
00:43:24,329 --> 00:43:21,339
opened up this field oh my goodness and

1011
00:43:29,160 --> 00:43:24,339
that's the history of a dark PP RG p p

1012
00:43:31,470 --> 00:43:29,170
RG and then nai comes along in 1999 and

1013
00:43:36,500 --> 00:43:31,480

it doesn't matter what you plotted that

1014
00:43:41,910 --> 00:43:36,510
ordinate man the that plot is accurate

1015
00:43:44,250 --> 00:43:41,920
well in 1994-1995 juris often called me

1016
00:43:47,460 --> 00:43:44,260
from from washington and he says look i

1017
00:43:49,950 --> 00:43:47,470
want to set up the ni AI could I come

1018
00:43:51,660 --> 00:43:49,960
out to Los Angeles to UCLA talk with you

1019
00:43:53,370 --> 00:43:51,670
but he said I don't want to meet in your

1020
00:43:56,069 --> 00:43:53,380
lab I don't want to meet in your office

1021
00:43:58,079 --> 00:43:56,079
I want to meet at your home I do not

1022
00:44:00,359 --> 00:43:58,089
know why Dan Goldin has done the same

1023
00:44:02,640 --> 00:44:00,369
thing to me I don't they they think I'm

1024
00:44:04,010 --> 00:44:02,650
either either somebody's listening in I

1025
00:44:06,599 --> 00:44:04,020
don't know

1026
00:44:09,450 --> 00:44:06,609
anyhow he was the chief scientist for

1027
00:44:13,630 --> 00:44:09,460
Mars missions he was charged by golden

1028
00:44:17,680 --> 00:44:13,640
to establish a virtual PB RG he

1029
00:44:21,309 --> 00:44:17,690
in fact in 1999 NASA NASA establishes

1030
00:44:24,670 --> 00:44:21,319
the the virtual PP RG known as the nai

1031
00:44:26,740 --> 00:44:24,680
the nai I set the format for the format

1032
00:44:30,849 --> 00:44:26,750
for NASA's search for life in other

1033
00:44:35,170 --> 00:44:30,859
worlds and most importantly folks not

1034
00:44:38,759 --> 00:44:35,180
only astrobiology Sciences benefited but

1035
00:44:55,890 --> 00:44:38,769
everyone in this room has benefited as

1036
00:45:02,890 --> 00:44:55,900
well done thanks Bill

1037
00:45:05,200 --> 00:45:02,900
good times huh our next speaker John

1038
00:45:08,380 --> 00:45:05,210

Speer is a fellow caver friend and

1039
00:45:10,539 --> 00:45:08,390
fellow caver I say that first cuz that's

1040
00:45:13,390 --> 00:45:10,549
the most important thing and he had the

1041
00:45:16,990 --> 00:45:13,400
nerve to actually start his talk title

1042
00:45:21,249 --> 00:45:17,000
off with a an equation I'm just going to

1043
00:45:23,740 --> 00:45:21,259
call it an equal one John's gonna talk

1044
00:45:34,020 --> 00:45:23,750
about lessons on Earth from 20 years of

1045
00:45:40,840 --> 00:45:37,630
yeah first I'd like to thank the

1046
00:45:42,580 --> 00:45:40,850
organizers for this session and I would

1047
00:45:43,780 --> 00:45:42,590
like to thank all the previous speakers

1048
00:45:47,370 --> 00:45:43,790
up until now for making my job

1049
00:45:56,350 --> 00:45:54,790
dr. Soph you just nailed that so I work

1050
00:45:57,940 --> 00:45:56,360
at an engineering school Colorado School

1051
00:45:59,500 --> 00:45:57,950
of Mines and engineers like to speak in

1052
00:46:03,610 --> 00:45:59,510
equations and so that's why I threw up

1053
00:46:06,160 --> 00:46:03,620
an equation for my title and for from

1054
00:46:09,250 --> 00:46:06,170
prob stats this is N equals one union or

1055
00:46:11,740 --> 00:46:09,260
intersection X and to me we're wondering

1056
00:46:13,090 --> 00:46:11,750
you know there's elements in our

1057
00:46:15,460 --> 00:46:13,100
universe we're all made of these

1058
00:46:17,050 --> 00:46:15,470
elements and is there life elsewhere and

1059
00:46:19,000 --> 00:46:17,060
how are we connected to that life and to

1060
00:46:21,580 --> 00:46:19,010
me that's what astrobiology is so that's

1061
00:46:23,050 --> 00:46:21,590
what I wanted to begin with so I want to

1062
00:46:24,970 --> 00:46:23,060
begin with thanks I need to shout out

1063
00:46:27,340 --> 00:46:24,980

all the people of astrobiology many of

1064
00:46:28,990 --> 00:46:27,350
you are in this room and many of us have

1065
00:46:31,930 --> 00:46:29,000
been through here with time many people

1066
00:46:34,140 --> 00:46:31,940
are not in this room but the beauty of

1067
00:46:36,460 --> 00:46:34,150
the beauty the beautiful thing about

1068
00:46:38,830 --> 00:46:36,470
research to me is that it's a social

1069
00:46:39,940 --> 00:46:38,840
enterprise and Vicky mentioned for

1070
00:46:44,400 --> 00:46:39,950
example you don't want to work with

1071
00:46:46,420 --> 00:46:44,410
jerks I equivalent I equate that to

1072
00:46:50,350 --> 00:46:46,430
basically look at yourself and don't

1073
00:46:53,650 --> 00:46:50,360
ever be a dick I'm sorry it's just

1074
00:46:55,330 --> 00:46:53,660
that's what it is you want to work with

1075
00:46:58,390 --> 00:46:55,340
good people and I'm sorry to throw that

1076
00:47:01,660 --> 00:46:58,400
out there I just did science is we

1077
00:47:04,060 --> 00:47:01,670
science is not me it's all about we and

1078
00:47:06,580 --> 00:47:04,070
so if science only comes from a single

1079
00:47:07,930 --> 00:47:06,590
individual I say it comes from teams and

1080
00:47:09,370 --> 00:47:07,940
I want to thank the International geo

1081
00:47:11,020 --> 00:47:09,380
biology course which I worked with for

1082
00:47:12,490 --> 00:47:11,030
about 13 years and it's still going on

1083
00:47:14,020 --> 00:47:12,500
and I'll mention that pretty quick the

1084
00:47:16,990 --> 00:47:14,030
work I'm talking about briefly today has

1085
00:47:19,060 --> 00:47:17,000
been funded by three NASA entities I was

1086
00:47:21,790 --> 00:47:19,070
part of can one can three and can

1087
00:47:23,500 --> 00:47:21,800
currently can seven we also had some

1088
00:47:26,020 --> 00:47:23,510

funding from the NASA directors

1089
00:47:28,120 --> 00:47:26,030
discretionary fund under Carl and NASA

1090
00:47:31,090 --> 00:47:28,130
exobiology so I want to begin with

1091
00:47:33,100 --> 00:47:31,100
Earthrise this is a famous photo really

1092
00:47:34,960 --> 00:47:33,110
you know this kind of when I was a

1093
00:47:37,390 --> 00:47:34,970
little kid this photo changed my life

1094
00:47:39,520 --> 00:47:37,400
and it was taken by Bill Anders on

1095
00:47:42,520 --> 00:47:39,530
Apollo 8 and it was taken on Christmas

1096
00:47:43,660 --> 00:47:42,530
Eve of 1968 so we're up on the 50th year

1097
00:47:45,760 --> 00:47:43,670
or phenome

1098
00:47:47,350 --> 00:47:45,770
just over 50 years since this was taken

1099
00:47:49,030 --> 00:47:47,360
but he had this quote about it we went

1100
00:47:50,680 --> 00:47:49,040
all that way to discover the moon and

1101
00:47:53,320 --> 00:47:50,690
what we really discovered was the earth

1102
00:47:56,230 --> 00:47:53,330
and I think there's some validity to

1103
00:47:58,060 --> 00:47:56,240
that Galen Rowell who was himself a very

1104
00:47:59,200 --> 00:47:58,070
well known environmental photographer

1105
00:48:00,850 --> 00:47:59,210
considered this to be the most

1106
00:48:02,770 --> 00:48:00,860
influential environmental photograph

1107
00:48:05,470 --> 00:48:02,780
ever taken and it was commemorated on a

1108
00:48:09,250 --> 00:48:05,480
stamp for six cents you can mail a

1109
00:48:10,540 --> 00:48:09,260
first-class letter in 1969 and there

1110
00:48:11,770 --> 00:48:10,550
used to be this thing called mail you

1111
00:48:13,750 --> 00:48:11,780
can put stuff in an envelope you can

1112
00:48:16,780 --> 00:48:13,760
stick a stamp on it and you could

1113
00:48:20,410 --> 00:48:16,790

collect those stamps it was amazing and

1114
00:48:21,790 --> 00:48:20,420
so that's one of those stamps so this

1115
00:48:23,800 --> 00:48:21,800
thing called astrobiology we've been

1116
00:48:26,260 --> 00:48:23,810
talking about these last few days to me

1117
00:48:28,810 --> 00:48:26,270
has all these words in it so it's got a

1118
00:48:31,240 --> 00:48:28,820
strobe iog of physics I put physical but

1119
00:48:33,460 --> 00:48:31,250
physics mathematical chemical but it

1120
00:48:36,130 --> 00:48:33,470
also has a healthy dose of engineering

1121
00:48:38,470 --> 00:48:36,140
economics Liberal and Fine Arts all

1122
00:48:40,780 --> 00:48:38,480
these things come together into what I

1123
00:48:43,090 --> 00:48:40,790
consider to be astrobiology so I have to

1124
00:48:45,310 --> 00:48:43,100
give you a second equation and for me

1125
00:48:47,200 --> 00:48:45,320
the second equation is interfaces and

1126
00:48:49,600 --> 00:48:47,210
intersections equals opportunity divided

1127
00:48:52,300 --> 00:48:49,610
by people times generation so there it

1128
00:48:54,340 --> 00:48:52,310
is I 1 plus I 2 equals over P times G

1129
00:48:56,710 --> 00:48:54,350
and the reason why I put this up there

1130
00:48:58,360 --> 00:48:56,720
is because this equation has a few

1131
00:49:01,150 --> 00:48:58,370
variables in it and you need to decide

1132
00:49:02,560 --> 00:49:01,160
which variable you want to be and you

1133
00:49:05,560 --> 00:49:02,570
need to decide how are you gonna make

1134
00:49:08,230 --> 00:49:05,570
this equation work to solve the problems

1135
00:49:10,810 --> 00:49:08,240
that we all need to solve going forward

1136
00:49:12,190 --> 00:49:10,820
with astrobiology and I had two cups of

1137
00:49:14,620 --> 00:49:12,200
tea when I made that equation so there's

1138
00:49:17,890 --> 00:49:14,630

probably errors in it I needed like four

1139
00:49:21,010 --> 00:49:17,900
cups of tea when I went to my first nei

1140
00:49:22,720 --> 00:49:21,020
meeting it was at NASA Ames in 1999 when

1141
00:49:25,300 --> 00:49:22,730
I was the start at the start of a

1142
00:49:26,530 --> 00:49:25,310
beginning of a six year long postdoc it

1143
00:49:28,630 --> 00:49:26,540
was actually the very first meeting I

1144
00:49:31,450 --> 00:49:28,640
went to as a postdoc the first guy I met

1145
00:49:33,700 --> 00:49:31,460
was an extremely well-dressed man and

1146
00:49:35,500 --> 00:49:33,710
that was Jerry soften he was the nicest

1147
00:49:38,320 --> 00:49:35,510
guy he was the project scientist for

1148
00:49:40,840 --> 00:49:38,330
Viking Viking was built in my hometown

1149
00:49:43,210 --> 00:49:40,850
by all of my parents friends in LA

1150
00:49:45,940 --> 00:49:43,220
cañada California so I was very familiar

1151
00:49:48,040 --> 00:49:45,950
with Viking when I was a little kid cuz

1152
00:49:49,330 --> 00:49:48,050
all my parents friends work there I mean

1153
00:49:51,490 --> 00:49:49,340
all my friends parents worked there it

1154
00:49:53,890 --> 00:49:51,500
was great second first I met was Barry

1155
00:49:55,390 --> 00:49:53,900
Bloomberg and I actually met Barry 10

1156
00:49:55,870 --> 00:49:55,400
years prior because we both worked with

1157
00:49:57,970 --> 00:49:55,880
virus

1158
00:50:00,309 --> 00:49:57,980
is he got the Nobel Prize for working on

1159
00:50:03,670 --> 00:50:00,319
hepatitis B I did not for working on

1160
00:50:05,680 --> 00:50:03,680
herpes but we used we used to tease each

1161
00:50:08,799 --> 00:50:05,690
other that's like you know helps better

1162
00:50:11,380 --> 00:50:08,809
than her you know and there are all

1163
00:50:13,749 --> 00:50:11,390

these other people that are critical to

1164
00:50:16,599 --> 00:50:13,759
my astrobiological path and there are

1165
00:50:18,309 --> 00:50:16,609
really hundreds or thousands that are

1166
00:50:20,140 --> 00:50:18,319
that should be on this list but I can't

1167
00:50:22,839 --> 00:50:20,150
stick hundreds or thousands on there so

1168
00:50:24,670 --> 00:50:22,849
I just stuck up a few and all these

1169
00:50:26,319 --> 00:50:24,680
people have been instrumental in my own

1170
00:50:27,460 --> 00:50:26,329
development as a scientist and this is

1171
00:50:28,769 --> 00:50:27,470
something the way we need to think about

1172
00:50:31,120 --> 00:50:28,779
each other

1173
00:50:32,799 --> 00:50:31,130
the first project project that I worked

1174
00:50:34,720 --> 00:50:32,809
on was with David Deamer a brad Beebe

1175
00:50:36,609 --> 00:50:34,730
out and Tory Haller we worked on

1176
00:50:39,370 --> 00:50:36,619
laminated microbial mats in Guerrero

1177
00:50:42,370 --> 00:50:39,380
negro Baja California Sur about ten

1178
00:50:44,769 --> 00:50:42,380
hours south of San Diego and these mats

1179
00:50:46,749 --> 00:50:44,779
are incredible they are five six

1180
00:50:48,819 --> 00:50:46,759
centimeters thick I worked on them with

1181
00:50:50,349 --> 00:50:48,829
Ruth ley we were postdocs at the time

1182
00:50:52,509 --> 00:50:50,359
with Norman paste at the University of

1183
00:50:55,599 --> 00:50:52,519
Colorado Boulder we stuck out a paper

1184
00:50:57,519 --> 00:50:55,609
and in this paper we described you know

1185
00:51:00,160 --> 00:50:57,529
microbial life and these laminated mats

1186
00:51:02,890 --> 00:51:00,170
we figured that about a cubic centimeter

1187
00:51:05,230 --> 00:51:02,900
of this mat has the equivalent diversity

1188
00:51:07,809 --> 00:51:05,240

of a square kilometer of rainforest at a

1189
00:51:09,370 --> 00:51:07,819
minimum in terms of numbers and kinds of

1190
00:51:12,009 --> 00:51:09,380
whatever you want to think of as a

1191
00:51:15,190 --> 00:51:12,019
species or an operational taxonomic unit

1192
00:51:16,420 --> 00:51:15,200
ot use as they are known the second

1193
00:51:17,740 --> 00:51:16,430
thing we worked out a career our Negro

1194
00:51:20,499 --> 00:51:17,750
were evaporites

1195
00:51:22,539 --> 00:51:20,509
and these are gypsum halite combinations

1196
00:51:25,269 --> 00:51:22,549
of solid rock when you break one open

1197
00:51:27,160 --> 00:51:25,279
they are this vivid rainbow and they're

1198
00:51:29,650 --> 00:51:27,170
beautiful and they're fun to look at and

1199
00:51:32,380 --> 00:51:29,660
fun to describe and Jason Saul and I put

1200
00:51:36,099 --> 00:51:32,390
out a paper about what's in there my

1201
00:51:37,839 --> 00:51:36,109
next moved on to DEP Thanks this is the

1202
00:51:40,120 --> 00:51:37,849
deep free attic thermal Explorer I

1203
00:51:43,059 --> 00:51:40,130
worked with Carnegie Mellon University

1204
00:51:44,769 --> 00:51:43,069
and stone Aerospace with Bill stone down

1205
00:51:46,930 --> 00:51:44,779
in Austin Texas and we developed this

1206
00:51:49,740 --> 00:51:46,940
machine to be a robotic environmental

1207
00:51:51,880 --> 00:51:49,750
microbiologist that could explore

1208
00:51:54,130 --> 00:51:51,890
limestone holes in the ground that are

1209
00:51:56,140 --> 00:51:54,140
filled with water and depth-x was a

1210
00:51:57,700 --> 00:51:56,150
great project this was a hoot it was a

1211
00:52:00,039 --> 00:51:57,710
lot of fun we worked on this for a

1212
00:52:02,230 --> 00:52:00,049
number of years this is where it became

1213
00:52:05,109 --> 00:52:02,240

really apparent to me that the blending

1214
00:52:06,609 --> 00:52:05,119
of engineering different disciplines and

1215
00:52:09,250 --> 00:52:06,619
what you can accomplish and what you can

1216
00:52:12,250 --> 00:52:09,260
do is really boundless you can

1217
00:52:14,350 --> 00:52:12,260
do so much this is a project that is an

1218
00:52:17,410 --> 00:52:14,360
illustration because it never happened

1219
00:52:18,340 --> 00:52:17,420
this is a dream our next robotic project

1220
00:52:20,860 --> 00:52:18,350
that we always want to do that we

1221
00:52:22,840 --> 00:52:20,870
pitched a P star a couple of times was

1222
00:52:24,430 --> 00:52:22,850
to develop an arrow bot that could

1223
00:52:26,350 --> 00:52:24,440
explore things like hot springs and

1224
00:52:28,810 --> 00:52:26,360
we've since developed this a little

1225
00:52:31,150 --> 00:52:28,820
further along but it's still in dream

1226
00:52:32,770 --> 00:52:31,160
phase thank you

1227
00:52:35,260 --> 00:52:32,780
project we've worked on at Ellesmere

1228
00:52:37,660 --> 00:52:35,270
Island is an analogue for Jupiter's moon

1229
00:52:40,120 --> 00:52:37,670
Europa where it's sulfur on ice this is

1230
00:52:41,770 --> 00:52:40,130
the barb fjord pass glacier project and

1231
00:52:44,320 --> 00:52:41,780
we've had a couple of papers out on that

1232
00:52:45,700 --> 00:52:44,330
we can talk further should you like to

1233
00:52:47,440 --> 00:52:45,710
in our current project is with rock

1234
00:52:49,840 --> 00:52:47,450
powered life and we're working on the

1235
00:52:52,450 --> 00:52:49,850
samayal via light of Oman looking at

1236
00:52:54,700 --> 00:52:52,460
serpentinization reactions where we're

1237
00:52:56,560 --> 00:52:54,710
looking at Rock cores to see how water

1238
00:52:58,390 --> 00:52:56,570

reacts with iron bearing rock to make

1239
00:53:00,400 --> 00:52:58,400
molecular hydrogen that microbes then

1240
00:53:02,500 --> 00:53:00,410
thrive on and this is a fantastic

1241
00:53:04,390 --> 00:53:02,510
project that's ongoing right now

1242
00:53:07,000 --> 00:53:04,400
Emily Krauss will be talking at this

1243
00:53:09,580 --> 00:53:07,010
afternoon at 4:40 about some early work

1244
00:53:11,320 --> 00:53:09,590
where we're finding a methanogens story

1245
00:53:13,150 --> 00:53:11,330
or a story about methanogens in this

1246
00:53:15,850 --> 00:53:13,160
environment I encourage you to check

1247
00:53:17,500 --> 00:53:15,860
that out if you can the last thing I

1248
00:53:19,660 --> 00:53:17,510
wanted to mention was our work with the

1249
00:53:21,730 --> 00:53:19,670
international geo biology course this

1250
00:53:23,950 --> 00:53:21,740
started in 2002 we've had some

1251
00:53:26,620 --> 00:53:23,960
astrobiology and exobiology money along

1252
00:53:28,300 --> 00:53:26,630
the way we've had almost 300 alumni go

1253
00:53:30,580 --> 00:53:28,310
through this course many are in this

1254
00:53:33,220 --> 00:53:30,590
room is a fantastic thing and the reason

1255
00:53:35,380 --> 00:53:33,230
why I do it or did it was because of

1256
00:53:37,240 --> 00:53:35,390
this quote from Cicero I think who knows

1257
00:53:40,060 --> 00:53:37,250
only his own generation remains always a

1258
00:53:42,940 --> 00:53:40,070
child and so to that my call to you is

1259
00:53:44,500 --> 00:53:42,950
train the next generation well and you

1260
00:53:46,300 --> 00:53:44,510
can say that we are coming but you also

1261
00:53:49,420 --> 00:53:46,310
need to think about they are coming

1262
00:53:56,930 --> 00:53:51,480
[Music]

1263
00:54:02,180 --> 00:53:56,940

[Applause]

