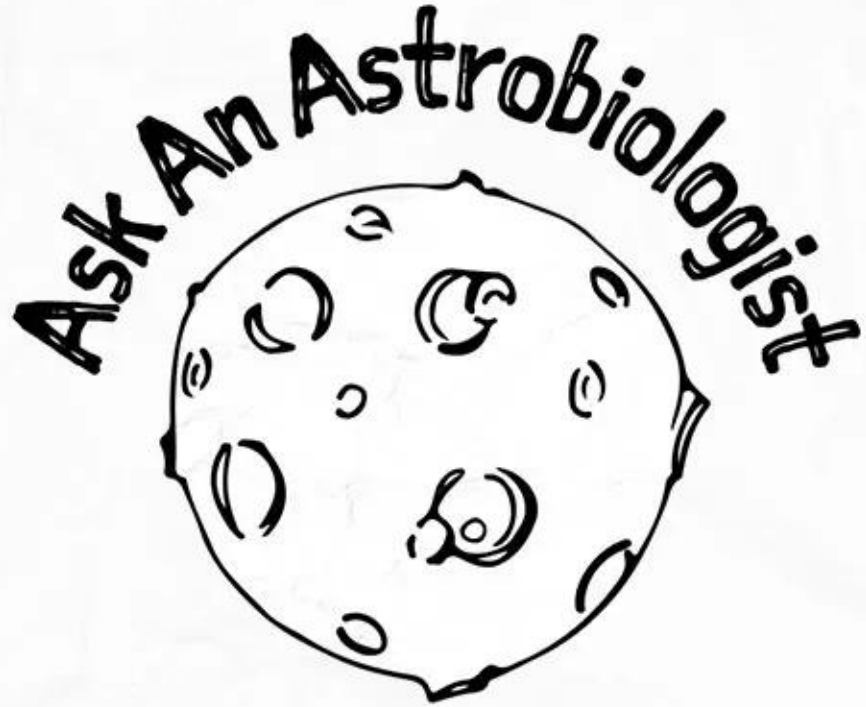

Episode 20: March 26th, 2019

Dr. Jason Wright

NASA Astrobiology Program

1
00:00:00,500 --> 00:00:29,710
[Music]