1264
00:54:07,500 --> 00:54:02,190
so our next speaker is Bob Hazen and I

1265
00:54:09,180 --> 00:54:07,510
blame him for having to change my way of

1266
00:54:13,319 --> 00:54:09,190
teaching geobiology when I was a

1267
00:54:17,160 --> 00:54:13,329
professor the whole concept of mineral

1268
00:54:19,770 --> 00:54:17,170
evolution I think is revolutionized our

1269
00:54:24,059 --> 00:54:19,780
thinking our field and certainly my

1270
00:54:25,500 --> 00:54:24,069
approach to the subject so thank you

1271
00:54:27,799 --> 00:54:25,510
penny and Carl and all of you and the

1272
00:54:30,329 --> 00:54:27,809
chance to thank astrobiology Institute

1273
00:54:31,799 --> 00:54:30,339
I'm come here with the perspective

1274
00:54:33,420 --> 00:54:31,809
obviously from the Carnegie Institution

1275
00:54:35,640 --> 00:54:33,430
and even more so from my personal

1276
00:54:37,890 --> 00:54:35,650
perspective is a mineralogist but I

1277
00:54:40,470 --> 00:54:37,900
think it has lessons for all of us I

1278
00:54:42,329 --> 00:54:40,480
first got into this field in 1996 when

1279
00:54:44,640 --> 00:54:42,339
Harold Moore what's came to my office is

1280
00:54:46,500 --> 00:54:44,650
Bob look at this I've just discovered

1281
00:54:48,480 --> 00:54:46,510
here was a theoretical biologist some of

1282
00:54:50,190 --> 00:54:48,490
you may note and he was showing me the

1283
00:54:52,079 --> 00:54:50,200
dielectric constant of water at high

1284
00:54:53,880 --> 00:54:52,089
temperature and pressure was more like

1285
00:54:55,380 --> 00:54:53,890
an organic solvent than you might think

1286
00:54:58,559 --> 00:54:55,390
and he said has anybody been doing

1287
00:55:00,390 --> 00:54:58,569
organic chemistry at high pressure and

1288
00:55:02,670 --> 00:55:00,400

high temperature well I didn't know that

1289
00:55:03,990 --> 00:55:02,680
much about it and so I said let's look

1290
00:55:06,420 --> 00:55:04,000
at it and it turns out there were some

1291
00:55:08,370 --> 00:55:06,430
experiments to do so I contacted my lab

1292
00:55:10,530 --> 00:55:08,380
colleague hatton Yoder he had a great

1293
00:55:12,270 --> 00:55:10,540
high pressure high temperature apparatus

1294
00:55:13,799 --> 00:55:12,280
although he was an experimental

1295
00:55:15,720 --> 00:55:13,809
petrology stand he also didn't know

1296
00:55:17,490 --> 00:55:15,730
anything about organic chemists but

1297
00:55:18,870 --> 00:55:17,500
George Cody happened to have come to the

1298
00:55:20,940 --> 00:55:18,880
lab recently he's an organic

1299
00:55:22,950 --> 00:55:20,950
geochemistry of us worked together on

1300
00:55:25,410 --> 00:55:22,960
what I think now are incredibly naive

1301
00:55:28,049 --> 00:55:25,420
experiments the first one we took a gold

1302
00:55:29,730 --> 00:55:28,059
tube we sealed pyruvic acid and co2 into

1303
00:55:32,339 --> 00:55:29,740
the capsule and we're hoping to make a

1304
00:55:34,289 --> 00:55:32,349
pure oxaloacetate that's a step in the

1305
00:55:36,410 --> 00:55:34,299
TCA cycle we got a science paper out of

1306
00:55:39,270 --> 00:55:36,420
it and would only take a couple of weeks

1307
00:55:41,099 --> 00:55:39,280
yes that isn't what happened we got we

1308
00:55:42,630 --> 00:55:41,109
got a real mess out of that capsule what

1309
00:55:45,000 --> 00:55:42,640
it showed us is there's an awful lot to

1310
00:55:47,220 --> 00:55:45,010
learn about hydrothermal organic

1311
00:55:49,049 --> 00:55:47,230
synthesis and that this perhaps is a

1312
00:55:51,059 --> 00:55:49,059
promising area you know we have to

1313
00:55:53,880 --> 00:55:51,069

understand in the context of the 1990s

1314
00:55:56,190 --> 00:55:53,890
this was not a popular idea the leader

1315
00:55:58,289 --> 00:55:56,200
in origins of life field Stanley Miller

1316
00:56:00,539 --> 00:55:58,299
in his group were adamantly opposed the

1317
00:56:02,549 --> 00:56:00,549
idea of the hydrothermal hypothesis this

1318
00:56:04,990 --> 00:56:02,559
quote the hydrothermal vent hypothesis

1319
00:56:06,970 --> 00:56:05,000
is a real loser I don't understand why

1320
00:56:08,770 --> 00:56:06,980
we even have to discuss it that's

1321
00:56:11,140 --> 00:56:08,780
published in Discover Magazine and and

1322
00:56:14,260 --> 00:56:11,150
he basically it made it very difficult

1323
00:56:16,630 --> 00:56:14,270
to get funding through NSF so we were

1324
00:56:18,760 --> 00:56:16,640
funded by the Carnegie Institution until

1325
00:56:21,340 --> 00:56:18,770
thank goodness the astrobiology

1326
00:56:23,170 --> 00:56:21,350
Institute call came along so 1997 I

1327
00:56:25,660 --> 00:56:23,180
wrote the first draft of this Sean

1328
00:56:28,000 --> 00:56:25,670
Solomon was the pi4 the can one proposal

1329
00:56:30,730 --> 00:56:28,010
that was accepted Sean as you may know

1330
00:56:32,350 --> 00:56:30,740
as a real leader in in NASA missions the

1331
00:56:34,420 --> 00:56:32,360
Marc messenger mission so he knew how to

1332
00:56:36,160 --> 00:56:34,430
run big programs and and we were very

1333
00:56:38,350 --> 00:56:36,170
happy to do this so in the first five

1334
00:56:40,150 --> 00:56:38,360
years we focus on a whole variety of

1335
00:56:42,010 --> 00:56:40,160
things related to hydrothermal organic

1336
00:56:43,720 --> 00:56:42,020
synthesis we thought about the possible

1337
00:56:45,160 --> 00:56:43,730
roles and minerals and reactants and

1338
00:56:45,760 --> 00:56:45,170

George Cody did some really interesting

1339
00:56:47,800 --> 00:56:45,770
work

1340
00:56:49,360 --> 00:56:47,810
looking how different minerals catalyze

1341
00:56:52,120 --> 00:56:49,370
different kinds of carbon addition

1342
00:56:54,130 --> 00:56:52,130
reactions I wish I had time to talk in

1343
00:56:56,530 --> 00:56:54,140
detail about all these experiments he

1344
00:56:58,450 --> 00:56:56,540
looked at that TCA cycle and found out

1345
00:57:00,970 --> 00:56:58,460
that most but not all the steps of the

1346
00:57:02,230 --> 00:57:00,980
TCA cycle could easily be accomplished

1347
00:57:05,320 --> 00:57:02,240
in hydrothermal conditions with

1348
00:57:07,480 --> 00:57:05,330
different mineral catalysts we also work

1349
00:57:09,490 --> 00:57:07,490
with Dave Deemer Marilyn Fogle looked at

1350
00:57:11,530 --> 00:57:09,500
a self-organizing and fulfilling

1351
00:57:13,300 --> 00:57:11,540
molecules that we produced and many of

1352
00:57:15,460 --> 00:57:13,310
you know Dave Demers pioneering works in

1353
00:57:17,080 --> 00:57:15,470
the origin of life I worked on chirality

1354
00:57:18,100 --> 00:57:17,090
and mineral surfaces so you see the

1355
00:57:20,620 --> 00:57:18,110
theme and we were looking at

1356
00:57:22,270 --> 00:57:20,630
geochemistry we were looking at minerals

1357
00:57:24,670 --> 00:57:22,280
we were thinking about how organic

1358
00:57:26,290 --> 00:57:24,680
molecules all from a real deep naive

1359
00:57:28,410 --> 00:57:26,300
point of view but the astrobiology

1360
00:57:31,360 --> 00:57:28,420
Institute embraced us nonetheless

1361
00:57:33,220 --> 00:57:31,370
because of the first five years we got a

1362
00:57:36,280 --> 00:57:33,230
second cycle that was the can three

1363
00:57:38,470 --> 00:57:36,290

Shawn Solomon again was the lead on that

1364
00:57:40,690 --> 00:57:38,480
and we did more experiments I began

1365
00:57:42,370 --> 00:57:40,700
thinking about mineral surface reactions

1366
00:57:44,020 --> 00:57:42,380
and did various roles that minerals

1367
00:57:46,150 --> 00:57:44,030
played in the origin of life this became

1368
00:57:48,340 --> 00:57:46,160
more solidified and so as you know

1369
00:57:50,080 --> 00:57:48,350
there's molecular synthesis can occur in

1370
00:57:53,200 --> 00:57:50,090
mineral surfaces like the conversion of

1371
00:57:55,030 --> 00:57:53,210
nitrogen to ammonia in the chiral

1372
00:57:56,950 --> 00:57:55,040
selection again the idea of of

1373
00:57:58,720 --> 00:57:56,960
preserving molecules and mineral

1374
00:58:00,310 --> 00:57:58,730
surfaces and protecting them in a

1375
00:58:02,350 --> 00:58:00,320
hydrothermal environment became very

1376
00:58:04,660 --> 00:58:02,360
important as a rebuttal to Stanley

1377
00:58:06,910 --> 00:58:04,670
Millers arguments and also various kinds

1378
00:58:08,380 --> 00:58:06,920
of molecular assembly that occur so so

1379
00:58:11,020 --> 00:58:08,390
we did all sorts of things particularly

1380
00:58:12,970 --> 00:58:11,030
study mineral molecule surface reactions

1381
00:58:14,620 --> 00:58:12,980
and I have to point out here the

1382
00:58:16,810 --> 00:58:14,630
incredible group of early career

1383
00:58:18,430 --> 00:58:16,820
scientists I've had to work with one

1384
00:58:20,079 --> 00:58:18,440
things that must be dramatically

1385
00:58:22,420 --> 00:58:20,089
all of you is that the nature of

1386
00:58:26,460 --> 00:58:22,430
astrobiology today is very different

1387
00:58:29,109 --> 00:58:26,470
from the speaker list this morning yeah

1388
00:58:30,819 --> 00:58:29,119

thank goodness but I've been so

1389
00:58:32,410 --> 00:58:30,829
privileged to work with these kinds of

1390
00:58:34,329 --> 00:58:32,420
early career scientists and we studied

1391
00:58:36,220 --> 00:58:34,339
various kinds of details of how

1392
00:58:38,109 --> 00:58:36,230
molecules interact with mineral surfaces

1393
00:58:40,809 --> 00:58:38,119
and how they react and so forth so that

1394
00:58:43,150 --> 00:58:40,819
was an important part of can three our

1395
00:58:45,730 --> 00:58:43,160
second cycle the third cycle is led by

1396
00:58:47,500 --> 00:58:45,740
george cody and and again we were

1397
00:58:49,240 --> 00:58:47,510
looking at various aspects of everything

1398
00:58:52,180 --> 00:58:49,250
from the molecular to the planetary

1399
00:58:54,190 --> 00:58:52,190
scale of reactions but what I want to

1400
00:58:55,660 --> 00:58:54,200
say here is I kind of diverged from the

1401
00:58:57,970 --> 00:58:55,670
astrobiology Institute I still was

1402
00:58:59,230 --> 00:58:57,980
working with it but I got a cold call

1403
00:59:01,059 --> 00:58:59,240
because of the work we had done on

1404
00:59:03,309 --> 00:59:01,069
hydrothermal synthesis from the Alfred P

1405
00:59:05,920 --> 00:59:03,319
sloan Foundation and they said basically

1406
00:59:07,420 --> 00:59:05,930
over the phone a high Bob would you like

1407
00:59:09,370 --> 00:59:07,430
to run a hundred million dollar 10-year

1408
00:59:11,940 --> 00:59:09,380
project to study the deep origins of

1409
00:59:14,620 --> 00:59:11,950
life that's not a call you get every day

1410
00:59:16,930 --> 00:59:14,630
and and in fact this was direct

1411
00:59:18,819 --> 00:59:16,940
outgrowth of an na I so we now have the

1412
00:59:20,349 --> 00:59:18,829
deep carbon Observatory I'm P I and

1413
00:59:23,650 --> 00:59:20,359

executive director it's a 10-year

1414
00:59:25,270 --> 00:59:23,660
project launched about ten years ago now

1415
00:59:27,400 --> 00:59:25,280
we've gotten fifty five million in

1416
00:59:29,079 --> 00:59:27,410
funding but the thing is this is an

1417
00:59:30,880 --> 00:59:29,089
international program that has really

1418
00:59:32,079 --> 00:59:30,890
expanded and grown I'm sure there are a

1419
00:59:33,609 --> 00:59:32,089
lot of people in this room that have

1420
00:59:35,890 --> 00:59:33,619
been touched by it one way or another

1421
00:59:37,059 --> 00:59:35,900
and it leverages over 700 million

1422
00:59:38,770 --> 00:59:37,069
dollars in support so that's an

1423
00:59:41,230 --> 00:59:38,780
important part of Nai that we should

1424
00:59:44,170 --> 00:59:41,240
remember that it's not just nai as all

1425
00:59:46,300 --> 00:59:44,180
the other groups the Simon's up funding

1426
00:59:48,099 --> 00:59:46,310
of the origin of life initiative LLC I

1427
00:59:49,240 --> 00:59:48,109
think that these groups these these

1428
00:59:50,800 --> 00:59:49,250
hundreds of millions of dollars and

1429
00:59:53,020 --> 00:59:50,810
funding simply wouldn't have happened if

1430
00:59:55,960 --> 00:59:53,030
it hadn't been for ni eyes leadership in

1431
00:59:57,309 --> 00:59:55,970
developing a community so deep carbon

1432
00:59:58,660 --> 00:59:57,319
Observatory we're trying to understand

1433
01:00:00,730 --> 00:59:58,670
carbon in earth but that of course

1434
01:00:03,579 --> 01:00:00,740
relates to carbon and other planets as

1435
01:00:05,109 --> 01:00:03,589
well we've designed and build all kinds

1436
01:00:08,050 --> 01:00:05,119
of new instruments very much in the

1437
01:00:09,760 --> 01:00:08,060
spirit of Nai funding instruments that

1438
01:00:11,730 --> 01:00:09,770

will allow us to do new science we have

1439
01:00:13,839 --> 01:00:11,740
a hundred and fifty field sites

1440
01:00:15,520 --> 01:00:13,849
especially the early cure group more

1441
01:00:18,220 --> 01:00:15,530
than half of our Hollies are early

1442
01:00:18,790 --> 01:00:18,230
career scientists and we have like the

1443
01:00:22,150 --> 01:00:18,800
NAI

1444
01:00:24,490 --> 01:00:22,160
really supported the nurtured early

1445
01:00:25,839 --> 01:00:24,500
career scientists too to be leaders to

1446
01:00:29,859 --> 01:00:25,849
have their own workshops to have their

1447
01:00:32,140 --> 01:00:29,869
own grants and they are members of all

1448
01:00:34,000 --> 01:00:32,150
of our leadership committees

1449
01:00:36,160 --> 01:00:34,010
so please go to deep carbon net to learn

1450
01:00:38,680 --> 01:00:36,170
more about that but that's not all from

1451
01:00:40,420 --> 01:00:38,690
that we had a small group of us with a

1452
01:00:42,700 --> 01:00:40,430
Keck Foundation grant to study the Co

1453
01:00:44,289 --> 01:00:42,710
evolving geosphere and biosphere some of

1454
01:00:46,690 --> 01:00:44,299
the leaders of that include people who

1455
01:00:48,190 --> 01:00:46,700
are important in astrobiology like handy

1456
01:00:49,140 --> 01:00:48,200
know but also I want to point out Paul

1457
01:00:51,130 --> 01:00:49,150
Falkowski

1458
01:00:54,640 --> 01:00:51,140
because this sort of comes full circle

1459
01:00:56,380 --> 01:00:54,650
for me we have another effort a deep

1460
01:00:57,430 --> 01:00:56,390
time data-driven infrastructure which

1461
01:00:59,920 --> 01:00:57,440
I'll talk about a little bit this

1462
01:01:02,319 --> 01:00:59,930
afternoon but most important we just got

1463
01:01:04,599 --> 01:01:02,329

funding it can eight with paul falkowski

1464
01:01:07,240 --> 01:01:04,609
as the leader of the Rutgers and nigma

1465
01:01:09,430 --> 01:01:07,250
group so you know I've been so

1466
01:01:10,960 --> 01:01:09,440
privileged for more than 20 years now to

1467
01:01:13,299 --> 01:01:10,970
be associated with Nai

1468
01:01:15,400 --> 01:01:13,309
and it has leveraged much much more than

1469
01:01:17,170 --> 01:01:15,410
just the astrobiology support that Nesta

1470
01:01:19,539 --> 01:01:17,180
has given I think for all of us it has

1471
01:01:21,460 --> 01:01:19,549
changed our field and created incredible

1472
01:01:24,220 --> 01:01:21,470
opportunities so with that I want to

1473
01:01:26,650 --> 01:01:24,230
thank NASA and other people and thank

1474
01:01:39,010 --> 01:01:26,660
you for the chance to say something

1475
01:01:40,720 --> 01:01:39,020
about our history so we are going to

1476
01:01:46,569 --> 01:01:40,730
return to the subsurface one of my

1477
01:01:49,510 --> 01:01:46,579
favorite subjects okay with Yann almond

1478
01:01:51,000 --> 01:01:49,520
and he is going to his a long title I'm

1479
01:01:53,920 --> 01:01:51,010
gonna read it anyway life underground

1480
01:01:55,630 --> 01:01:53,930
always a good thing investigations of

1481
01:02:00,599 --> 01:01:55,640
the terrestrial subsurface biosphere

1482
01:02:09,039 --> 01:02:03,609
thanks alright I'll continue the nei

1483
01:02:10,930 --> 01:02:09,049
awake my name is Yann I'm and I'm the I

1484
01:02:13,539 --> 01:02:10,940
was the PI of a can six life on a ground

1485
01:02:16,539 --> 01:02:13,549
team and the way we pitched this to NASA

1486
01:02:19,660 --> 01:02:16,549
back in 2013 was if there is or ever was

1487
01:02:21,789 --> 01:02:19,670
life on Mars Europa etc evidence of that

1488
01:02:23,890 --> 01:02:21,799

life would best be preserved and thus

1489
01:02:25,720 --> 01:02:23,900
most likely found in the subsurface and

1490
01:02:27,730 --> 01:02:25,730
this was very much echoed by the

1491
01:02:30,279 --> 01:02:27,740
National Academy of Sciences committee

1492
01:02:32,170 --> 01:02:30,289
on astrobiology just last year stating

1493
01:02:35,140 --> 01:02:32,180
that NASA's programs and missions should

1494
01:02:37,299 --> 01:02:35,150
reflect a dedicated focus on research

1495
01:02:39,760 --> 01:02:37,309
and exploration of subsurface

1496
01:02:43,059 --> 01:02:39,770
habitability in light of anissa's key

1497
01:02:44,470 --> 01:02:43,069