2
00:00:35,150 --> 00:00:31,910
earthlings and welcome to another

3
00:00:36,920 --> 00:00:35,160
episode of ask an astrobiologist this is

4
00:00:39,470 --> 00:00:36,930
the show where we celebrate science and

5
00:00:43,400 --> 00:00:39,480
celebrate scientists specifically

6
00:00:45,560 --> 00:00:43,410
involved in astrobiology this quest that

7
00:00:48,670 --> 00:00:45,570
we have to better understand our place

8
00:00:52,130 --> 00:00:48,680
and the cosmos really involves all of us

9
00:00:54,290 --> 00:00:52,140
and so we're here as a platform for all

10
00:00:56,510 --> 00:00:54,300
of you for all of us to have a voice to

11
00:00:58,029 --> 00:00:56,520
ask the important questions of ourselves

12
00:01:00,380 --> 00:00:58,039
and of each other

13
00:01:02,840 --> 00:01:00,390

specifically we're here to ask our great

14
00:01:05,179 --> 00:01:02,850
scientists in astrobiology about their

15
00:01:07,609 --> 00:01:05,189
careers their research and the things

16
00:01:09,080 --> 00:01:07,619
that drive them forward this show is

17
00:01:11,870 --> 00:01:09,090
produced by the NASA Astrobiology

18
00:01:14,000 --> 00:01:11,880
program and Cyborg

19
00:01:16,219 --> 00:01:14,010
now before we get to today's episode

20
00:01:17,929 --> 00:01:16,229
which I'm really excited about we're

21
00:01:20,510 --> 00:01:17,939
gonna start off with our background quiz

22
00:01:22,249 --> 00:01:20,520
so our returned audience knows that

23
00:01:25,130 --> 00:01:22,259
every month there's a new background

24
00:01:28,100 --> 00:01:25,140
behind myself or my cup of Sanjoy a song

25
00:01:30,200 --> 00:01:28,110
and every month we ask you what these

26
00:01:33,950 --> 00:01:30,210
pictures show with a chance to win some

27
00:01:37,569 --> 00:01:33,960
prizes so last picture was kind of this

28
00:01:41,240 --> 00:01:37,579
weird gunky looking nasty glob of

29
00:01:43,310 --> 00:01:41,250
orangish radish stuff that was actually

30
00:01:46,340 --> 00:01:43,320
a microbial mat from Grand Prismatic

31
00:01:47,030 --> 00:01:46,350
spring in Yellowstone National Park in

32
00:01:49,249 --> 00:01:47,040
Wyoming

33
00:01:52,310 --> 00:01:49,259
we're in prismatic is the third largest

34
00:01:53,990 --> 00:01:52,320
hot spring in the world and in the

35
00:01:56,770 --> 00:01:54,000
center of this spring are this really

36
00:01:58,999 --> 00:01:56,780
beautiful deep ultramarine blue color

37
00:02:01,700 --> 00:01:59,009
and you see the steam kind of boiling

38
00:02:04,249 --> 00:02:01,710

off but out around the edges of this hot

39
00:02:05,350 --> 00:02:04,259
spring you see the colors of the rainbow

40
00:02:08,020 --> 00:02:05,360
oranges and

41
00:02:10,330 --> 00:02:08,030
yellows and greens and Red's kind of all

42
00:02:12,400 --> 00:02:10,340
mixed together on the outer edges that

43
00:02:15,130 --> 00:02:12,410
are caused by microbes living in these

44
00:02:16,570 --> 00:02:15,140
microbial mats specifically the colors

45
00:02:18,910 --> 00:02:16,580
you see the greens are coming primarily

46
00:02:20,530 --> 00:02:18,920
from chlorophyll and then the reds and

47
00:02:23,590 --> 00:02:20,540
oranges are coming from carotenoid

48
00:02:25,030 --> 00:02:23,600
pigments inside of these microbes now

49
00:02:27,160 --> 00:02:25,040
one really cool thing about Grand

50
00:02:29,260 --> 00:02:27,170
Prismatic is that in the summertime you

51
00:02:31,390 --> 00:02:29,270
tend to see more of the Reds and the

52
00:02:33,520 --> 00:02:31,400
oranges and in the wintertime when it's

53
00:02:35,199 --> 00:02:33,530
a little bit cooler around the edges of

54
00:02:37,210 --> 00:02:35,209
the spring you see more of the green

55
00:02:38,830 --> 00:02:37,220
than the chlorophyll and so if you're in

56
00:02:40,840 --> 00:02:38,840
dramatic is this is beautiful and

57
00:02:43,810 --> 00:02:40,850
colored but the color also varies

58
00:02:45,400 --> 00:02:43,820
throughout the year now for our

59
00:02:48,010 --> 00:02:45,410
background quiz we always give out

60
00:02:50,440 --> 00:02:48,020
prizes we have a bunch of people always

61
00:02:52,330 --> 00:02:50,450
answer and get it right and so now we

62
00:02:54,670 --> 00:02:52,340
take that pool of right answers and pick

63
00:02:56,530 --> 00:02:54,680

out a few winners our third-place

64
00:02:59,830 --> 00:02:56,540
winners will get some of our very cool

65
00:03:02,020 --> 00:02:59,840
NASA stickers our second-place winners

66
00:03:04,140 --> 00:03:02,030
get some of those stickers plus some of

67
00:03:06,610 --> 00:03:04,150
our awesome graphic histories of NASA

68
00:03:08,710 --> 00:03:06,620
Astrobiology and then our first-place

69
00:03:14,020 --> 00:03:08,720
winners get both of those as well as a

70
00:03:16,690 --> 00:03:14,030
Sagan net or drinking glass and so for

71
00:03:20,620 --> 00:03:16,700
this past month swears we have in the

72
00:03:23,860 --> 00:03:20,630
third place was Gustavo Duvall in second

73
00:03:26,530 --> 00:03:23,870
place was Bush route to the bush and the

74
00:03:28,509 --> 00:03:26,540
first place was AMA and so

75
00:03:31,150 --> 00:03:28,519
congratulations to all of you on laying

76
00:03:33,430 --> 00:03:31,160
our awards for our background question

77
00:03:35,650 --> 00:03:33,440
this past month hopefully I pronounce

78
00:03:37,330 --> 00:03:35,660
your names right specifically mutrah I

79
00:03:39,580 --> 00:03:37,340
did look up how to pronounce your name

80
00:03:42,400 --> 00:03:39,590
in Turkish so if I pronounced it wrong I

81
00:03:44,140 --> 00:03:42,410
apologize I do try my best so for next

82
00:03:45,850 --> 00:03:44,150
month pay attention to what I have here

83
00:03:49,270 --> 00:03:45,860
behind me and we'll do yet another

84
00:03:51,759 --> 00:03:49,280
background quiz so with that said I'm

85
00:03:54,160 --> 00:03:51,769
very excited to introduce you to today's

86
00:03:56,560 --> 00:03:54,170
special guest dr. Jason Wright of Penn

87
00:03:58,630 --> 00:03:56,570
State University dr. Wright hello and

88
00:04:01,210 --> 00:03:58,640

welcome to ask an astrobiologist hello

89
00:04:04,060 --> 00:04:01,220
glad to be here yes it's great to have

90
00:04:05,910 --> 00:04:04,070
you before we get anywhere in discussing

91
00:04:08,740 --> 00:04:05,920
your awesome working things you've done

92
00:04:11,380 --> 00:04:08,750
like five minutes before we started the

93
00:04:13,449 --> 00:04:11,390
episode I saw on Twitter that you were

94
00:04:16,650 --> 00:04:13,459
just announced as the recipient of the

95
00:04:18,990 --> 00:04:16,660
2019 Drake award from the SETI Institute

96
00:04:22,530 --> 00:04:19,000
relations on that thank you yeah it's

97
00:04:23,610 --> 00:04:22,540
it's a quite an honor to be announced

98
00:04:25,860 --> 00:04:23,620
for that award I'm really looking

99
00:04:28,860 --> 00:04:25,870
forward to the to the ceremony in May

100
00:04:31,260 --> 00:04:28,870
down in down there in the San Francisco

101
00:04:32,550 --> 00:04:31,270
Bay Area yeah that's wonderful yeah I'm

102
00:04:35,210 --> 00:04:32,560
actually not happy I can be there we'll

103
00:04:37,080 --> 00:04:35,220
see it's possible my travel schedule

104
00:04:39,090 --> 00:04:37,090
sowhat's talking then about your

105
00:04:40,530 --> 00:04:39,100
research since it involves some SETI but

106
00:04:42,420 --> 00:04:40,540
it also involves a lot of things and

107
00:04:45,000 --> 00:04:42,430
understanding stars and exoplanets

108
00:04:47,760 --> 00:04:45,010
you've been involved in in instrument

109
00:04:49,050 --> 00:04:47,770
development and utilization and you've

110
00:04:50,910 --> 00:04:49,060
also worked with lots of teams of

111
00:04:53,300 --> 00:04:50,920
graduate students undergraduate students

112
00:04:55,560 --> 00:04:53,310
so I'm really excited to hear about this

113
00:04:57,150 --> 00:04:55,570

before we get into it though I'd love

114
00:05:00,060 --> 00:04:57,160
for you to give our audience a little

115
00:05:01,980 --> 00:05:00,070
bit of a background about yourself what

116
00:05:04,370 --> 00:05:01,990
inspired you to get started in science

117
00:05:07,800 --> 00:05:04,380
and what kind of rocky where you are now

118
00:05:09,990 --> 00:05:07,810
well I wish I remembered I've wanted to

119
00:05:11,700 --> 00:05:10,000
be an astronomer as long as I can

120
00:05:13,770 --> 00:05:11,710
remember when I was just a little kid

121
00:05:15,150 --> 00:05:13,780
looking at books about space I thought

122
00:05:16,920 --> 00:05:15,160
that's that's what I want to do that's

123
00:05:20,790 --> 00:05:16,930
what I want to be and I was really

124
00:05:22,260 --> 00:05:20,800
fortunate that that the job turned out

125
00:05:24,990 --> 00:05:22,270
to be something that I really enjoy

126
00:05:26,400 --> 00:05:25,000
doing something I'm good at a lot of

127
00:05:27,900 --> 00:05:26,410
times you know we imagine we're gonna be

128
00:05:29,460 --> 00:05:27,910
something you know like a space

129
00:05:31,950 --> 00:05:29,470
firefighter or something and that just

130
00:05:33,450 --> 00:05:31,960
turns out back to be practical but I was

131
00:05:36,180 --> 00:05:33,460
lucky enough that it's something that

132
00:05:38,330 --> 00:05:36,190
I've enjoyed every step of the way so

133
00:05:41,790 --> 00:05:38,340
I've just followed that through my whole

134
00:05:43,650 --> 00:05:41,800
schooling from being an astronomy and

135
00:05:46,140 --> 00:05:43,660
physics major at Boston University

136
00:05:49,980 --> 00:05:46,150
getting BC Berkeley for graduate studies

137
00:05:51,690 --> 00:05:49,990
in astronomy and astrophysics and now as

138
00:05:53,550 --> 00:05:51,700

an associate professor here at Penn

139
00:05:57,120 --> 00:05:53,560
State University where I mean my tenth

140
00:06:00,900 --> 00:05:57,130
year now doing the things that my my

141
00:06:03,420 --> 00:06:00,910
mentors did for me advising groups of

142
00:06:05,160 --> 00:06:03,430
students coming up with new research

143
00:06:08,700 --> 00:06:05,170
projects fun things to work on that