life and earth's sub-surface and the nei

1498
01:02:45,819 --> 01:02:44,480
was actually one of the first if you

1499
01:02:48,370 --> 01:02:45,829
want to call the funding agencies to

1500
01:02:52,029 --> 01:02:48,380
ports sub-surface life back in can to

1501
01:02:53,499 --> 01:02:52,039
2001 they funded Steve Don led team a

1502
01:02:56,440 --> 01:02:53,509
university Rhode Island which was 100

1503
01:02:59,979 --> 01:02:56,450
cents on the marine subsurface biosphere

1504
01:03:03,190 --> 01:02:59,989
and the missions with the IO DP the next

1505
01:03:05,559 --> 01:03:03,200
can funded this threesome of Indiana and

1506
01:03:07,509 --> 01:03:05,569
Princeton and Toronto looking at the

1507
01:03:09,849 --> 01:03:07,519
continental subsurface biosphere as I

1508
01:03:11,380 --> 01:03:09,859
mentioned we were funded in cans six out

1509
01:03:13,269 --> 01:03:11,390
of the University of Southern California

1510
01:03:15,130 --> 01:03:13,279
focusing on the Continental subsurface

1511
01:03:18,420 --> 01:03:15,140
biosphere with an eye towards planetary

1512
01:03:20,499 --> 01:03:18,430
systems and although not specifically a

1513
01:03:23,589 --> 01:03:20,509

subsurface team the university colorado

1514
01:03:25,900 --> 01:03:23,599
LED team and can seven with alexis

1515
01:03:28,319 --> 01:03:25,910
Templeton at the helm for heavily

1516
01:03:30,370 --> 01:03:28,329
focused on subsurface biosphere as well

1517
01:03:33,069 --> 01:03:30,380
unfortunately none of these centers got

1518
01:03:36,579 --> 01:03:33,079
renewed but there was certainly this

1519
01:03:39,009 --> 01:03:36,589
history within the nei of supporting

1520
01:03:44,069 --> 01:03:39,019
subsurface biosphere work until 2017

1521
01:03:46,719 --> 01:03:44,079
with us and 2019 with Cu several other

1522
01:03:48,370 --> 01:03:46,729
funded program programs and projects

1523
01:03:49,569 --> 01:03:48,380
have also sort of ended they're just

1524
01:03:51,670 --> 01:03:49,579
around the same time which is little bit

1525
01:03:53,410 --> 01:03:51,680
unfortunate so it was just mentioned

1526
01:03:55,479 --> 01:03:53,420
that the sloan Foundation the carbon

1527
01:03:57,579 --> 01:03:55,489
Observatory with a with a big subsurface

1528
01:03:59,799 --> 01:03:57,589
life component the NSF funded see Debbie

1529
01:04:02,259 --> 01:03:59,809
team is ending next year and the ball

1530
01:04:05,979 --> 01:04:02,269
Jurgen lead Center out of Denmark ended

1531
01:04:07,719 --> 01:04:05,989
in 2017 the helm has been picked up by

1532
01:04:09,670 --> 01:04:07,729
some international centers that have

1533
01:04:11,680 --> 01:04:09,680
just starting up focusing on subsurface

1534
01:04:13,719 --> 01:04:11,690
biosphere so the International Center on

1535
01:04:16,900 --> 01:04:13,729
deep life investigations on China

1536
01:04:19,120 --> 01:04:16,910
started last year Germany has put a lot

1537
01:04:21,069 --> 01:04:19,130
of money into Universal aim and the

1538
01:04:22,539 --> 01:04:21,079

mahram team with Kai Hendricks with a

1539
01:04:24,939 --> 01:04:22,549
big focus on the marine subsurface

1540
01:04:27,160 --> 01:04:24,949
biosphere and the Canadians have just

1541
01:04:30,009 --> 01:04:27,170
selected barbershop with Lawler and Jack

1542
01:04:31,719 --> 01:04:30,019
mustard to lead a team also focusing on

1543
01:04:34,890 --> 01:04:31,729
the continental subsurface biosphere

1544
01:04:37,299 --> 01:04:34,900
with a focus on planetary sub surfaces

1545
01:04:39,069 --> 01:04:37,309
so why do so many people so he assigned

1546
01:04:40,900 --> 01:04:39,079
us care about the subsurface biosphere

1547
01:04:42,640 --> 01:04:40,910
numerous papers have been written in the

1548
01:04:44,680 --> 01:04:42,650
last 20 years or so here's just one

1549
01:04:46,509 --> 01:04:44,690
example from Baran at all in 2018

1550
01:04:49,180 --> 01:04:46,519
showing that somewhere on the order of

1551
01:04:52,299 --> 01:04:49,190
80 to 85 90 percent of the microbial

1552
01:04:53,439 --> 01:04:52,309
biomass resides in the terrestrial and

1553
01:04:56,499 --> 01:04:53,449
the marine subsurface

1554
01:04:56,930 --> 01:04:56,509
simply put this is where the microbes

1555
01:04:59,359 --> 01:04:56,940
are

1556
01:05:02,960 --> 01:04:59,369
earth so we should use that to study

1557
01:05:04,910 --> 01:05:02,970
other systems as well Karen Lloyd the

1558
01:05:06,890 --> 01:05:04,920
professor University Tennessee gave to

1559
01:05:08,599 --> 01:05:06,900
talk to TED Talks just in the last two

1560
01:05:11,780 --> 01:05:08,609
years completely separate TED talks on

1561
01:05:13,790 --> 01:05:11,790
subsurface biosphere 2017 on marine

1562
01:05:16,790 --> 01:05:13,800
subsurface and just a month ago or so on

1563
01:05:18,710 --> 01:05:16,800

the Continental subsurface so my team

1564
01:05:21,079 --> 01:05:18,720
and the the co eyes are listed here

1565
01:05:22,609 --> 01:05:21,089
below the picture have been interested

1566
01:05:24,620 --> 01:05:22,619
in the subsurface biosphere and studied

1567
01:05:26,630 --> 01:05:24,630
it for five years in the center here is

1568
01:05:28,670 --> 01:05:26,640
a yellow circle suggesting that we have

1569
01:05:31,700 --> 01:05:28,680
access to of this team and access to

1570
01:05:33,890 --> 01:05:31,710
incredibly exciting set of subsurface

1571
01:05:37,250 --> 01:05:33,900
environments and the samples they're in

1572
01:05:40,700 --> 01:05:37,260
and use that basically in three research

1573
01:05:42,500 --> 01:05:40,710
themes in six you life detection guided

1574
01:05:44,930 --> 01:05:42,510
cultivation of the intra terrestrials

1575
01:05:47,180 --> 01:05:44,940
and then using all that information for

1576
01:05:49,819 --> 01:05:47,190
metabolic modeling again all with an eye

1577
01:05:54,109 --> 01:05:49,829
towards planetary surfaces Mars Europa

1578
01:05:57,079 --> 01:05:54,119
Enceladus and so on alright so the main

1579
01:05:58,670 --> 01:05:57,089
site for our life anagon team was the

1580
01:06:00,020 --> 01:05:58,680
former home state gold mine in South

1581
01:06:02,109 --> 01:06:00,030
Dakota and now called the Sanford

1582
01:06:04,550 --> 01:06:02,119
underground research facility or Cerf

1583
01:06:06,380 --> 01:06:04,560
and Maggie oz burned

1584
01:06:08,660 --> 01:06:06,390
Kauai on this team was tasked with

1585
01:06:12,370 --> 01:06:08,670
establishing the deep mine microbial

1586
01:06:15,470 --> 01:06:12,380
Observatory or demo a set of six holes

1587
01:06:17,990 --> 01:06:15,480
down to about 1500 meters in that former

1588
01:06:19,970 --> 01:06:18,000

gold mine and then using that for

1589
01:06:21,980 --> 01:06:19,980
continuous monitoring you can see in

1590
01:06:24,559 --> 01:06:21,990
that bar chart below that the rock types

1591
01:06:26,930 --> 01:06:24,569
of very diverse for those six demo holes

1592
01:06:28,819 --> 01:06:26,940
well not just the rock types but also

1593
01:06:30,950 --> 01:06:28,829
the aqueous geochemistry that goes with

1594
01:06:32,930 --> 01:06:30,960
it is very diverse a couple plots here

1595
01:06:35,990 --> 01:06:32,940
we have this is these are two year

1596
01:06:38,059 --> 01:06:36,000
timeframes sampling those six demo holes

1597
01:06:40,819 --> 01:06:38,069
here we have the redox species ferrous

1598
01:06:42,620 --> 01:06:40,829
iron nitrate ammonium and sulfide but

1599
01:06:44,000 --> 01:06:42,630
you can see that there's very stable geo

1600
01:06:45,920 --> 01:06:44,010
chemical signature over that two-year

1601
01:06:47,480 --> 01:06:45,930
period but one whole is different from

1602
01:06:49,880 --> 01:06:47,490
another hole from another hole and so on

1603
01:06:52,400 --> 01:06:49,890
not just the aqueous geochemistry in the

1604
01:06:55,160 --> 01:06:52,410
redox sense but also gases here co2 Co

1605
01:06:56,690 --> 01:06:55,170
hydrogen helium methane all very stable

1606
01:06:59,000 --> 01:06:56,700
over that two-year sampling period

1607
01:07:01,309 --> 01:06:59,010
numerous sampling times but different

1608
01:07:03,079 --> 01:07:01,319
from every whole amongst the different

1609
01:07:04,940 --> 01:07:03,089
holes and then lastly the carbon

1610
01:07:06,440 --> 01:07:04,950
chemistry including some isotopes again

1611
01:07:06,920 --> 01:07:06,450
stable over the time period we've

1612
01:07:10,430 --> 01:07:06,930
sampled

1613
01:07:11,380 --> 01:07:10,440

but every hole is quite different that's

1614
01:07:13,360 --> 01:07:11,390
basically some

1615
01:07:15,220 --> 01:07:13,370
in this plot here again the different

1616
01:07:17,740 --> 01:07:15,230
colors of the difference on demo holes

1617
01:07:19,720 --> 01:07:17,750
but each time we went back which is each

1618
01:07:22,360 --> 01:07:19,730
twig on this little tree here suggest

1619
01:07:23,620 --> 01:07:22,370
that the samples are a similar each time

1620
01:07:26,320 --> 01:07:23,630
around but different from one another

1621
01:07:29,170 --> 01:07:26,330
it's not just the geochemistry that it

1622
01:07:31,570 --> 01:07:29,180
was stable from site from time to time

1623
01:07:32,530 --> 01:07:31,580
and different from site to site but

1624
01:07:34,570 --> 01:07:32,540
that's also true of the molecular

1625
01:07:37,900 --> 01:07:34,580
biology the microbiology again seen here

1626
01:07:40,900 --> 01:07:37,910
this this clustering with a 16s over

1627
01:07:43,150 --> 01:07:40,910
that two-year period Maggie when she was

1628
01:07:44,380 --> 01:07:43,160
a postdoc with me several years ago used

1629
01:07:46,270 --> 01:07:44,390
that geochemistry and some

1630
01:07:49,330 --> 01:07:46,280
thermodynamics to calculate the reaction

1631
01:07:52,150 --> 01:07:49,340
energetics of 140 potential catabolism

1632
01:07:54,790 --> 01:07:52,160
and what's shown here on the left are

1633
01:07:57,640 --> 01:07:54,800
all those energetics color-coded by

1634
01:08:00,400 --> 01:07:57,650
electron acceptor so gray as oxygen

1635
01:08:02,440 --> 01:08:00,410
green is nitrate purple is manganese 4

1636
01:08:04,180 --> 01:08:02,450
and so on and so forth on the left hand

1637
01:08:05,800 --> 01:08:04,190
side are the endergonic reactions right

1638
01:08:07,330 --> 01:08:05,810

hand side the exergonic energy yielding

1639
01:08:08,650 --> 01:08:07,340
reactions and the only point I'm trying

1640
01:08:11,860 --> 01:08:08,660
to make here is that you can recognize

1641
01:08:14,290 --> 01:08:11,870
patterns of energy yields looking at it

1642
01:08:16,330 --> 01:08:14,300
this way on the right is the exact same

1643
01:08:17,320 --> 01:08:16,340
data set but this time color-coded on

1644
01:08:20,140 --> 01:08:17,330
the electron donor

1645
01:08:21,880 --> 01:08:20,150
so ferrous iron and red methane and blue

1646
01:08:24,430 --> 01:08:21,890
and so on and so forth so again you can

1647
01:08:26,530 --> 01:08:24,440
you can see patterns emerging over these

1648
01:08:28,930 --> 01:08:26,540
different sites my former graduate

1649
01:08:31,210 --> 01:08:28,940
student Lily mom / then started looking

1650
01:08:32,380 --> 01:08:31,220
at metagenomics and here is submitted

1651
01:08:35,680 --> 01:08:32,390
genomic studies forms just one of those

1652
01:08:38,470 --> 01:08:35,690
holes the deepest holes demo six and she

1653
01:08:41,560 --> 01:08:38,480
found 74 genomes from metagenomes known

1654
01:08:42,910 --> 01:08:41,570
as Maggs with 43 of them more than 80%

1655
01:08:45,310 --> 01:08:42,920
complete for those who do not look at

1656
01:08:47,590 --> 01:08:45,320
this very often this is incredibly good

1657
01:08:50,200 --> 01:08:47,600
data said having this kind of completion

1658
01:08:52,120 --> 01:08:50,210
she also found that sulfate and nitrate

1659
01:08:54,000 --> 01:08:52,130
slash nitrite reduction were the most

1660
01:08:56,410 --> 01:08:54,010
common petered of energy metabolisms

1661
01:08:59,320 --> 01:08:56,420
supporting what Maggie had found with

1662
01:09:01,150 --> 01:08:59,330
her energetic calculations and Lily

1663
01:09:03,760 --> 01:09:01,160

found that approximately 40% of those

1664
01:09:05,920 --> 01:09:03,770
mags come from microbial dark matter or

1665
01:09:08,530 --> 01:09:05,930
from organisms on the Tree of Life where

1666
01:09:12,340 --> 01:09:08,540
there are no known close cultured

1667
01:09:14,290 --> 01:09:12,350
representatives she also looked at some

1668
01:09:16,420 --> 01:09:14,300
carbon fixation pathways and found that

1669
01:09:18,340 --> 01:09:16,430
more than 50% of those mags have

1670
01:09:19,900 --> 01:09:18,350
complete carbon fixation pathways

1671
01:09:21,430 --> 01:09:19,910
suggesting that they are in fact chemo

1672
01:09:23,050 --> 01:09:21,440
lift though autotrophs and that the

1673
01:09:27,010 --> 01:09:23,060
acetyl co a pathway is the mole

1674
01:09:28,900 --> 01:09:27,020
common by far another former postdoc of

1675
01:09:31,030 --> 01:09:28,910
mine is a Nero then decided to do some

1676
01:09:32,829 --> 01:09:31,040
electrochemistry in situ which is rarely

1677
01:09:34,630 --> 01:09:32,839
done most electrochemistry work is done

1678
01:09:36,610 --> 01:09:34,640
in the laboratory so she took the whole

1679
01:09:39,040 --> 01:09:36,620
reactor into the former mine down to the

1680
01:09:40,960 --> 01:09:39,050
1500 meter level and using

1681
01:09:43,570 --> 01:09:40,970
electrochemistry to demonstrate

1682
01:09:45,220 --> 01:09:43,580
microbial activity in situ but also

1683
01:09:48,059 --> 01:09:45,230
using that approach to isolate

1684
01:09:50,740 --> 01:09:48,069
environmentally relevant microorganisms

1685
01:09:54,430 --> 01:09:50,750
and so here just a couple of her data

1686
01:09:57,010 --> 01:09:54,440
plots so this year shows fluctuations

1687
01:09:59,110 --> 01:09:57,020
and current and that's going both from

1688
01:10:01,780 --> 01:09:59,120

anodic to anode a cathode which is very

1689
01:10:03,880 --> 01:10:01,790
exciting and the current is quite high

1690
01:10:06,460 --> 01:10:03,890
in the micro amp range here whereas

1691
01:10:08,200 --> 01:10:06,470
abiotic or chemical reactions tend to be

1692
01:10:10,210 --> 01:10:08,210
more than an arab range so again signal

1693
01:10:12,520 --> 01:10:10,220
suggesting of microbial activity with

1694
01:10:14,440 --> 01:10:12,530
electrochemistry here and then looking

1695
01:10:16,720 --> 01:10:14,450
at it with cyclic voltammetry these

1696
01:10:20,230 --> 01:10:16,730
s-shaped curves are very similar in

1697
01:10:22,300 --> 01:10:20,240
shape and and values to what we see when

1698
01:10:25,090 --> 01:10:22,310
we do pure culture ket catalysis in the

1699
01:10:27,090 --> 01:10:25,100
laboratory again suggesting microbial

1700
01:10:29,050 --> 01:10:27,100
activity in Scituate this environment

1701
01:10:30,430 --> 01:10:29,060
last thing I want to do is mention a

1702
01:10:34,780 --> 01:10:30,440
couple more talks that are also going to

1703
01:10:37,270 --> 01:10:34,790
be presenting data from from demo from

1704
01:10:38,980 --> 01:10:37,280
this surf site so Lily mom / I'm now

1705
01:10:41,020 --> 01:10:38,990
working as a postdoc with with Maggie

1706
01:10:42,850 --> 01:10:41,030
Osbourne has a talk tomorrow at 3:15

1707
01:10:46,330 --> 01:10:42,860
where she'll talk in detail about every

1708
01:10:48,220 --> 01:10:46,340
single one of her 500 genomes and then

1709
01:10:48,850 --> 01:10:48,230
Caitlin kazar who is a graduate student

1710
01:10:50,290 --> 01:10:48,860
with a key

1711
01:10:52,210 --> 01:10:50,300
on Thursday will be speaking about

1712
01:10:54,490 --> 01:10:52,220
mineral hosted biofilm communities also

1713
01:10:57,370 --> 01:10:54,500

in that demo site when in the demo holes

1714
01:10:59,440 --> 01:10:57,380
that I've just mentioned and lastly just

1715
01:11:01,180 --> 01:10:59,450
a shout-out to the people who have done

1716
01:11:03,610 --> 01:11:01,190
most of the heavy lifting in the field

1717
01:11:05,830 --> 01:11:03,620
as Carla boolean was an undergraduate of

1718
01:11:07,270 --> 01:11:05,840
mine and you know I've already mentioned

1719
01:11:09,400 --> 01:11:07,280
never wanted to show her face for the

1720
01:11:11,530 --> 01:11:09,410
photo Lily mom part didn't want to show

1721
01:11:13,210 --> 01:11:11,540
her face either and then on the right

1722
01:11:17,130 --> 01:11:13,220
hand side Britney Krueger who was the

1723
01:11:20,260 --> 01:11:17,140
field lead for the entire Nai project

1724
01:11:21,550 --> 01:11:20,270
basically going underground on just

1725
01:11:22,990 --> 01:11:21,560
about every expedition I believe and

1726
01:11:24,850 --> 01:11:23,000
then Caitlin as I mentioned before in

1727
01:11:26,260 --> 01:11:24,860
that picture as well and with that I'll

1728
01:11:26,800 --> 01:11:26,270
turn it over to the next speaker thanks

1729
01:11:27,260 --> 01:11:26,810
very much

1730
01:11:36,189 --> 01:11:27,270
[Music]