144
00:06:10,680 --> 00:06:08,710
matter and just finding lots of fun

145
00:06:15,240 --> 00:06:10,690
problems to work on one of the things I

146
00:06:17,610 --> 00:06:15,250
love about this field is that there are

147
00:06:19,230 --> 00:06:17,620
more problems than there are astronomers

148
00:06:20,780 --> 00:06:19,240
that is they're more interesting things

149
00:06:23,310 --> 00:06:20,790
to work on the people that can work on

150
00:06:25,050 --> 00:06:23,320
which means that while there are a lot

151
00:06:27,030 --> 00:06:25,060
of really big problems that require huge

152
00:06:28,119 --> 00:06:27,040
teams of people to all solve that one

153
00:06:33,399 --> 00:06:28,129
problem

154
00:06:34,749 --> 00:06:33,409
kind of have all to yourself that are

155
00:06:36,309 --> 00:06:34,759
really interesting to work on and you

156
00:06:38,169 --> 00:06:36,319
can just have going on you know on the

157
00:06:41,559 --> 00:06:38,179
side as you as you learn more and think

158
00:06:43,419 --> 00:06:41,569
more about it and so for my career since

159
00:06:45,790 --> 00:06:43,429
I've been a graduate student most of the

160
00:06:49,570 --> 00:06:45,800
bread-and-butter research in teams and

161
00:06:51,429 --> 00:06:49,580
groups has been finding new exoplanets

162
00:06:53,709 --> 00:06:51,439
these planets orbiting other stars so

163
00:06:56,589 --> 00:06:53,719

when I started you know between 20 and

164
00:06:58,600 --> 00:06:56,599
30 exoplanets known and now we have over

165
00:07:01,149 --> 00:06:58,610
a hundred timer over a hundred times

166
00:07:05,169 --> 00:07:01,159
that which is just amazing to have watch

167
00:07:07,089 --> 00:07:05,179
the deal that's flowed and but that I've

168
00:07:09,009 --> 00:07:07,099
also worked on problems that are a bit

169
00:07:12,159 --> 00:07:09,019
less flashy you know understanding how

170
00:07:13,659 --> 00:07:12,169
sun-like stars work has always been

171
00:07:16,059 --> 00:07:13,669
something that I've worked on is my very

172
00:07:17,799 --> 00:07:16,069
first research project and then even

173
00:07:19,389 --> 00:07:17,809
more out there little hobby projects

174
00:07:21,009 --> 00:07:19,399
involving search for extraterrestrial

175
00:07:22,719 --> 00:07:21,019
intelligence which is something I

176
00:07:25,629 --> 00:07:22,729
started working on just a few years ago

177
00:07:28,479 --> 00:07:25,639
actually and it's been a lot of fun well

178
00:07:30,100 --> 00:07:28,489
that's wonderful yeah so I first and I

179
00:07:32,919 --> 00:07:30,110
guess about some of your work in looking

180
00:07:34,480 --> 00:07:32,929
at exoplanets yeah and like you said

181
00:07:37,059 --> 00:07:34,490
like a hundredth time increase since

182
00:07:39,129 --> 00:07:37,069
when you first started looking sometimes

183
00:07:41,859 --> 00:07:39,139
i'm blown away by when i see children

184
00:07:43,869 --> 00:07:41,869
these days who grown up in an era where

185
00:07:45,879 --> 00:07:43,879
we know thousands of exoplanets when I

186
00:07:47,290 --> 00:07:45,889
was a kid that wasn't the case right and

187
00:07:49,299 --> 00:07:47,300
it makes me wonder for like the next

188
00:07:51,489 --> 00:07:49,309

generation is how many tens of thousands

189
00:07:54,129 --> 00:07:51,499
or hundreds of thousands will actually

190
00:07:55,299 --> 00:07:54,139
know of so for instance I saw on your

191
00:07:57,249 --> 00:07:55,309
website that you're involved in two

192
00:07:59,799 --> 00:07:57,259
different instruments that are kind of

193
00:08:02,889 --> 00:07:59,809
up and coming right now on telescopes to

194
00:08:04,779 --> 00:08:02,899
look for exoplanets around other stars

195
00:08:06,699 --> 00:08:04,789
one of those is knew it and the other

196
00:08:09,100 --> 00:08:06,709
one is the habitable zone planet finder

197
00:08:11,290 --> 00:08:09,110
I'm wondering to speak to us a bit about

198
00:08:14,679 --> 00:08:11,300
those instruments and what they're going

199
00:08:16,719 --> 00:08:14,689
to show us about exoplanets sure so

200
00:08:20,339 --> 00:08:16,729
these are both instruments that were

201
00:08:24,009 --> 00:08:20,349
conceived of designed and mostly built

202
00:08:26,469 --> 00:08:24,019
here at Penn State University the first

203
00:08:30,659 --> 00:08:26,479
is the habitable zone planet finder or

204
00:08:34,629 --> 00:08:30,669
hpf as we call it it's a stable

205
00:08:36,519 --> 00:08:34,639
spectrograph so it a starlight from a

206
00:08:37,779 --> 00:08:36,529
telescope and it spreads it out and all

207
00:08:41,430 --> 00:08:37,789
the colors are the rainbow so that we

208
00:08:42,839 --> 00:08:41,440
can see the the fingerprints

209
00:08:45,569 --> 00:08:42,849
the chemical elements in sparse

210
00:08:47,189 --> 00:08:45,579
atmospheres and then it's stable which

211
00:08:48,900 --> 00:08:47,199
means that the wavelengths that we

212
00:08:51,090 --> 00:08:48,910
measure those fingerprints at are known

213
00:08:53,249 --> 00:08:51,100

extremely well and if we come back

214
00:08:54,840 --> 00:08:53,259
months or years later and measure them

215
00:08:59,369 --> 00:08:54,850
again we know exactly how much they've

216
00:09:02,819 --> 00:08:59,379
shifted and we with this spectrograph we

217
00:09:05,220 --> 00:09:02,829
can watch as stars seem to move back and

218
00:09:07,439 --> 00:09:05,230
forth or do move back and forth because

219
00:09:09,509 --> 00:09:07,449
of planets orbiting them so this was the

220
00:09:12,269 --> 00:09:09,519
original method by which planets around

221
00:09:14,550 --> 00:09:12,279
other Suns like stars were first

222
00:09:17,960 --> 00:09:14,560
discovered with 51 pegasi and the ones

223
00:09:20,699 --> 00:09:17,970
that followed for many years and it's

224
00:09:22,170 --> 00:09:20,709
it's how we indirectly infer the

225
00:09:23,639 --> 00:09:22,180
presence of these planets but we know

226
00:09:24,990 --> 00:09:23,649
all sorts of things about the planets

227
00:09:27,360 --> 00:09:25,000
who discover that way we know they're

228
00:09:29,249 --> 00:09:27,370
all the periods there are approximate

229
00:09:31,319 --> 00:09:29,259
temperatures and we have a pretty good

230
00:09:33,300 --> 00:09:31,329
handle on their masses when we

231
00:09:37,319 --> 00:09:33,310
discovered them that way so the

232
00:09:39,240 --> 00:09:37,329
habitable zone planet finder is special

233
00:09:41,850 --> 00:09:39,250
in a couple of ways one is that it's on

234
00:09:43,800 --> 00:09:41,860
the the nine meter or hobby everly

235
00:09:45,480 --> 00:09:43,810
telescope at Texas so it gets to collect

236
00:09:47,790 --> 00:09:45,490
a lot of light and we can study very

237
00:09:50,790 --> 00:09:47,800
faint stars with it another is that it

238
00:09:52,439 --> 00:09:50,800

works at infrared wavelengths or maybe

239
00:09:54,600 --> 00:09:52,449
infrared astronomers might call it the

240
00:09:56,370 --> 00:09:54,610
NIR optical it's kind of right right

241
00:09:57,960 --> 00:09:56,380
redder than you can see with the eye but

242
00:09:59,280 --> 00:09:57,970
not quite at the infrared level that

243
00:10:02,189 --> 00:09:59,290
infrared astronomers talk about

244
00:10:04,199 --> 00:10:02,199
sometimes and the advantage there is

245
00:10:06,870 --> 00:10:04,209
that we can look at the very coolest

246
00:10:09,030 --> 00:10:06,880
stars most of the stars in the galaxies

247
00:10:10,889 --> 00:10:09,040
are actually thought you faint to see in

248
00:10:13,650 --> 00:10:10,899
fact the very closest stars to earth

249
00:10:16,019 --> 00:10:13,660
like Proxima Centauri or Barnard's star

250
00:10:17,790 --> 00:10:16,029
are invisible to the eye they're just

251
00:10:20,040 --> 00:10:17,800
far too faint at optical wavelengths so

252
00:10:22,050 --> 00:10:20,050
it's hard to look for planets around but

253
00:10:23,189 --> 00:10:22,060
if we move into the infrared they're

254
00:10:24,840 --> 00:10:23,199
much brighter they're because they're

255
00:10:27,540 --> 00:10:24,850
cool and that's where they give off most

256
00:10:29,730 --> 00:10:27,550
of their light so in this instrument we

257
00:10:31,980 --> 00:10:29,740
can look around the most abundant kinds

258
00:10:34,650 --> 00:10:31,990
of stars in the galaxy these are also

259
00:10:36,120 --> 00:10:34,660
the closest stars to earth and the

260
00:10:40,049 --> 00:10:36,130
reason it's called the habitable zone

261
00:10:41,549 --> 00:10:40,059
planets finder is that the region around

262
00:10:43,470 --> 00:10:41,559
those stars where planets might have

263
00:10:45,569 --> 00:10:43,480

liquid water is very close to the star

264
00:10:46,949 --> 00:10:45,579
which means that they pull on the star

265
00:10:49,590 --> 00:10:46,959
really hard and they go around really

266
00:10:51,240 --> 00:10:49,600
fast which means that the signal that we

267
00:10:52,319 --> 00:10:51,250
see from the star going back and forth

268
00:10:53,999 --> 00:10:52,329
is pretty strong

269
00:10:55,780 --> 00:10:54,009
which means with that instrument we can

270
00:10:58,870 --> 00:10:55,790
actually detect

271
00:11:00,310 --> 00:10:58,880
presumably terrestrial rocky planets at

272
00:11:02,170 --> 00:11:00,320
the right temperature for liquid water

273
00:11:03,850 --> 00:11:02,180
around the very nearest star so we can

274
00:11:05,560 --> 00:11:03,860
only do that because we have this giant

275
00:11:07,870 --> 00:11:05,570
telescope we're in the near-infrared so

276
00:11:09,580 --> 00:11:07,880
that's on the telescope now and in fact

277
00:11:11,680 --> 00:11:09,590
every week we see the new velocities

278
00:11:13,330 --> 00:11:11,690
that are coming in and get excited about

279
00:11:14,710 --> 00:11:13,340
the new planets that we're just starting

280
00:11:16,890 --> 00:11:14,720
to discover with that instrument so

281
00:11:19,810 --> 00:11:16,900
that's that's great

282
00:11:21,670 --> 00:11:19,820
the second spectrograph that we're

283
00:11:26,310 --> 00:11:21,680
building is one that's still in progress