1731
01:11:43,820 --> 01:11:41,050
our next speaker is Scott Sanford and

1732
01:11:46,160 --> 01:11:43,830
Scott has made time to do this even

1733
01:11:48,439 --> 01:11:46,170
though he's on the osiris-rex team it's

1734
01:11:50,209 --> 01:11:48,449
very busy and he's going to talk to us

1735
01:11:52,550 --> 01:11:50,219
about from astrochemistry to

1736
01:11:54,200 --> 01:11:52,560
astrobiology the evolving role of the

1737
01:11:57,979 --> 01:11:54,210
Astro chemistry lab at NASA's Ames

1738
01:12:00,169 --> 01:11:57,989

Research Center okay it has nothing to

1739
01:12:02,560 --> 01:12:00,179
do with my talk but I will mention that

1740
01:12:05,419 --> 01:12:02,570
as of last Friday we think we picked our

1741
01:12:10,370 --> 01:12:05,429
first of four possible sample sites for

1742
01:12:11,630 --> 01:12:10,380
osiris-rex so can be a challenge and

1743
01:12:12,860 --> 01:12:11,640
it's gonna be a lot of fun okay so I've

1744
01:12:14,810 --> 01:12:12,870
been asked to talk a little bit about

1745
01:12:17,510 --> 01:12:14,820
how they asked her chemistry lab at NASA

1746
01:12:19,850 --> 01:12:17,520
Ames has interacted with astrobiology

1747
01:12:21,800 --> 01:12:19,860
and the NAI and as you're gonna see I'm

1748
01:12:23,990 --> 01:12:21,810
going to talk to some extent about the

1749
01:12:33,800 --> 01:12:24,000
benefit that the astral chemistry lab

1750
01:12:36,220 --> 01:12:33,810
has has gotten from that so see there we

1751
01:12:40,250 --> 01:12:36,230
go okay well so the Astro chemistry lab

1752
01:12:41,870 --> 01:12:40,260
wasn't started in the mid-1980s and at

1753
01:12:44,030 --> 01:12:41,880
the time it consisted of Lou allamandola

1754
01:12:46,580 --> 01:12:44,040
and myself and a broken-down abandoned

1755
01:12:47,720 --> 01:12:46,590
infrared spectrometer which we set up in

1756
01:12:50,840 --> 01:12:47,730
hallway because they couldn't even

1757
01:12:52,580 --> 01:12:50,850
afford a room for us but over time we

1758
01:12:55,250 --> 01:12:52,590
accumulated good people better equipment

1759
01:12:57,290 --> 01:12:55,260
and got involved in a lot of things and

1760
01:13:00,050 --> 01:12:57,300
it's been a very productive group now at

1761
01:13:02,750 --> 01:13:00,060
the time it was created its main goal

1762
01:13:04,490 --> 01:13:02,760
was to help in Fred astronomers at that

1763
01:13:06,020 --> 01:13:04,500

time infra technology was improving by

1764
01:13:07,580 --> 01:13:06,030
leaps and bounds the infrared universe

1765
01:13:09,800 --> 01:13:07,590
was opening up to us we were seeing

1766
01:13:11,270 --> 01:13:09,810
spectra with all sorts of funny features

1767
01:13:12,709 --> 01:13:11,280
in it nobody knew what they were and so

1768
01:13:15,140 --> 01:13:12,719
our job was to try to help figure out

1769
01:13:17,149 --> 01:13:15,150
what is all this stuff out there and so

1770
01:13:19,459 --> 01:13:17,159
there was a very sort of heavy period in

1771
01:13:20,959 --> 01:13:19,469
my career where literally nights I'd be

1772
01:13:22,669 --> 01:13:20,969
flying in the stratosphere in the Kuiper

1773
01:13:24,080 --> 01:13:22,679
airborne Observatory taking data of

1774
01:13:25,189 --> 01:13:24,090
astronomical objects and then I would

1775
01:13:26,600 --> 01:13:25,199
come down and get a couple hours of

1776
01:13:28,370 --> 01:13:26,610
sleep running the lab and try to take

1777
01:13:30,590 --> 01:13:28,380
spectra of materials in the laboratory

1778
01:13:31,580 --> 01:13:30,600
so we could compare and one of the big

1779
01:13:34,189 --> 01:13:31,590
things that was going on at that time

1780
01:13:35,959 --> 01:13:34,199
was there was this idea very contentious

1781
01:13:37,700 --> 01:13:35,969
at the time that a lot of these features

1782
01:13:39,280 --> 01:13:37,710
that were seen in a mission almost all

1783
01:13:41,150 --> 01:13:39,290
throughout the universe where due to

1784
01:13:42,650 --> 01:13:41,160
polycyclic aromatic

1785
01:13:43,760 --> 01:13:42,660
Hartman's this is now very well accepted

1786
01:13:45,770 --> 01:13:43,770
and they're known to be very ubiquitous

1787
01:13:47,420 --> 01:13:45,780
in space but at the time it was a good

1788
01:13:49,310 --> 01:13:47,430

way to get into a fistfight was to tell

1789
01:13:52,490 --> 01:13:49,320
somebody which side of the argument you

1790
01:13:55,070 --> 01:13:52,500
were on and so we were working very hard

1791
01:13:56,450 --> 01:13:55,080
on that in addition we were getting lots

1792
01:13:58,310 --> 01:13:56,460
of wonderful spectra from things like

1793
01:14:00,350 --> 01:13:58,320
protostars which where we were seeing

1794
01:14:03,080 --> 01:14:00,360
features due to Isis that were

1795
01:14:04,250 --> 01:14:03,090
surrounding these forming stars and so

1796
01:14:06,460 --> 01:14:04,260
we spent a lot of time in the laboratory

1797
01:14:08,570 --> 01:14:06,470
making the ISIS of all kinds of weird

1798
01:14:09,920 --> 01:14:08,580
compositions to try to explain the

1799
01:14:12,700 --> 01:14:09,930
spectra we're saying and in the course

1800
01:14:15,290 --> 01:14:12,710
of this we just identified a number of

1801
01:14:17,930 --> 01:14:15,300
molecules all very simple by biological

1802
01:14:21,410 --> 01:14:17,940
standards but you know carbon monoxide

1803
01:14:22,850 --> 01:14:21,420
methanol ammonia things like this and it

1804
01:14:25,580 --> 01:14:22,860
could even do enough work to start

1805
01:14:27,200 --> 01:14:25,590
showing that things like the carbon

1806
01:14:28,850 --> 01:14:27,210
monoxide was actually in more than one

1807
01:14:30,710 --> 01:14:28,860
kind of ice there was carbon monoxide

1808
01:14:32,450 --> 01:14:30,720
that was in the polar ice probably water

1809
01:14:36,470 --> 01:14:32,460
and carbon monoxide that was a non-polar

1810
01:14:38,720 --> 01:14:36,480
ice maybe n2o2 or just pure CO and so on

1811
01:14:40,460 --> 01:14:38,730
and so this was what a lot of our work

1812
01:14:41,690 --> 01:14:40,470
was doing but at some point we noticed

1813
01:14:44,270 --> 01:14:41,700

that there was at least one feature that

1814
01:14:46,430 --> 01:14:44,280
only showed up if we took these ices and

1815
01:14:49,730 --> 01:14:46,440
we zapped them with radiation and that

1816
01:14:51,050 --> 01:14:49,740
was kind of interesting and as we sort

1817
01:14:53,600 --> 01:14:51,060
of started to explain all the features

1818
01:14:55,040 --> 01:14:53,610
we started to worry about basically of

1819
01:14:56,210 --> 01:14:55,050
the next step which was okay if you've

1820
01:14:58,730 --> 01:14:56,220
identified the things what are their

1821
01:15:00,020 --> 01:14:58,740
chemical consequences what does it mean

1822
01:15:02,060 --> 01:15:00,030
if they're there what can happen after

1823
01:15:03,860 --> 01:15:02,070
that now most of these materials are

1824
01:15:05,180 --> 01:15:03,870
present in space at temperatures like 10

1825
01:15:06,470 --> 01:15:05,190
degrees Kelvin you don't expect any

1826
01:15:08,660 --> 01:15:06,480
chemistry to happen under those

1827
01:15:10,940 --> 01:15:08,670
conditions but in the presence of

1828
01:15:13,070 --> 01:15:10,950
ionizing radiation you can get things to

1829
01:15:14,170 --> 01:15:13,080
move forward despite the low

1830
01:15:16,610 --> 01:15:14,180
temperatures and that's because

1831
01:15:19,520 --> 01:15:16,620
materials can freeze out on to dust

1832
01:15:21,140 --> 01:15:19,530
grains get irradiated by ionizing

1833
01:15:22,910 --> 01:15:21,150
radiation this breaks down some of these

1834
01:15:26,030 --> 01:15:22,920
simple molecules like water methanol

1835
01:15:27,320 --> 01:15:26,040
ammonia into ions and radicals these

1836
01:15:28,970 --> 01:15:27,330
don't have any energy barriers and

1837
01:15:31,310 --> 01:15:28,980
they're perfectly happy to react at 10

1838
01:15:33,070 --> 01:15:31,320

degrees Kelvin and so you can get a very

1839
01:15:35,600 --> 01:15:33,080
rich chemistry under those circumstances

1840
01:15:37,010 --> 01:15:35,610
that can generate a great deal of

1841
01:15:38,600 --> 01:15:37,020
chemical complexity you go from

1842
01:15:40,970 --> 01:15:38,610
molecules that have one or two carbon

1843
01:15:42,470 --> 01:15:40,980
atoms all of the things that have very

1844
01:15:44,150 --> 01:15:42,480
large numbers still again small by

1845
01:15:47,000 --> 01:15:44,160
biological standards but huge compared

1846
01:15:48,470 --> 01:15:47,010
to what you started with so let me talk

1847
01:15:50,420 --> 01:15:48,480
a little bit about ice photochemistry

1848
01:15:52,760 --> 01:15:50,430
because it's not sort of your physics

1849
01:15:54,270 --> 01:15:52,770
professors chemistry so the ions and

1850
01:15:55,620 --> 01:15:54,280
radicals that are created

1851
01:15:57,779 --> 01:15:55,630
they can react immediately with their

1852
01:15:59,760 --> 01:15:57,789
neighbors or they can simply be stored

1853
01:16:02,189 --> 01:15:59,770
in place and then react later if they

1854
01:16:03,390 --> 01:16:02,199
can become mobile and move around so

1855
01:16:06,720 --> 01:16:03,400
it's very much a chemistry of

1856
01:16:08,189 --> 01:16:06,730
opportunity it's stochastic to reactants

1857
01:16:09,930 --> 01:16:08,199
don't get together to form the most

1858
01:16:11,250 --> 01:16:09,940
stable thing to reactants just react

1859
01:16:13,529 --> 01:16:11,260
because they can and you get whatever

1860
01:16:15,060 --> 01:16:13,539
you get and so the net result is you

1861
01:16:17,640 --> 01:16:15,070
don't get equations where a plus B goes

1862
01:16:22,799 --> 01:16:17,650
to C you have a plus B plus C plus D

1863
01:16:24,839 --> 01:16:22,809

goes to efg hijk left and a lot of the

1864
01:16:26,370 --> 01:16:24,849
normal rules don't apply for chemistry

1865
01:16:27,899 --> 01:16:26,380
so this is actually a perfect area for

1866
01:16:30,180 --> 01:16:27,909
me I didn't have to understand redox

1867
01:16:32,459 --> 01:16:30,190
conditions or any of that stuff because

1868
01:16:34,589 --> 01:16:32,469
it doesn't apply so you know in the same

1869
01:16:36,419 --> 01:16:34,599
eyes you can radiate and and you can

1870
01:16:40,109 --> 01:16:36,429
make co and co2 at the same time you're

1871
01:16:42,569 --> 01:16:40,119
making methane okay and you and and so

1872
01:16:44,669 --> 01:16:42,579
it's a it's a very much try it and see

1873
01:16:46,950 --> 01:16:44,679
what you get kind of chemistry and if

1874
01:16:50,189 --> 01:16:46,960
you look at even simple ices like this

1875
01:16:51,899 --> 01:16:50,199
one here just has water methanol ammonia

1876
01:16:54,240 --> 01:16:51,909
and carbon monoxide in it you radiate it

1877
01:16:55,859 --> 01:16:54,250
and you make thousands if not tens of

1878
01:16:58,589 --> 01:16:55,869
thousands of compounds and most of these

1879
01:17:00,359 --> 01:16:58,599
Peaks in them this mass spectrum are not

1880
01:17:01,919 --> 01:17:00,369
a compound or multiple compounds because

1881
01:17:03,510 --> 01:17:01,929
this chemistry if you can make a

1882
01:17:06,689 --> 01:17:03,520
molecule you probably make all it's

1883
01:17:08,399 --> 01:17:06,699
isomers as well and it's a fairly robust

1884
01:17:09,930 --> 01:17:08,409
chemistry because it's relatively

1885
01:17:11,129 --> 01:17:09,940
insensitive to the ice temperature as

1886
01:17:13,379 --> 01:17:11,139
long as it's cold enough for the

1887
01:17:15,450 --> 01:17:13,389
molecules to freeze the chemistry can

1888
01:17:17,189 --> 01:17:15,460

happen the radiation doesn't even matter

1889
01:17:20,939 --> 01:17:17,199
in many cases you can use protons

1890
01:17:24,060 --> 01:17:20,949
electrons UV photons and so on and so

1891
01:17:26,640 --> 01:17:24,070
you can get a huge jump in a chemical

1892
01:17:28,350 --> 01:17:26,650
complexity from very simple things so

1893
01:17:29,399 --> 01:17:28,360
now when we were doing this we were all

1894
01:17:32,970 --> 01:17:29,409
doing this thinking we were

1895
01:17:34,260 --> 01:17:32,980
astrophysicists and Astro chemists you

1896
01:17:35,729 --> 01:17:34,270
know up until this time probably the

1897
01:17:38,160 --> 01:17:35,739
single only thing I had done that had

1898
01:17:40,950 --> 01:17:38,170
any implications for astrobiology at all

1899
01:17:44,399 --> 01:17:40,960
was I was on the ants med field team in

1900
01:17:46,260 --> 01:17:44,409
1984 that found Allen hills 84001 ok

1901
01:17:48,029 --> 01:17:46,270
which at the time had no Astra

1902
01:17:49,529 --> 01:17:48,039
biological consequences whatsoever and

1903
01:17:55,799 --> 01:17:49,539
it took a decade for them to realize it

1904
01:17:57,270 --> 01:17:55,809
did but once the concept of astrobiology

1905
01:17:58,439 --> 01:17:57,280
at field of astrobiology came out

1906
01:18:00,359 --> 01:17:58,449
there's a lot of discussion about what

1907
01:18:02,320 --> 01:18:00,369
exactly should this be incorporated into

1908
01:18:04,370 --> 01:18:02,330
this field

1909
01:18:06,410 --> 01:18:04,380
there was a lot of discussion a lot of

1910
01:18:07,430 --> 01:18:06,420
disagreement but as I sometimes joke

1911
01:18:09,050 --> 01:18:07,440
with Lou we went to bed as an

1912
01:18:10,700 --> 01:18:09,060
astrophysicist and astrochemistry woke

1913
01:18:13,190 --> 01:18:10,710

up and found out we were astrobiologists

1914
01:18:14,780 --> 01:18:13,200
so but that was okay I've been called a

1915
01:18:17,090 --> 01:18:14,790
lot other things but I that time sitting

1916
01:18:21,740 --> 01:18:17,100
in my life so I managed to weather that

1917
01:18:24,380 --> 01:18:21,750
but but that gave us an opportunity to

1918
01:18:27,710 --> 01:18:24,390
join with the aims team when Dave dem

1919
01:18:30,230 --> 01:18:27,720
Rey set up our our proposal for kn1 so

1920
01:18:30,920 --> 01:18:30,240