284
00:11:28,180 --> 00:11:26,320
it's in the lab right now undergoing

285
00:11:30,430 --> 00:11:28,190
working on and putting it all together

286
00:11:32,560 --> 00:11:30,440
and testing things out and and finding

287
00:11:34,930 --> 00:11:32,570
bugs and fixing them this was a

288
00:11:37,000 --> 00:11:34,940

spectrograph that was commissioned by

289
00:11:41,260 --> 00:11:37,010
NASA and the National Science Foundation

290
00:11:43,870 --> 00:11:41,270
as a national premiere facility for

291
00:11:45,700 --> 00:11:43,880
finding planets around other stars so it

292
00:11:47,740 --> 00:11:45,710
will go on the winning three point five

293
00:11:50,620 --> 00:11:47,750
meter telescope peak National

294
00:11:52,870 --> 00:11:50,630
Observatory and it will be available for

295
00:11:55,180 --> 00:11:52,880
the entire world to propose foreign to

296
00:11:56,950 --> 00:11:55,190
use in fact the call for proposals for

297
00:11:59,230 --> 00:11:56,960
the first people to use it for the first

298
00:12:01,030 --> 00:11:59,240
time those proposals are due at the end

299
00:12:02,410 --> 00:12:01,040
of this month so we're all rapidly

300
00:12:04,420 --> 00:12:02,420
writing proposals trying to put those

301
00:12:06,360 --> 00:12:04,430
together to use this thing so let's

302
00:12:12,040 --> 00:12:06,370
claim the thing is that it will be

303
00:12:14,079 --> 00:12:12,050
exquisitely stable it's an amount of the

304
00:12:16,240 --> 00:12:14,089
amount of instrumental noise that it

305
00:12:17,800 --> 00:12:16,250
will contribute to our instruments will

306
00:12:19,960 --> 00:12:17,810
be so low it'll actually be hard to

307
00:12:21,250 --> 00:12:19,970
detect for most stars and in terms of

308
00:12:23,890 --> 00:12:21,260
the velocities we measure

309
00:12:26,829 --> 00:12:23,900
it'll be over 30 centimeters per second

310
00:12:28,840 --> 00:12:26,839
so to give you a sense when a planet

311
00:12:30,670 --> 00:12:28,850
Wiggles a star around like when Jupiter

312
00:12:32,950 --> 00:12:30,680
littlez the Sun around as it goes around

313
00:12:35,290 --> 00:12:32,960

every 12 years the Sun goes through

314
00:12:37,060 --> 00:12:35,300
moving in one direction in about 12

315
00:12:38,890 --> 00:12:37,070
meters per second so it's a little

316
00:12:41,110 --> 00:12:38,900
faster than the fastest human sprinters

317
00:12:44,110 --> 00:12:41,120
and then six years later it'll be going

318
00:12:47,290 --> 00:12:44,120
away in the other direction at 12 m/s

319
00:12:49,720 --> 00:12:47,300
the earth around the Sun makes the Sun

320
00:12:52,420 --> 00:12:49,730
go back and forth every year at about 10

321
00:12:53,710 --> 00:12:52,430
centimeters per second an instrumental

322
00:12:55,930 --> 00:12:53,720
stability of this instrument will be

323
00:12:58,360 --> 00:12:55,940
around three times that 30 centimeters a

324
00:13:01,300 --> 00:12:58,370
second so the instrument will not be

325
00:13:03,160 --> 00:13:01,310
limiting us from detecting things maybe

326
00:13:04,329 --> 00:13:03,170
three times the mass of the Earth or

327
00:13:06,549 --> 00:13:04,339
around the massive

328
00:13:09,220 --> 00:13:06,559
in the habitable zone around a star a

329
00:13:11,590 --> 00:13:09,230
little less massive than the Sun there's

330
00:13:13,210 --> 00:13:11,600
a lot of other issues with measuring the

331
00:13:16,150 --> 00:13:13,220
velocities of stars to that precision

332
00:13:19,059 --> 00:13:16,160
but that this instrument will at least

333
00:13:20,579 --> 00:13:19,069
be able to allow us to tackle that

334
00:13:22,449 --> 00:13:20,589
problem with measuring those velocities

335
00:13:24,489 --> 00:13:22,459
that's incredible

336
00:13:26,619 --> 00:13:24,499
so if you have to guess how many

337
00:13:28,150 --> 00:13:26,629
earth-like or the size roughly earth

338
00:13:30,819 --> 00:13:28,160

sized planets do you think that we'll be

339
00:13:33,639 --> 00:13:30,829
finding in just the next few years using

340
00:13:35,559 --> 00:13:33,649
just these instruments oh and precise

341
00:13:37,329 --> 00:13:35,569
radial velocities that will be limited

342
00:13:39,939 --> 00:13:37,339
just by how many stars we complained at

343
00:13:42,040 --> 00:13:39,949
basically what we've discovered with

344
00:13:45,489 --> 00:13:42,050
Kepler and other and other surveys is

345
00:13:46,660 --> 00:13:45,499
that most stars have planets we didn't

346
00:13:48,160 --> 00:13:46,670
you know we didn't know this before

347
00:13:50,259 --> 00:13:48,170
Kepler we knew that there were giant

348
00:13:51,999 --> 00:13:50,269
planets around lots of stars and we have

349
00:13:53,920 --> 00:13:52,009
a typical point and maybe one in ten

350
00:13:55,299 --> 00:13:53,930
stars that'd be pointed at we'd find

351
00:13:57,579 --> 00:13:55,309
planets and then as we started getting

352
00:14:00,730 --> 00:13:57,589
much more precise with instruments like

353
00:14:01,960 --> 00:14:00,740
the predecessors to hpf and newid we

354
00:14:03,549 --> 00:14:01,970
started finding that that number was

355
00:14:04,720 --> 00:14:03,559
much higher would be 50 percent or

356
00:14:06,670 --> 00:14:04,730
something like that but it was hard to

357
00:14:08,829 --> 00:14:06,680
tell because you know measuring these

358
00:14:11,559 --> 00:14:08,839
things is very difficult and then when

359
00:14:14,350 --> 00:14:11,569
Kepler launched and just discovered how

360
00:14:16,030 --> 00:14:14,360
many small planets that we had been

361
00:14:18,189 --> 00:14:16,040
insensitive to with the radial velocity

362
00:14:20,410 --> 00:14:18,199
technique we're really out there we

363
00:14:22,480 --> 00:14:20,420

started running the numbers and like the

364
00:14:27,610 --> 00:14:22,490
the typical number of planets per star

365
00:14:29,739 --> 00:14:27,620
is more than one and so these this next

366
00:14:31,449 --> 00:14:29,749
generation of instruments we can expect

367
00:14:33,999 --> 00:14:31,459
that almost every star we point at has

368
00:14:35,290 --> 00:14:34,009
planets the question will just be can we

369
00:14:38,139 --> 00:14:35,300
make enough measurements and are we

370
00:14:41,110 --> 00:14:38,149
sensitive enough to count them well it's

371
00:14:43,540 --> 00:14:41,120
incredible remind our audience that you

372
00:14:45,999 --> 00:14:43,550
can ask questions for dr. Wright on the

373
00:14:48,610 --> 00:14:46,009
second org on the NASA Astrobiology

374
00:14:51,730 --> 00:14:48,620
Facebook page and on Twitter using the

375
00:14:53,619 --> 00:14:51,740
hashtag ask Astro bio so it's pretty

376
00:14:56,230 --> 00:14:53,629
incredible now we have things like hpf

377
00:14:59,079 --> 00:14:56,240
and newid coming out for ground-based

378
00:15:00,879 --> 00:14:59,089
observations you mentioned Kepler we now

379
00:15:03,160 --> 00:15:00,889
have tests the transiting exoplanet

380
00:15:04,389 --> 00:15:03,170
survey satellite which many of us are

381
00:15:06,299 --> 00:15:04,399
looking forward to the possible

382
00:15:08,590 --> 00:15:06,309
thousands of planets will find with Tess

383
00:15:11,110 --> 00:15:08,600
I'm wondering what do you think the

384
00:15:13,509 --> 00:15:11,120
future now holds for exoplanet discovery

385
00:15:13,960 --> 00:15:13,519
for these next-generation telescopes

386
00:15:16,869 --> 00:15:13,970
that have been

387
00:15:18,009 --> 00:15:16,879
propose like leVoir and JWST and some of

388
00:15:20,410 --> 00:15:18,019

these other instruments that are going

389
00:15:23,379 --> 00:15:20,420
to be out there in space and on the

390
00:15:24,759 --> 00:15:23,389
ground do you think say but maybe the

391
00:15:27,400 --> 00:15:24,769
next 10 years that we'll have another

392
00:15:29,829 --> 00:15:27,410
10,000 exoplanets that we'll know over

393
00:15:31,119 --> 00:15:29,839
is that a little too optimistic um so

394
00:15:34,329 --> 00:15:31,129
you know when we started this every

395
00:15:36,460 --> 00:15:34,339
planet was New York Times headline every

396
00:15:39,249 --> 00:15:36,470
planet every system was new and strange

397
00:15:40,749 --> 00:15:39,259
and interesting and different and then

398
00:15:42,610 --> 00:15:40,759
once we started getting past about a

399
00:15:43,780 --> 00:15:42,620
hundred just you know one more exoplanet

400
00:15:47,920 --> 00:15:43,790
wasn't necessarily something

401
00:15:49,809 --> 00:15:47,930
groundbreaking and then when we started

402
00:15:51,460 --> 00:15:49,819
finding planets transiting other stars

403
00:15:53,530 --> 00:15:51,470
passing between us and the star making

404
00:15:55,600 --> 00:15:53,540
the star get dimmer that opened up the

405
00:15:58,050 --> 00:15:55,610
possibility for something like Kepler

406
00:16:01,179 --> 00:15:58,060
well we might find thousands of them

407
00:16:02,650 --> 00:16:01,189
it's a with Kepler that's happened we

408
00:16:04,929 --> 00:16:02,660
have thousands of planets from Kepler

409
00:16:07,360 --> 00:16:04,939
you're gonna get thousands more from

410
00:16:09,790 --> 00:16:07,370
tests and so that's allowing us to do

411
00:16:11,470 --> 00:16:09,800
this statistics mostly a shorter period

412
00:16:12,129 --> 00:16:11,480
planet so most of those planets we're

413
00:16:14,199 --> 00:16:12,139

talking about

414
00:16:16,030 --> 00:16:14,209
orbit those stars in less than a year

415
00:16:19,600 --> 00:16:16,040
many of them orbit their stars in less

416
00:16:21,100 --> 00:16:19,610
than 30 days which is much closer to

417
00:16:24,189 --> 00:16:21,110
their stars than anything in our solar

418
00:16:25,960 --> 00:16:24,199
system orbits the Sun so we have those

419
00:16:29,619 --> 00:16:25,970
statistics for these very close in

420
00:16:31,389 --> 00:16:29,629
planets pretty well nailed and so I

421
00:16:33,069 --> 00:16:31,399
don't think those that there it's gonna

422
00:16:35,220 --> 00:16:33,079
be an opportunity to get another like

423
00:16:37,629 --> 00:16:35,230
10,000 of those because that by itself

424
00:16:39,699 --> 00:16:37,639