we got to be part of can wanna and be

1921
01:18:33,770 --> 01:18:30,930
part of the NAI

1922
01:18:35,600 --> 01:18:33,780
ever since and this was a huge boon to

1923
01:18:37,700 --> 01:18:35,610
us in multiple ways Rooker's first of

1924
01:18:40,520 --> 01:18:37,710
all there was this stable funding also

1925
01:18:42,500 --> 01:18:40,530
we had the wonderful leadership of David

1926
01:18:44,180 --> 01:18:42,510
Emma Rae I mean he I think it's quite a

1927
01:18:45,800 --> 01:18:44,190
visionary given that what he does and

1928
01:18:47,330 --> 01:18:45,810
what we do is so different that he could

1929
01:18:50,660 --> 01:18:47,340
somehow see the potential in what we

1930
01:18:53,060 --> 01:18:50,670
were going to try to do but also it I

1931
01:18:54,530 --> 01:18:53,070
think the biggest advantage of us gave

1932
01:18:57,170 --> 01:18:54,540
us a different way to think about things

1933
01:18:58,910 --> 01:18:57,180
if you have a spectrum like this the

1934
01:19:00,710 --> 01:18:58,920
astra chemist and the astrophysicist and

1935
01:19:01,970 --> 01:19:00,720
lou and i wanted to say well we want

1936
01:19:03,740 --> 01:19:01,980
understand this residue we should try to

1937
01:19:06,200 --> 01:19:03,750
identify the ten biggest peaks or

1938
01:19:07,700 --> 01:19:06,210

something like that but that's almost an

1939
01:19:09,410 --> 01:19:07,710
impossible task when you have that many

1940
01:19:11,050 --> 01:19:09,420
molecules but it's a much easier

1941
01:19:12,590 --> 01:19:11,060
approach to say like well if we're

1942
01:19:14,000 --> 01:19:12,600
astrobiologists what does an

1943
01:19:15,260 --> 01:19:14,010
astrobiologists care about they don't

1944
01:19:16,490 --> 01:19:15,270
care about the biggest peak they care

1945
01:19:19,250 --> 01:19:16,500
about weathering those peaks are amino

1946
01:19:21,200 --> 01:19:19,260
acids or something like that and so

1947
01:19:22,910 --> 01:19:21,210
that's a much more tractable problem and

1948
01:19:25,310 --> 01:19:22,920
so that's what we did we've been

1949
01:19:26,750 --> 01:19:25,320
spending years trying to find out what

1950
01:19:29,180 --> 01:19:26,760
kinds of things are actually in these

1951
01:19:30,650 --> 01:19:29,190
residues and so we've discovered all the

1952
01:19:33,110 --> 01:19:30,660
things in this list these all have

1953
01:19:34,940 --> 01:19:33,120
various astrobiological implications

1954
01:19:37,790 --> 01:19:34,950
many of them are you know obvious to

1955
01:19:40,970 --> 01:19:37,800
everybody amino acids but we also make

1956
01:19:42,440 --> 01:19:40,980
amphiphiles sugars michele nuevo talked

1957
01:19:44,630 --> 01:19:42,450
about this in yesterday morning session

1958
01:19:45,920 --> 01:19:44,640
we can make nucleobases Partho Barrow

1959
01:19:48,530 --> 01:19:45,930
talked about that in yesterday's session

1960
01:19:50,450 --> 01:19:48,540
the amphiphiles was worked largely done

1961
01:19:53,290 --> 01:19:50,460
by Jason Dworkin who you've heard from

1962
01:19:55,520 --> 01:19:53,300
here earlier my paperwork says I'm a

1963
01:19:57,230 --> 01:19:55,530

senior laboratory astrophysicist but

1964
01:19:59,600 --> 01:19:57,240
what I really am as a person who trains

1965
01:20:06,450 --> 01:19:59,610
young great scientists to go work at

1966
01:20:08,939 --> 01:20:07,470
so anyways I'm gonna just talk very

1967
01:20:12,930 --> 01:20:08,949
briefly about a couple of how am i doing

1968
01:20:17,149 --> 01:20:12,940
for time here okay I'll just talk very

1969
01:20:19,950 --> 01:20:17,159
briefly about some of these so back in

1970
01:20:21,330 --> 01:20:19,960
95 we demonstrated that one big part of

1971
01:20:23,100 --> 01:20:21,340
the residues is hexamethylene tetramine

1972
01:20:24,750 --> 01:20:23,110
which degrades in all kinds of

1973
01:20:26,700 --> 01:20:24,760
interesting ways and makes amino acids

1974
01:20:30,839 --> 01:20:26,710
amongst other things we make lots of

1975
01:20:32,100 --> 01:20:30,849
polyoxymethylene polymers both just pure

1976
01:20:33,660 --> 01:20:32,110
polyoxymethylene and also

1977
01:20:36,419 --> 01:20:33,670
polyoxymethylene decorated with all

1978
01:20:38,040 --> 01:20:36,429
kinds of other functional groups one of

1979
01:20:40,049 --> 01:20:38,050
the things I find really amazing is that

1980
01:20:42,060 --> 01:20:40,059
our residues contain a class of

1981
01:20:43,319 --> 01:20:42,070
compounds which are amphiphilic they'll

1982
01:20:46,859 --> 01:20:43,329
if you put them in water they'll

1983
01:20:48,569 --> 01:20:46,869
spontaneously form vesicles which we

1984
01:20:51,450 --> 01:20:48,579
don't know what these molecules are yet

1985
01:20:55,140 --> 01:20:51,460
but that's a profoundly potentially

1986
01:20:57,180 --> 01:20:55,150
profoundly important phenomenon and this

1987
01:20:58,830 --> 01:20:57,190
is this material was made from a

1988
01:21:01,649 --> 01:20:58,840

radiating water methanol and ammonia

1989
01:21:04,080 --> 01:21:01,659
that's all so that's pretty amazing and

1990
01:21:05,970 --> 01:21:04,090
they de de mer had mentioned earlier

1991
01:21:07,260 --> 01:21:05,980
this is some of his stuff from me right

1992
01:21:08,490 --> 01:21:07,270
we worked with him because we didn't

1993
01:21:10,760 --> 01:21:08,500
understand anything about amphiphiles

1994
01:21:14,310 --> 01:21:10,770
and so he came and helped us with that

1995
01:21:15,330 --> 01:21:14,320
if polycyclic aromatic hydrocarbons are

1996
01:21:18,240 --> 01:21:15,340
round and we know that they're

1997
01:21:20,339 --> 01:21:18,250
ubiquitous in space and you radiate them

1998
01:21:22,080 --> 01:21:20,349
you can both substitute the carbon atoms

1999
01:21:24,000 --> 01:21:22,090
in the Rings with a hetero atoms so you

2000
01:21:25,770 --> 01:21:24,010
can make heterocycles and you can also

2001
01:21:28,080 --> 01:21:25,780
decorate the edges with all sorts of

2002
01:21:30,540 --> 01:21:28,090
extra functional groups so for example

2003
01:21:32,399 --> 01:21:30,550
you can add oxygens and make Quinn owns

2004
01:21:35,640 --> 01:21:32,409
which are used by life for all sorts of

2005
01:21:37,350 --> 01:21:35,650
things and of course hetero cycles are

2006
01:21:38,910 --> 01:21:37,360
very important in biochemistry

2007
01:21:40,830 --> 01:21:38,920
Partho Barrow talked about this a bit

2008
01:21:42,540 --> 01:21:40,840
yesterday but we can make all the

2009
01:21:45,029 --> 01:21:42,550
nucleobases if you have aromatic

2010
01:21:46,410 --> 01:21:45,039
hydrocarbons in the ices one of the

2011
01:21:48,660 --> 01:21:46,420
things I find most interesting about

2012
01:21:50,689 --> 01:21:48,670
this is not so much that we can make all

2013
01:21:53,100 --> 01:21:50,699

the nucleobases which is gratifying but

2014
01:21:54,330 --> 01:21:53,110
that the but it's sort of interesting

2015
01:21:55,560 --> 01:21:54,340
that some of the ones that you think are

2016
01:21:57,990 --> 01:21:55,570
important aren't the ones that are made

2017
01:21:59,459 --> 01:21:58,000
most easily so for example wanting we

2018
01:22:01,049 --> 01:21:59,469
can make it but we don't make a lot of

2019
01:22:02,129 --> 01:22:01,059
it but we make a lot of hypo xanthine

2020
01:22:04,919 --> 01:22:02,139
which is something that's been suggested

2021
01:22:06,529 --> 01:22:04,929
as a guanine alternative on the early

2022
01:22:08,399 --> 01:22:06,539
Earth and so I think sometimes these

2023
01:22:11,609 --> 01:22:08,409
experiments can give you clues about

2024
01:22:15,089 --> 01:22:11,619
maybe the pathway we took to get here to

2025
01:22:18,689 --> 01:22:15,099
what you taught modern biology ok so I'm

2026
01:22:19,739 --> 01:22:18,699
just about done here so so I guess

2027
01:22:22,040 --> 01:22:19,749
one of my main conclusions is the

2028
01:22:24,180 --> 01:22:22,050
combination of telescopic observations

2029
01:22:26,569 --> 01:22:24,190
in combination with laboratory

2030
01:22:29,100 --> 01:22:26,579
simulations really seem to excess

2031
01:22:30,569 --> 01:22:29,110
suggests that abiotic organic synthesis

2032
01:22:32,729 --> 01:22:30,579
is common in space where we're

2033
01:22:34,439 --> 01:22:32,739
simulating environments that are found

2034
01:22:35,939 --> 01:22:34,449
in dense molecular clouds everywhere and

2035
01:22:39,060 --> 01:22:35,949
in star formation regions and in the

2036
01:22:42,209 --> 01:22:39,070
disks of forming planetary systems so

2037
01:22:43,680 --> 01:22:42,219
these kinds of materials should be made

2038
01:22:45,779 --> 01:22:43,690

all over the place and then once they're

2039
01:22:47,699 --> 01:22:45,789
made and get incorporated into a

2040
01:22:49,589 --> 01:22:47,709
planetary a forming planetary system

2041
01:22:50,969 --> 01:22:49,599
these materials are available to be

2042
01:22:52,859 --> 01:22:50,979
rained down on the surfaces of new

2043
01:22:56,609 --> 01:22:52,869
planets the comet dust

2044
01:22:59,520 --> 01:22:56,619
meteorites and so on and so if you make

2045
01:23:03,029 --> 01:22:59,530
a planet this stuff will come probably

2046
01:23:05,370 --> 01:23:03,039
so it's still even the organic stuff is

2047
01:23:06,779 --> 01:23:05,380
still very simple compared to the kinds

2048
01:23:08,310 --> 01:23:06,789
of things we see in modern biochemistry

2049
01:23:10,859 --> 01:23:08,320
but it's a huge step up from carbon

2050
01:23:13,439 --> 01:23:10,869
monoxide so if you think of life as

2051
01:23:16,199 --> 01:23:13,449
being very elaborate Lego castles it

2052
01:23:19,319 --> 01:23:16,209
seems like this work suggests that Legos

2053
01:23:21,060 --> 01:23:19,329
come for free so what you do with them

2054
01:23:23,669 --> 01:23:21,070
then is a next step which I can't really

2055
01:23:25,500 --> 01:23:23,679
comment on much but but I think that

2056
01:23:28,439 --> 01:23:25,510
that's an important step forward so

2057
01:23:29,939 --> 01:23:28,449
fully abiotic processes can can give you

2058
01:23:34,770 --> 01:23:29,949
a lot of biological building brach

2059
01:23:36,540 --> 01:23:34,780
blocks and insofar as they may play key

2060
01:23:38,239 --> 01:23:36,550
roles and getting things started I think

2061
01:23:41,149 --> 01:23:38,249
you can count on them being there and

2062
01:23:43,620 --> 01:23:41,159
this was always suggested to me that

2063
01:23:53,530 --> 01:23:43,630

given the right conditions life may not

2064
01:23:58,400 --> 01:23:55,150
thanks God

2065
01:24:00,440 --> 01:23:58,410
so our next presentation is by Tim Lyons

2066
01:24:03,530 --> 01:24:00,450
and while I pull it up I want to say

2067
01:24:05,470 --> 01:24:03,540
that one of the pleasures of being the

2068
01:24:08,360 --> 01:24:05,480
director of Nai for the last three years

2069
01:24:10,370 --> 01:24:08,370
it's not just that I got to interact

2070
01:24:13,460 --> 01:24:10,380
with people I already knew but somehow

2071
01:24:14,720 --> 01:24:13,470
Tim and I had never crossed paths and so

2072
01:24:16,670 --> 01:24:14,730
one of the great pleasures has been

2073
01:24:20,300 --> 01:24:16,680
getting to know him his work his lovely

2074
01:24:23,720 --> 01:24:20,310
wife Sarah and his two great kids so you

2075
01:24:25,400 --> 01:24:23,730
have ten minutes well thanks penny

2076
01:24:28,190 --> 01:24:25,410
that's really kind and I would I would

2077
01:24:31,190 --> 01:24:28,200
echo those sentiments I also wanted to

2078
01:24:33,770 --> 01:24:31,200
begin by commenting on Ariel's comment

2079
01:24:35,900 --> 01:24:33,780
about my gray hair I would say either

2080
01:24:37,880 --> 01:24:35,910
one that it comes from working with him

2081
01:24:43,640 --> 01:24:37,890
or two that I die at this color to

2082
01:24:45,980 --> 01:24:43,650
capture more respect so my my voyage

2083
01:24:48,140 --> 01:24:45,990
into space really began on a ship and as

2084
01:24:51,550 --> 01:24:48,150
part of my dissertation I sailed to the

2085
01:24:54,080 --> 01:24:51,560
Black Sea and soon after that I

2086
01:24:56,780 --> 01:24:54,090
extrapolated knowledge based on this

2087
01:24:59,780 --> 01:24:56,790
famous large an toxic basin in the world

2088
01:25:01,700 --> 01:24:59,790

- I took a risk really with some NSF

2089
01:25:02,810 --> 01:25:01,710
money to study very old rocks and I

2090
01:25:06,380 --> 01:25:02,820
thought that this would be sort of a

2091
01:25:09,050 --> 01:25:06,390
one-off this was in the mid 90s and soon

2092
01:25:12,050 --> 01:25:09,060
thereafter came Alan Hills and and the

2093
01:25:13,940 --> 01:25:12,060
astrobiology Institute in 1998 and they

2094
01:25:15,380 --> 01:25:13,950
did at that time something that I had

2095
01:25:17,660 --> 01:25:15,390
profoundly benefited from and I think

2096
01:25:19,340 --> 01:25:17,670
was a wise decision it made the dismay

2097
01:25:21,290 --> 01:25:19,350
the argument that understanding life on

2098
01:25:23,600 --> 01:25:21,300
Earth and its relationships to it it's

2099
01:25:25,460 --> 01:25:23,610
involving environments would be an

2100
01:25:29,990 --> 01:25:25,470
important part for looking for life

2101
01:25:32,090 --> 01:25:30,000
beyond our own planet and so I began as

2102
01:25:33,740 --> 01:25:32,100
part of kin one I was invited to be part

2103
01:25:36,260 --> 01:25:33,750
of the piece are at the Penn State group

2104
01:25:38,120 --> 01:25:36,270
by Hiroshi Emoto who at that time was

2105
01:25:39,620 --> 01:25:38,130
trying to convince all of us that oxygen

2106
01:25:41,720 --> 01:25:39,630
was very very high early in Earth

2107
01:25:43,730 --> 01:25:41,730
history and I was one of the many who

2108
01:25:45,290 --> 01:25:43,740
felt that that was not so but to his

2109
01:25:47,930 --> 01:25:45,300
credit he said let's mix us all together

2110
01:25:49,070 --> 01:25:47,940
and see what we come up come up with and

2111
01:25:50,930 --> 01:25:49,080
it was a very earth centric perspective

2112
01:25:53,240 --> 01:25:50,940
again with the idea that this

2113
01:25:55,340 --> 01:25:53,250

information would be useful looking far

2114
01:25:56,930 --> 01:25:55,350
beyond our own planet and then I became

2115
01:25:59,120 --> 01:25:56,940
a very substantive part of the NAI

2116
01:26:01,970 --> 01:25:59,130
through the kind invitation of our

2117
01:26:03,920 --> 01:26:01,980
al-anbar to join ken five in his group

2118
01:26:04,400 --> 01:26:03,930
and he outlined many of the things that

2119
01:26:06,140 --> 01:26:04,410
we've done

2120
01:26:07,760 --> 01:26:06,150
we did at that time and we continued to

2121
01:26:10,160 --> 01:26:07,770
do and I won't go into any more details

2122
01:26:13,670 --> 01:26:10,170
but again this was a very earth centric

2123
01:26:15,290 --> 01:26:13,680
perspective but always with the idea

2124
01:26:17,990 --> 01:26:15,300
that this information would be useful to

2125
01:26:20,240 --> 01:26:18,000
NASA's NASA's missions and then Along

2126
01:26:21,800 --> 01:26:20,250
Came can seven and we were waiting for

2127
01:26:24,920 --> 01:26:21,810
the right time in the right language

2128
01:26:26,780 --> 01:26:24,930
which within the can and we felt that

2129
01:26:28,100 --> 01:26:26,790
can seven did that that we really were

2130
01:26:29,870 --> 01:26:28,110
going to have our hands held to the fire

2131
01:26:32,690 --> 01:26:29,880
that we were going to use earth in very

2132
01:26:34,370 --> 01:26:32,700
meaningful ways and so we pitched at

2133
01:26:36,290 --> 01:26:34,380
that time that we would be exploring

2134
01:26:38,300 --> 01:26:36,300
Earth's four billion years a persistent

2135
01:26:39,770 --> 01:26:38,310
habitability at on a dynamic early Earth

2136
01:26:41,870 --> 01:26:39,780
and it's remarkable if you think about

2137
01:26:43,760 --> 01:26:41,880
it that we have been habitable for more

2138
01:26:46,400 --> 01:26:43,770

than four billion years in the face of a

2139
01:26:49,310 --> 01:26:46,410
dramatically changing atmosphere redox

2140
01:26:51,860 --> 01:26:49,320
chemistry a cooling interior or warming

2141
01:26:54,320 --> 01:26:51,870
Sun and through the processes that that

2142
01:26:56,870 --> 01:26:54,330
that work integrative ly on our planets

2143
01:27:00,320 --> 01:26:56,880
we have stayed a magic planet in many

2144
01:27:02,240 --> 01:27:00,330
respects but we knew that and and what

2145
01:27:04,700 --> 01:27:02,250
we really wanted to and as you'll see by

2146
01:27:06,740 --> 01:27:04,710
the end we think we have extended that

2147
01:27:08,870 --> 01:27:06,750
to help guide NASA's mission specific

2148
01:27:10,670 --> 01:27:08,880
search for life on distant worlds what I

2149
01:27:13,070 --> 01:27:10,680
really wanted to do in the later stage

2150
01:27:15,080 --> 01:27:13,080
of my career was was reinvent myself as

2151
01:27:17,480 --> 01:27:15,090
a planetary scientist and just start to

2152
01:27:18,770 --> 01:27:17,490
explore in a meaningful way how earth

2153
01:27:22,790 --> 01:27:18,780
could help us look for life on

2154
01:27:25,400 --> 01:27:22,800
exoplanets and so early on we had this

2155
01:27:27,050 --> 01:27:25,410
developing expertise and understanding

2156
01:27:29,570 --> 01:27:27,060
the redox evolution of the deep ocean

2157
01:27:31,250 --> 01:27:29,580
that's really where I wet my feet in all

2158
01:27:33,860 --> 01:27:31,260
of this and that was something that our

2159
01:27:36,020 --> 01:27:33,870
alien Arielle and I and our students did

2160
01:27:37,370 --> 01:27:36,030
with with great enthusiasm and we

2161
01:27:39,920 --> 01:27:37,380
convinced ourselves that the early

2162
01:27:41,210 --> 01:27:39,930
oceans stayed deficient and oxygen for

2163
01:27:44,720 --> 01:27:41,220

almost all of its history perhaps

2164
01:27:47,750 --> 01:27:44,730
extending it to the Paleozoic so for for

2165
01:27:49,340 --> 01:27:47,760
more than four billion years and we were

2166
01:27:52,130 --> 01:27:49,350
increasingly looking at different kinds

2167
01:27:54,440 --> 01:27:52,140
of proxies to to extend this information

2168
01:27:56,120 --> 01:27:54,450
and then along came some really

2169
01:27:57,890 --> 01:27:56,130
remarkable students and I could never

2170
01:27:59,300 --> 01:27:57,900
cover all the ones that I've been so

2171
01:28:01,040 --> 01:27:59,310
fortunate to work with but two

2172
01:28:02,750 --> 01:28:01,050
particularly remarkable ones no apply

2173
01:28:05,300 --> 01:28:02,760
now ski now at Yale and Chris Reinhardt

2174
01:28:07,460 --> 01:28:05,310
now at Georgia Tech entered the scene as

2175
01:28:11,060 --> 01:28:07,470
we were really trying to develop this

2176
01:28:13,070 --> 01:28:11,070
idea for AK and seven submission and so

2177
01:28:15,980 --> 01:28:13,080
we have worked on many different proxy

2178
01:28:17,660 --> 01:28:15,990
types to to refine not only

2179
01:28:19,430 --> 01:28:17,670
understanding of the deep ocean but

2180
01:28:20,870 --> 01:28:19,440
to extend out to the atmosphere and to

2181
01:28:23,419 --> 01:28:20,880
the shallow motion where all the life

2182
01:28:25,250 --> 01:28:23,429
was happening and then Chris I think in

2183
01:28:27,169 --> 01:28:25,260
particular really opened our eyes to the

2184
01:28:31,520 --> 01:28:27,179
power of bringing numerical approaches

2185
01:28:33,800 --> 01:28:31,530
to build from these proxies and so they

2186
01:28:36,740 --> 01:28:33,810
are both central portions of our count

2187
01:28:38,419 --> 01:28:36,750
seven team their institutional leads and

2188
01:28:40,070 --> 01:28:38,429

control their own teams and their own

2189
01:28:42,110 --> 01:28:40,080
big pools of money and it's been a

2190
01:28:45,110 --> 01:28:42,120
continued pleasure to work with them and

2191
01:28:47,600 --> 01:28:45,120
so we have worked really hard to try and

2192
01:28:49,220 --> 01:28:47,610
understand the evolution of oxygen in

2193
01:28:51,950 --> 01:28:49,230
the in the in the atmosphere and the

2194
01:28:53,930 --> 01:28:51,960
shallow ocean and the deep ocean and as

2195
01:28:55,490 --> 01:28:53,940
I've said perhaps one of the most

2196
01:28:56,870 --> 01:28:55,500
important things that we brought to the

2197
01:28:58,820 --> 01:28:56,880
mix especially as we think about

2198
01:29:00,500 --> 01:28:58,830
exoplanets is really starting to think

2199
01:29:03,169 --> 01:29:00,510
about the ocean and its relationship to

2200
01:29:04,959 --> 01:29:03,179
evolving atmospheres and so that has

2201
01:29:07,729 --> 01:29:04,969
entered into some really wonderful

2202
01:29:10,010 --> 01:29:07,739
computational space we added whoops

2203
01:29:13,820 --> 01:29:10,020
we had it Andy Ridge well to our see if

2204
01:29:14,330 --> 01:29:13,830
I can go back on the keyboard of course

2205
01:29:16,400 --> 01:29:14,340
right

2206
01:29:18,410 --> 01:29:16,410
we added Andy Ridge well to our faculty

2207
01:29:21,290 --> 01:29:18,420
a few years ago and Andy is really the

2208
01:29:23,330 --> 01:29:21,300
father of the geni model which allows us

2209
01:29:25,280 --> 01:29:23,340
to bring biogeochemistry into the

2210
01:29:27,860 --> 01:29:25,290
three-dimensional processes of the ocean

2211
01:29:30,160 --> 01:29:27,870
and kazumi Ozaukee who was brought to

2212
01:29:32,450 --> 01:29:30,170
our mix through an MPP where he was

2213
01:29:34,880 --> 01:29:32,460

supported by Chris Reinhardt at Georgia

2214
01:29:36,560 --> 01:29:34,890
Tech and then Stephanie Olson who came

2215
01:29:39,020 --> 01:29:36,570
from Penn State already schooled in the

2216
01:29:39,740 --> 01:29:39,030
geni model having worked with Andy and

2217
01:29:42,770 --> 01:29:39,750
Lee Kump

2218
01:29:44,479 --> 01:29:42,780
and Jim casting and so a big part of

2219
01:29:47,030 --> 01:29:44,489
what we do and again I think perhaps

2220
01:29:49,370 --> 01:29:47,040
unique to our team is think about the

2221
01:29:51,919 --> 01:29:49,380
ocean the processes the evolution and

2222
01:29:54,650 --> 01:29:51,929
the fluxes to the atmosphere and and and

2223
01:30:00,050 --> 01:29:54,660
how those then can inform evolving

2224
01:30:01,939 --> 01:30:00,060
compositions of exoplanets and really

2225
01:30:04,729 --> 01:30:01,949
the extraordinary thing about the about

2226
01:30:06,050 --> 01:30:04,739
the NAI from my personal perspective is

2227
01:30:08,419 --> 01:30:06,060
that when we entered through Cannes

2228
01:30:10,790 --> 01:30:08,429
seven the hope was that we were going to

2229
01:30:12,260 --> 01:30:10,800
be allowed to explore how to take all

2230
01:30:15,380 --> 01:30:12,270
this collective knowledge over a couple

2231
01:30:17,330 --> 01:30:15,390
of decades into exoplanetary space we

2232
01:30:19,280 --> 01:30:17,340
didn't have exoplanetary scientists as

2233
01:30:22,070 --> 01:30:19,290
part of our team but we had the hope I

2234
01:30:23,660 --> 01:30:22,080
think the genuine realistic hope that we

2235
01:30:25,700 --> 01:30:23,670
would start working with members of the

2236
01:30:28,130 --> 01:30:25,710
NAI that that did have that expertise

2237
01:30:30,380 --> 01:30:28,140
and I have to really cite our connection

2238
01:30:30,870 --> 01:30:30,390

to to Vickie meadows in the BPL I'm part

2239
01:30:33,510 --> 01:30:30,880
of the veep

2240
01:30:35,580 --> 01:30:33,520
many of us are now part there is a true

2241
01:30:38,190 --> 01:30:35,590
integration between those teams and

2242
01:30:40,080 --> 01:30:38,200
again through the MPA MPP making the

2243
01:30:41,880 --> 01:30:40,090
pitch that the bridges that are built by

2244
01:30:44,070 --> 01:30:41,890
exchanging personnel are ultimately the

2245
01:30:46,140 --> 01:30:44,080
ways to go and so Eddie sweet ermine

2246
01:30:48,210 --> 01:30:46,150
came by way of an MVP and brought all

2247
01:30:50,130 --> 01:30:48,220
that computational strength and now we

2248
01:30:51,960 --> 01:30:50,140
are exoplanetary scientists quite

2249
01:30:55,200 --> 01:30:51,970
remarkable and Eddie is joining our

2250
01:30:58,980 --> 01:30:55,210
faculty I was able to leverage that yeah

2251
01:31:01,320 --> 01:30:58,990
yeah and and also I was able to leverage

2252
01:31:03,210 --> 01:31:01,330
a faculty position for Steven Kane who

2253
01:31:05,640 --> 01:31:03,220
is another X of planetary scientists in

2254
01:31:07,230 --> 01:31:05,650
a remarkable addition and such is the

2255
01:31:08,880 --> 01:31:07,240
interest on our campus that we just

2256
01:31:11,400 --> 01:31:08,890
changed our name to a Department of

2257
01:31:13,980 --> 01:31:11,410
Earth and Planetary Sciences so yeah

2258
01:31:17,190 --> 01:31:13,990
right so this is all about the NAI and

2259
01:31:19,800 --> 01:31:17,200
so you know my gratitude runs deep and

2260
01:31:22,050 --> 01:31:19,810
so we could spend a long time talking

2261
01:31:23,760 --> 01:31:22,060
about what Eddie and Vicky in the VPL

2262
01:31:26,070 --> 01:31:23,770
and all of their collective experience

2263
01:31:28,140 --> 01:31:26,080

brings to the mix for us but this this

2264
01:31:29,940 --> 01:31:28,150
summarizes it very quickly is that all

2265
01:31:31,620 --> 01:31:29,950
this computational strength we did all

2266
01:31:33,120 --> 01:31:31,630
this earth stuff they brought the

2267
01:31:35,430 --> 01:31:33,130
photochemical models the radiative

2268
01:31:37,740 --> 01:31:35,440
transfer models the telescope simulators

2269
01:31:40,140 --> 01:31:37,750
and allow us to really think about what

2270
01:31:42,480 --> 01:31:40,150
planets do and so one of the things that

2271
01:31:44,160 --> 01:31:42,490
we found somewhat depressingly but

2272
01:31:46,290 --> 01:31:44,170
actually as a motivator for the things

2273
01:31:48,450 --> 01:31:46,300
that will follow very quickly is that

2274
01:31:50,460 --> 01:31:48,460
false negatives are really important so

2275
01:31:52,770 --> 01:31:50,470
the famous methane oxygen disequilibrium

2276
01:31:54,450 --> 01:31:52,780
was probably never detectable over Earth

2277
01:31:56,370 --> 01:31:54,460
history early on you would have seen

2278
01:31:58,440 --> 01:31:56,380
whoops I did it again early on you would

2279
01:31:59,880 --> 01:31:58,450
have seen methane later in our history

2280
01:32:01,800 --> 01:31:59,890
you would have seen oxygen in the mid

2281
01:32:03,540 --> 01:32:01,810
portions of our earth history based on

2282
01:32:05,850 --> 01:32:03,550
all the work that we did with proxies

2283
01:32:07,380 --> 01:32:05,860
you might not have seen either perhaps

2284
01:32:09,060 --> 01:32:07,390
you would have seen a zone which caused

2285
01:32:10,950 --> 01:32:09,070
us to write a white paper or making an

2286
01:32:13,140 --> 01:32:10,960
argument for UV capabilities on next

2287
01:32:14,610 --> 01:32:13,150
generation telescopes I never would have

2288
01:32:16,020 --> 01:32:14,620

imagined that I would have been part of

2289
01:32:19,200 --> 01:32:16,030
such things when I was sailing in the

2290
01:32:21,570 --> 01:32:19,210
Black Sea and so we have been forced to

2291
01:32:23,100 --> 01:32:21,580
think creatively about other ways to do

2292
01:32:25,500 --> 01:32:23,110
these things we and many other people

2293
01:32:27,270 --> 01:32:25,510
and so we've been again as informed by

2294
01:32:29,310 --> 01:32:27,280
our own planet when thinking about

2295
01:32:31,410 --> 01:32:29,320
seasonality is an important potential

2296
01:32:34,020 --> 01:32:31,420
biosignature if you think about co2 and

2297
01:32:36,270 --> 01:32:34,030
methane and o2 variability and ozone

2298
01:32:38,880 --> 01:32:36,280
variability on our own planet

2299
01:32:40,920 --> 01:32:38,890
we have revisited the idea of the co

2300
01:32:42,960 --> 01:32:40,930
anti-bias signature the argument being

2301
01:32:44,200 --> 01:32:42,970
that if Co Co is building up it's

2302
01:32:45,520 --> 01:32:44,210
probably a product of photo

2303
01:32:49,000 --> 01:32:45,530
mystery and it doesn't have a biological

2304
01:32:51,430 --> 01:32:49,010
sink by thinking about the possibilities

2305
01:32:53,140 --> 01:32:51,440
in an ocean in a more diverse way we can

2306
01:32:54,790 --> 01:32:53,150
imagine actually Ezio might be a bio

2307
01:32:56,440 --> 01:32:54,800
signature that it might build up under

2308
01:32:59,470 --> 01:32:56,450
the right conditions in the presence of

2309
01:33:00,850 --> 01:32:59,480
life we have also most recently about

2310
01:33:02,380 --> 01:33:00,860
two weeks ago published a paper

2311
01:33:04,240 --> 01:33:02,390
revisiting the habitable zone and

2312
01:33:06,250 --> 01:33:04,250
thought not just about the star and the

2313
01:33:08,260 --> 01:33:06,260

distance from a star but the composition

2314
01:33:10,090 --> 01:33:08,270
of the greenhouse gas is required to

2315
01:33:11,560 --> 01:33:10,100
maintain liquid water and have

2316
01:33:13,420 --> 01:33:11,570
discovered from a complex life

2317
01:33:17,140 --> 01:33:13,430
standpoint that it's not very habitable

2318
01:33:18,670 --> 01:33:17,150
because of co2 and Co buildup and so

2319
01:33:20,229 --> 01:33:18,680
this is something that we all need to

2320
01:33:23,080 --> 01:33:20,239
think about depending on what we want to

2321
01:33:25,690 --> 01:33:23,090
look for and so this question of are we

2322
01:33:30,250 --> 01:33:25,700
alone drives all of us and essential to

2323
01:33:32,380 --> 01:33:30,260
our our guiding light and I would also

2324
01:33:34,090 --> 01:33:32,390
say is in the sense of what the NAI has

2325
01:33:36,040 --> 01:33:34,100
allowed me to leverage my University

2326
01:33:39,459 --> 01:33:36,050
gave me about a million dollars actually

2327
01:33:41,940 --> 01:33:39,469
as a supporting fund and from that we

2328
01:33:44,290 --> 01:33:41,950
hired someone to do outreach and to do

2329
01:33:47,110 --> 01:33:44,300
within the community and also to do

2330
01:33:49,410 --> 01:33:47,120
media support and so we run frequently

2331
01:33:52,840 --> 01:33:49,420
on and off campus lecture series

2332
01:33:55,060 --> 01:33:52,850
Sarah is a Sarah Simpson is a trained as

2333
01:33:57,310 --> 01:33:55,070
a science journalist and so she is our

2334
01:33:59,709 --> 01:33:57,320
media interface and so we've had a lot

2335
01:34:01,900 --> 01:33:59,719
of coverage as many of you have but we

2336
01:34:04,690 --> 01:34:01,910
think we do it well I had to put the Fox

2337
01:34:07,720 --> 01:34:04,700
News one up I couldn't resist not our

2338
01:34:10,240 --> 01:34:07,730

proudest moment but it is what it is and

2339
01:34:11,650 --> 01:34:10,250
then this thing I am really proud about

2340
01:34:13,720 --> 01:34:11,660
is that we do a lot of outreach

2341
01:34:15,820 --> 01:34:13,730
including a year ago we did an entire

2342
01:34:18,340 --> 01:34:15,830
Saturday session for the community in

2343
01:34:19,990 --> 01:34:18,350
Spanish only so we used our native

2344
01:34:21,370 --> 01:34:20,000
spanish-speaking students and postdocs

2345
01:34:23,170 --> 01:34:21,380
and people from throughout the

2346
01:34:25,030 --> 01:34:23,180
university we are we are a minority

2347
01:34:26,200 --> 01:34:25,040
serving institution and we view that

2348
01:34:28,300 --> 01:34:26,210
it's a great resource and we're very

2349
01:34:30,250 --> 01:34:28,310
proud of it and so then I'll end with

2350
01:34:32,500 --> 01:34:30,260
our latest chapter by saying that we are

2351
01:34:36,010 --> 01:34:32,510
proud members know of to our CNS as well

2352
01:34:38,140 --> 01:34:36,020
I'm a co-lead on the PC e3 RCN and we

2353
01:34:39,729 --> 01:34:38,150
are deeply through our initially through

2354
01:34:42,670 --> 01:34:39,739
our VP L connection and now through our

2355
01:34:50,270 --> 01:34:42,680
own growth as part of the of Nexus so in

2356
01:34:57,710 --> 01:34:53,670
our next speaker torque Tory hauler in

2357
01:35:00,570 --> 01:34:57,720
is along the same lines in terms of

2358
01:35:04,890 --> 01:35:00,580
being one of the leaders of one of the

2359
01:35:07,260 --> 01:35:04,900
new RCS and he's going to talk about a

2360
01:35:09,660 --> 01:35:07,270
different aspect of the work that nai

2361
01:35:11,400 --> 01:35:09,670
has done not only the research but

2362
01:35:22,020 --> 01:35:11,410
research and outreach and missions

2363
01:35:23,880 --> 01:35:22,030

oh my so this was a hard one for me to

2364
01:35:26,130 --> 01:35:23,890
put together because I wanted a trip I

2365
01:35:27,630 --> 01:35:26,140
wanted to contribute but but I Fred it a

2366
01:35:30,360 --> 01:35:27,640
little bit over where I could contribute

2367
01:35:32,100 --> 01:35:30,370
in this session not just because I had

2368
01:35:33,330 --> 01:35:32,110
to cover a talk title that in my defense

2369
01:35:36,660 --> 01:35:33,340
I wrote while I was chock-full of

2370
01:35:38,160 --> 01:35:36,670
painkillers and muscle relaxers so give

2371
01:35:40,560 --> 01:35:38,170
that a try sometime it puts you on the

2372
01:35:41,760 --> 01:35:40,570
hook for what you have to do next but

2373
01:35:44,580 --> 01:35:41,770
also you know so much of what we are

2374
01:35:46,500 --> 01:35:44,590
here here today is is a team level

2375
01:35:49,080 --> 01:35:46,510
perspective on science that was

2376
01:35:51,870 --> 01:35:49,090
accomplished at a team level and in the

2377
01:35:53,640 --> 01:35:51,880
30 team years worth of Nai affiliation

2378
01:35:55,190 --> 01:35:53,650
that I have represented among the three

2379
01:35:58,020 --> 01:35:55,200
teams that I've been able to work with

2380
01:35:59,460 --> 01:35:58,030
it was always Dave or Vicki or Alexis

2381
01:36:01,800 --> 01:35:59,470
that we're doing the hard work of

2382
01:36:03,540 --> 01:36:01,810
leading the way making it possible for

2383
01:36:05,490 --> 01:36:03,550
me and others on those teams to have the

2384
01:36:06,960 --> 01:36:05,500
fun part of doing the science and and so

2385
01:36:08,850 --> 01:36:06,970
I don't have that perspective to give

2386
01:36:10,410 --> 01:36:08,860
there's another really important

2387
01:36:13,020 --> 01:36:10,420
perspective that I don't think has come

2388
01:36:14,820 --> 01:36:13,030

out very much yet but but in my mind is

2389
01:36:16,970 --> 01:36:14,830
one of the important legacies of Nai and

2390
01:36:19,740 --> 01:36:16,980
that's what it did to foster a

2391
01:36:22,530 --> 01:36:19,750
remarkably self-organizing community of

2392
01:36:28,800 --> 01:36:22,540
young scientists that's been really

2393
01:36:31,620 --> 01:36:28,810
important I I hope that will come out in

2394
01:36:34,290 --> 01:36:31,630
in the posters and in the later sessions

2395
01:36:36,210 --> 01:36:34,300
I came along a little bit too early for

2396
01:36:37,980 --> 01:36:36,220
there to be a well-established and and

2397
01:36:39,870 --> 01:36:37,990
having organized group on those things

2398
01:36:42,540 --> 01:36:39,880
and so necessarily what I have to bring

2399
01:36:44,550 --> 01:36:42,550
is a personal level perspective on this

2400
01:36:45,570 --> 01:36:44,560
and and fortunately enough when I read

2401
01:36:48,030 --> 01:36:45,580
to the bottom of this session

2402
01:36:49,590 --> 01:36:48,040
description I found a single phrase that

2403
01:36:51,630 --> 01:36:49,600
said you know we also want some case

2404
01:36:53,880 --> 01:36:51,640
studies about people whose careers were

2405
01:36:56,919 --> 01:36:53,890
positively impacted by the NAI and that

2406
01:36:59,529 --> 01:36:56,929
is certainly the case for me so

2407
01:37:01,239 --> 01:36:59,539
I hope you'll forgive that this is a

2408
01:37:03,069 --> 01:37:01,249
necessarily personal perspective

2409
01:37:05,319 --> 01:37:03,079
hopefully not an overly self-centered

2410
01:37:06,839 --> 01:37:05,329
one and certainly not a unique one it's

2411
01:37:12,580 --> 01:37:06,849
just the one that I know best

2412
01:37:14,529 --> 01:37:12,590
so in 1979 back in March marked a 40

2413
01:37:16,839 --> 01:37:14,539

year anniversary of Voyager 1's flyby of

2414
01:37:18,729 --> 01:37:16,849
Jupiter and a few months later came the

2415
01:37:21,850 --> 01:37:18,739
Voyager 2 flyby of Jupiter and I was in

2416
01:37:24,370 --> 01:37:21,860
fourth grade then I had a big science

2417
01:37:26,109 --> 01:37:24,380
presentation to do the first class

2418
01:37:27,819 --> 01:37:26,119
project that I ever had to do in school

2419
01:37:29,379 --> 01:37:27,829
and I wrote to NASA using that thing

2420
01:37:31,870 --> 01:37:29,389
called mail that John Speer described

2421
01:37:33,910 --> 01:37:31,880
earlier and two weeks later I got back a

2422
01:37:36,729 --> 01:37:33,920
manila envelope full of glossy pictures

2423
01:37:38,859 --> 01:37:36,739
of Jupiter and what Voyager 2 had done

2424
01:37:39,939 --> 01:37:38,869
and I was blown away I was totally

2425
01:37:41,640 --> 01:37:39,949
hooked you know I had the coolest

2426
01:37:44,830 --> 01:37:41,650
science presentation in the whole class

2427
01:37:47,169 --> 01:37:44,840
and I was really hooked on space but

2428
01:37:49,029 --> 01:37:47,179
with that said it never was a goal of

2429
01:37:50,979 --> 01:37:49,039
mine it even occurred to me to try to

2430
01:37:52,629 --> 01:37:50,989
wind up working for NASA or working on

2431
01:37:55,689 --> 01:37:52,639
space projects and it's because I also

2432
01:37:57,520 --> 01:37:55,699
loved the ocean and so when I left

2433
01:37:59,140 --> 01:37:57,530
undergrad school I went to an

2434
01:38:00,699 --> 01:37:59,150
oceanography program where I studied

2435
01:38:02,410 --> 01:38:00,709
sediment chemistry so the stuff in my

2436
01:38:05,439 --> 01:38:02,420
hands that you can't see is the stinky

2437
01:38:07,089 --> 01:38:05,449
black mud which is actually really quite

2438
01:38:09,279 --> 01:38:07,099

intriguing and fascinating if you've got

2439
01:38:10,899 --> 01:38:09,289
to know it a little bit and to me there

2440
01:38:12,609 --> 01:38:10,909
was a fairly clear path that I was going

2441
01:38:15,489 --> 01:38:12,619
to follow and I didn't come to NASA to

2442
01:38:17,169 --> 01:38:15,499
to work on space I went to NASA to learn

2443
01:38:18,459 --> 01:38:17,179
isotope chemistry from Dave D Murray so

2444
01:38:23,229 --> 01:38:18,469
that I could go back and be a better

2445
01:38:25,509 --> 01:38:23,239
marine chemist and yet I now find myself

2446
01:38:27,759 --> 01:38:25,519
not only counting as my colleagues

2447
01:38:30,399 --> 01:38:27,769
people who were involved in the Voyager

2448
01:38:32,109 --> 01:38:30,409
mission but I find myself now with the

2449
01:38:33,729 --> 01:38:32,119
privilege of being able to contribute to

2450
01:38:37,509 --> 01:38:33,739
the planning of missions that are yet to

2451
01:38:39,250 --> 01:38:37,519
come and so lots of people from from

2452
01:38:42,040 --> 01:38:39,260
outside of science have asked me how

2453
01:38:46,899 --> 01:38:42,050
this happened and I think the answer is

2454
01:38:49,540 --> 01:38:46,909
it's it's not obvious I think the answer

2455
01:38:51,189 --> 01:38:49,550
is that it's the NAI if you look at the

2456
01:38:53,410 --> 01:38:51,199
time stamp on the middle picture that

2457
01:38:55,419 --> 01:38:53,420
was taken in 1998 just a couple of

2458
01:38:58,270 --> 01:38:55,429
months before I came to Ames and I got

2459
01:39:00,040 --> 01:38:58,280
to Ames an astrobiology and na I got to

2460
01:39:02,020 --> 01:39:00,050
Ames within a couple of months of one

2461
01:39:03,759 --> 01:39:02,030
another and so the Institute and I kind

2462
01:39:05,339 --> 01:39:03,769
of grew up together and that's the

2463
01:39:08,290 --> 01:39:05,349

perspective that I have to offer

2464
01:39:10,200 --> 01:39:08,300
so there's a document called the NASA

2465
01:39:11,610 --> 01:39:10,210
Astrobiology Institute implementation

2466
01:39:14,250 --> 01:39:11,620
plan if you look at the language in

2467
01:39:16,320 --> 01:39:14,260
there there's obviously a prioritization

2468
01:39:18,090 --> 01:39:16,330
of science and that's mostly what we've

2469
01:39:20,790 --> 01:39:18,100
heard about today there's also an

2470
01:39:22,979 --> 01:39:20,800
emphasis on on using the NAI as a tool

2471
01:39:26,400 --> 01:39:22,989
to promote the input of astrobiological

2472
01:39:27,870 --> 01:39:26,410
expertise into missions and a part that

2473
01:39:29,640 --> 01:39:27,880
talks about the importance of outreach

2474
01:39:31,110 --> 01:39:29,650
and I'm so glad that Tim included out at

2475
01:39:33,030 --> 01:39:31,120
the end of his talk because for me

2476
01:39:35,610 --> 01:39:33,040
that's been a really important impact on

2477
01:39:38,310 --> 01:39:35,620
the trajectory of my career so from a

2478
01:39:40,020 --> 01:39:38,320
research perspective I've had the good

2479
01:39:41,820 --> 01:39:40,030
fortune to be involved with three teams

2480
01:39:44,130 --> 01:39:41,830
first with the aims team then with the

2481
01:39:47,490 --> 01:39:44,140
VP L team and most recently with the ROC

2482
01:39:49,530 --> 01:39:47,500
powered life team in the beginning at

2483
01:39:50,970 --> 01:39:49,540
the start of Nai the teams were very

2484
01:39:53,040 --> 01:39:50,980
broad reaching in their scientific

2485
01:39:54,570 --> 01:39:53,050
expertise they they many of them

2486
01:39:56,760 --> 01:39:54,580
represented almost the entire

2487
01:39:58,820 --> 01:39:56,770
intellectual scope of astrobiology that

2488
01:40:02,070 --> 01:39:58,830

was certainly true for the aims team and

2489
01:40:05,310 --> 01:40:02,080
his significance to me of that was that

2490
01:40:07,320 --> 01:40:05,320
it forced me allowed me and forced me to

2491
01:40:09,090 --> 01:40:07,330
constantly think of what I had to bring

2492
01:40:11,070 --> 01:40:09,100
to the table in the broader context of

2493
01:40:14,970 --> 01:40:11,080
what our entire team was doing so I

2494
01:40:16,620 --> 01:40:14,980
easily learned as much from from Scott

2495
01:40:18,750 --> 01:40:16,630
and the astrochemistry group and the

2496
01:40:20,700 --> 01:40:18,760
other folks in our team as I did in the

2497
01:40:23,280 --> 01:40:20,710
conduct of my own research and it was

2498
01:40:25,080 --> 01:40:23,290
the the effort to understand the

2499
01:40:27,570 --> 01:40:25,090
connectedness between those different

2500
01:40:29,459 --> 01:40:27,580
portions of our team that for me has

2501
01:40:31,500 --> 01:40:29,469
consistently allowed me to think about

2502
01:40:33,300 --> 01:40:31,510
different trajectories and applications

2503
01:40:35,490 --> 01:40:33,310
of my own work that was a really

2504
01:40:38,040 --> 01:40:35,500
important aspect of a team level concept

2505
01:40:40,229 --> 01:40:38,050
of how to pursue research and then came

2506
01:40:42,450 --> 01:40:40,239
VPL which i think was really

2507
01:40:44,580 --> 01:40:42,460
transformational in many ways so you'll

2508
01:40:46,100 --> 01:40:44,590
notice the language from this

2509
01:40:47,580 --> 01:40:46,110
implementation planet refers to

2510
01:40:50,459 --> 01:40:47,590
astrobiology as a multidisciplinary

2511
01:40:51,870 --> 01:40:50,469
science and now we purposely use the

2512
01:40:53,550 --> 01:40:51,880
term interdisciplinary and I actually

2513
01:40:57,060 --> 01:40:53,560

think there is a difference and I think

2514
01:40:59,040 --> 01:40:57,070
that the evolution of Nai largely

2515
01:41:00,870 --> 01:40:59,050
reflects that that transition from

2516
01:41:02,370 --> 01:41:00,880
multidisciplinary to interdisciplinary

2517
01:41:04,860 --> 01:41:02,380
and I give Vicki a huge amount of credit

2518
01:41:07,920 --> 01:41:04,870
for for helping to enable that

2519
01:41:11,270 --> 01:41:07,930
transition in the following way you know

2520
01:41:14,310 --> 01:41:11,280
you heard Vicki say earlier that VPL has

2521
01:41:16,110 --> 01:41:14,320
you know a multi-term history but has

2522
01:41:17,880 --> 01:41:16,120
had the same question and the same

2523
01:41:20,610 --> 01:41:17,890
approach and methodology throughout all

2524
01:41:22,530 --> 01:41:20,620
of that time and yet has been remarkably

2525
01:41:23,790 --> 01:41:22,540
productive throughout that entire term

2526
01:41:26,729 --> 01:41:23,800
and I think that

2527
01:41:28,169 --> 01:41:26,739
really speaks to the vision and the

2528
01:41:30,479 --> 01:41:28,179
leadership that was inherent in that

2529
01:41:33,290 --> 01:41:30,489
effort because in in a couple of ways

2530
01:41:36,419 --> 01:41:33,300
one is I think the idea that that

2531
01:41:38,010 --> 01:41:36,429
providing conceptual and intellectual

2532
01:41:39,149 --> 01:41:38,020
framework that helped link together

2533
01:41:41,069 --> 01:41:39,159
different scientists you could

2534
01:41:44,549 --> 01:41:41,079
facilitate the interactions between them

2535
01:41:46,470 --> 01:41:44,559
and linking that framework to drive

2536
01:41:48,000 --> 01:41:46,480
mission requirements in the future both

2537
01:41:48,959 --> 01:41:48,010
of those I think were really innovative

2538
01:41:50,700 --> 01:41:48,969

and important things that have

2539
01:41:54,209 --> 01:41:50,710
influenced the way I think about my own

2540
01:41:57,390 --> 01:41:54,219
work going forward and finally in the

2541
01:41:59,819 --> 01:41:57,400
RPL much of that same mentality is now

2542
01:42:02,549 --> 01:41:59,829
transposed onto earthly systems so you

2543
01:42:04,470 --> 01:42:02,559
saw John and his talk show a picture of

2544
01:42:06,299 --> 01:42:04,480
a group of hard-headed scientists

2545
01:42:07,350 --> 01:42:06,309
clustered around a core all bringing

2546
01:42:09,060 --> 01:42:07,360
their different perspectives and

2547
01:42:11,220 --> 01:42:09,070
expertise onto that single point of

2548
01:42:12,930 --> 01:42:11,230
focus here's a different group of

2549
01:42:14,879 --> 01:42:12,940
scientists in hard hats clustered around

2550
01:42:16,490 --> 01:42:14,889
a different core in a different spot but

2551
01:42:18,390 --> 01:42:16,500
doing exactly the same thing

2552
01:42:20,040 --> 01:42:18,400
standardizing and transposing a

2553
01:42:23,549 --> 01:42:20,050
methodology from different places on

2554
01:42:25,260 --> 01:42:23,559
earth to make sure that we were

2555
01:42:26,520 --> 01:42:25,270
combining our expertise in a way that

2556
01:42:30,859 --> 01:42:26,530
could allow us to understand those

2557
01:42:33,270 --> 01:42:30,869
systems as a collective whole okay so

2558
01:42:36,180 --> 01:42:33,280
outreach for me has been really

2559
01:42:37,439 --> 01:42:36,190
important it was very heavily emphasized

2560
01:42:39,750 --> 01:42:37,449
in the early going of Nai

2561
01:42:41,939 --> 01:42:39,760
that's changed a little bit as the

2562
01:42:44,910 --> 01:42:41,949
program has evolved over time but but it

2563
01:42:46,169 --> 01:42:44,920

enabled me to become heavily involved in

2564
01:42:48,089 --> 01:42:46,179
outreach at a time when I probably

2565
01:42:51,120 --> 01:42:48,099
wouldn't have thought to do it myself

2566
01:42:54,510 --> 01:42:51,130
so the emphasis on this at a team level

2567
01:42:57,390 --> 01:42:54,520
I think you know I mean we're all

2568
01:43:01,560 --> 01:42:57,400
privileged to work in a field that is is

2569
01:43:03,330 --> 01:43:01,570
so heavily embraceable by the public it

2570
01:43:05,479 --> 01:43:03,340
gives us an opportunity to educate but I

2571
01:43:07,859 --> 01:43:05,489
think it also gives us the opportunity

2572
01:43:10,379 --> 01:43:07,869
to tell the public what we're doing with

2573
01:43:13,229 --> 01:43:10,389
their money and to thank them for it and

2574
01:43:14,729 --> 01:43:13,239
and I am NOT a kind of person who would

2575
01:43:16,439 --> 01:43:14,739
necessarily go out and seek these

2576
01:43:17,910 --> 01:43:16,449
opportunities on my own having an

2577
01:43:19,979 --> 01:43:17,920
infrastructure that enabled us to do

2578
01:43:21,780 --> 01:43:19,989
that was really important and I also

2579
01:43:23,280 --> 01:43:21,790
think the emphasis on that in the NAI so

2580
01:43:25,169 --> 01:43:23,290
this picture has taken to the California

2581
01:43:26,819 --> 01:43:25,179
Academy of Sciences where where the aims

2582
01:43:29,160 --> 01:43:26,829
team had a long tradition at working and

2583
01:43:31,680 --> 01:43:29,170
I had an opportunity to design from

2584
01:43:33,419 --> 01:43:31,690
scratch and exhibit there but it

2585
01:43:36,420 --> 01:43:33,429
represented a large investment of time

2586
01:43:37,800 --> 01:43:36,430
at a at a time when NASA had transit

2587
01:43:39,870 --> 01:43:37,810
into full cost accounting meaning that

2588
01:43:42,300 --> 01:43:39,880

we had to account for every little

2589
01:43:44,100 --> 01:43:42,310
fraction of our time and so Carl was

2590
01:43:45,660 --> 01:43:44,110
still the astrobiology program

2591
01:43:47,250 --> 01:43:45,670
scientists that and I went to Carleton I

2592
01:43:49,320 --> 01:43:47,260
explained the situation I can only do

2593
01:43:51,900 --> 01:43:49,330
this with some funding I think it was a

2594
01:43:53,160 --> 01:43:51,910
real test of the commitment and Carl

2595
01:43:54,810 --> 01:43:53,170
gave me the funding when I thanked him

2596
01:43:55,590 --> 01:43:54,820
for it he said it's the easiest money I

2597
01:43:57,300 --> 01:43:55,600
ever spent

2598
01:43:59,490 --> 01:43:57,310
and it really stuck with me I thought it

2599
01:44:02,220 --> 01:43:59,500
was just it spoke hugely of the

2600
01:44:03,810 --> 01:44:02,230
commitment to outreach and to me this is

2601
01:44:06,240 --> 01:44:03,820
the good stuff this is what remote

2602
01:44:07,770 --> 01:44:06,250
evades me every single time I do it and

2603
01:44:12,030 --> 01:44:07,780
I hope it's important to carry forward

2604
01:44:14,010 --> 01:44:12,040
and then finally you know I feel

2605
01:44:15,570 --> 01:44:14,020
privileged to have participated in a

2606
01:44:17,130 --> 01:44:15,580
couple of science definition activities

2607
01:44:18,720 --> 01:44:17,140
now a couple of programmatic level

2608
01:44:21,060 --> 01:44:18,730
activities about where the agency goes

2609
01:44:22,410 --> 01:44:21,070
in terms of its mission and I think all

2610
01:44:24,810 --> 01:44:22,420
of what has happened in the course of

2611
01:44:26,910 --> 01:44:24,820
the NAI the outreach the missions the

2612
01:44:28,860 --> 01:44:26,920
apps icons have put me in a position

2613
01:44:31,200 --> 01:44:28,870

where people understood what I had to

2614
01:44:34,740 --> 01:44:31,210
bring to the table and that's important

2615
01:44:36,540 --> 01:44:34,750
because as the goals of space research

2616
01:44:39,420 --> 01:44:36,550
transition from more physical to

2617
01:44:41,070 --> 01:44:39,430
chemical to ultimately biological the

2618
01:44:42,600 --> 01:44:41,080
community that needs to be tapped for

2619
01:44:45,000 --> 01:44:42,610
that expertise is more and more

2620
01:44:47,460 --> 01:44:45,010
far-flung and widespread and the need

2621
01:44:49,740 --> 01:44:47,470
for creating avenues to bring

2622
01:44:52,200 --> 01:44:49,750
astrobiology expertise into the mission

2623
01:44:54,090 --> 01:44:52,210
at all stages of development has has

2624
01:44:56,790 --> 01:44:54,100
recently been sort of re articulated in

2625
01:44:58,440 --> 01:44:56,800
this National Academies report and I

2626
01:45:00,390 --> 01:44:58,450
think it's profoundly important that we

2627
01:45:02,790 --> 01:45:00,400
find mechanisms to enable the same thing

2628
01:45:04,500 --> 01:45:02,800
that that happened for me you know

2629
01:45:06,300 --> 01:45:04,510
almost just kind of by osmosis that I

2630
01:45:08,340 --> 01:45:06,310
found that I was able to to to

2631
01:45:10,410 --> 01:45:08,350
contribute to and participate in these

2632
01:45:11,580 --> 01:45:10,420
mission activities it really matters

2633
01:45:14,310 --> 01:45:11,590
that we find a way to do that going

2634
01:45:15,750 --> 01:45:14,320
forward and so one final quote this is

2635
01:45:17,580 --> 01:45:15,760
taken from the very end of the session

2636
01:45:19,230 --> 01:45:17,590
description the session will document

2637
01:45:20,880 --> 01:45:19,240
case studies of individuals whose

2638
01:45:22,500 --> 01:45:20,890

careers were positively impacted by

2639
01:45:25,380 --> 01:45:22,510
their association with the NAI that is

2640
01:45:27,510 --> 01:45:25,390
certainly the case for me and so I will

2641
01:45:30,300 --> 01:45:27,520
say thank you to the NA and thanks to

2642
01:45:37,240 --> 01:45:34,080
[Applause]

2643
01:45:39,070 --> 01:45:37,250
so that concludes the papers for the

2644
01:45:41,170 --> 01:45:39,080
morning session don't forget to come

2645
01:45:43,840 --> 01:45:41,180
back to the same room at 1:30 let me

2646
01:45:45,850 --> 01:45:43,850
make a few remarks before you leave one

2647
01:45:48,940 --> 01:45:45,860
of the important ones is if you have not

2648
01:45:54,130 --> 01:45:48,950
seen the NAI family tree on the far wall

2649
01:45:56,230 --> 01:45:54,140
of the poster session room please go put

2650
01:45:58,390 --> 01:45:56,240
your leaves there you don't even have to

2651
01:46:00,370 --> 01:45:58,400
be an nai person there's places for

2652
01:46:03,160 --> 01:46:00,380
headquarters people an astrobiology

2653
01:46:04,930 --> 01:46:03,170
program people and the new RC ends are

2654
01:46:07,000 --> 01:46:04,940
sort of hovering around the outside and

2655
01:46:09,970 --> 01:46:07,010
the Library of Congress Bloomberg

2656
01:46:12,190 --> 01:46:09,980
fellows are at the top so we want to

2657
01:46:15,460 --> 01:46:12,200
unify our community in every possible

2658
01:46:16,870 --> 01:46:15,470
way so please visit that and feel free

2659
01:46:18,400 --> 01:46:16,880
to put leaves wherever you think it's

2660
01:46:21,910 --> 01:46:18,410
appropriate and let me just turn this

2661
01:46:26,200 --> 01:46:21,920
over to my co convener dr. Carl Pilcher

2662
01:46:27,610 --> 01:46:26,210
for a few closing remarks well there

2663
01:46:29,140 --> 01:46:27,620

have been a lot of thanks to the NAI I

2664
01:46:30,790 --> 01:46:29,150
just want to give a lot of thanks to

2665
01:46:32,980 --> 01:46:30,800
this community and to all the speakers

2666
01:46:34,480 --> 01:46:32,990
particularly at 2:00 a.m. I was lying

2667
01:46:37,050 --> 01:46:34,490
awake wondering how are we possibly

2668
01:46:40,000 --> 01:46:37,060
going to end this session on time and

2669
01:46:42,700 --> 01:46:40,010
and and thanks to the wonderful speakers

2670
01:46:45,340 --> 01:46:42,710
we did exactly that please do come back

2671
01:46:47,830 --> 01:46:45,350
at 1:30 Tory was actually a wonderful

2672
01:46:50,200 --> 01:46:47,840
transition talk between the morning

2673
01:46:52,600 --> 01:46:50,210
session in the afternoon session because

2674
01:46:54,700 --> 01:46:52,610
in the afternoon session you will hear

2675
01:46:57,910 --> 01:46:54,710
many more personal stories from people

2676
01:47:00,730 --> 01:46:57,920
who started off as young investigators

2677
01:47:02,710 --> 01:47:00,740
in this the morning was deliberately

2678
01:47:04,210 --> 01:47:02,720
more the senior investigators there were

2679
01:47:06,700 --> 01:47:04,220
a number of young investigators who are

2680
01:47:09,520 --> 01:47:06,710
now mid-career investigators who you'll

2681
01:47:12,580 --> 01:47:09,530
hear from this afternoon so thank you