probably isn't a sufficiently compelling

425
00:16:43,360 --> 00:16:39,709
science problem to launch a whole new

426
00:16:44,799 --> 00:16:43,370
mission so so especially the tests now

427
00:16:46,629 --> 00:16:44,809
that we're going to have something like

428
00:16:49,059 --> 00:16:46,639
10,000 planets when we're all done with

429
00:16:50,829 --> 00:16:49,069
that and all the Kepler data the

430
00:16:53,199 --> 00:16:50,839
question is here what do we do next and

431
00:16:55,030 --> 00:16:53,209
what we do next is we study the most

432
00:16:57,519 --> 00:16:55,040
interesting planets and get to know them

433
00:16:59,019 --> 00:16:57,529
better so what are some of the most

434
00:17:01,600 --> 00:16:59,029
interesting planets we'd like to find

435
00:17:03,189 --> 00:17:01,610
things like the earth that ties in

436
00:17:06,039 --> 00:17:03,199
closest to the search for life in the

437
00:17:07,360 --> 00:17:06,049
universe because well of course nature

438
00:17:08,590 --> 00:17:07,370

could surprise us and life could be

439
00:17:10,569 --> 00:17:08,600
anywhere and something they weren't

440
00:17:12,399 --> 00:17:10,579
expecting if we're gonna go looking for

441
00:17:14,679 --> 00:17:12,409
it we have to have some sense of where

442
00:17:17,529 --> 00:17:14,689
to look and so the best bet that we have

443
00:17:20,500 --> 00:17:17,539
when we go looking are places like Earth

444
00:17:22,960 --> 00:17:20,510
and places that life we know can form on

445
00:17:24,069 --> 00:17:22,970
earth so we'd like to find rocky planets

446
00:17:25,270 --> 00:17:24,079
around one or at this

447
00:17:26,980 --> 00:17:25,280
we'd like those planets to have

448
00:17:28,329 --> 00:17:26,990
something like the the

449
00:17:32,380 --> 00:17:28,339
the surface temperatures where we'd

450
00:17:33,789 --> 00:17:32,390
expect liquid water to be so we're gonna

451
00:17:35,680 --> 00:17:33,799
go looking for those and we don't know

452
00:17:37,510 --> 00:17:35,690
about very many of those planets that's

453
00:17:40,750 --> 00:17:37,520
what hpf is for that's what new it is

454
00:17:42,519 --> 00:17:40,760
for and we so hopefully we will be

455
00:17:45,220 --> 00:17:42,529
getting up to dozens and dozens of those

456
00:17:46,510 --> 00:17:45,230
in the future we also have the

457
00:17:48,639 --> 00:17:46,520
opportunity with these new space

458
00:17:50,919 --> 00:17:48,649
coronagraphs to actually directly image

459
00:17:54,159 --> 00:17:50,929
older planets maybe in reflected light

460
00:17:56,110 --> 00:17:54,169
and study what they're like and so many

461
00:17:58,230 --> 00:17:56,120
of those will be giant planets more like

462
00:18:01,120 --> 00:17:58,240
Jupiter some of them will be smaller and

463
00:18:03,190 --> 00:18:01,130

that'll be exciting to actually see that

464
00:18:04,539 --> 00:18:03,200
dot of light in an image and actually be

465
00:18:06,940 --> 00:18:04,549
able to get a spectrum of it and learn

466
00:18:08,919 --> 00:18:06,950
something about its atmosphere the other

467
00:18:11,500 --> 00:18:08,929
thing we can do is look for planets that

468
00:18:13,360 --> 00:18:11,510
we know pass in front of their star from

469
00:18:16,419 --> 00:18:13,370
our vantage point transiting planets

470
00:18:18,039 --> 00:18:16,429
that are like earth hopefully and study

471
00:18:20,110 --> 00:18:18,049
their atmosphere and transmission that

472
00:18:22,659 --> 00:18:20,120
is won't get a picture of that planet

473
00:18:24,760 --> 00:18:22,669
that we can look at but we will watch

474
00:18:27,010 --> 00:18:24,770
the star get dimmer and some of that

475
00:18:28,360 --> 00:18:27,020
light being blocked by the star is

476
00:18:31,299 --> 00:18:28,370
passing through the planet's atmosphere

477
00:18:32,440 --> 00:18:31,309
and so we can study the spectrum of the

478
00:18:33,909 --> 00:18:32,450
light as if it's passed through the

479
00:18:36,039 --> 00:18:33,919
atmosphere and study the atmospheric

480
00:18:38,139 --> 00:18:36,049
composition of those planets so the

481
00:18:39,820 --> 00:18:38,149
James Webb Space Telescope we're hopeful

482
00:18:42,130 --> 00:18:39,830
that we'll be able to measure actual

483
00:18:44,500 --> 00:18:42,140
planetary atmosphere constituents not

484
00:18:47,080 --> 00:18:44,510
just a very hot or giant planets like

485
00:18:49,870 --> 00:18:47,090
Jupiter or even bigger than Jupiter but

486
00:18:52,000 --> 00:18:49,880
hopefully much smaller things hopefully

487
00:18:54,669 --> 00:18:52,010
even things that might be rocky and have

488
00:18:56,649 --> 00:18:54,679

atmospheres like the earth that's so

489
00:18:58,299 --> 00:18:56,659
cool and I think a lot of us in the

490
00:19:00,700 --> 00:18:58,309
astrobiology community and enthusiasts

491
00:19:01,990 --> 00:19:00,710
of astrobiology are hopeful for one of

492
00:19:04,539 --> 00:19:02,000
those days and we find one of these

493
00:19:09,039 --> 00:19:04,549
atmospheres that could have the signs of

494
00:19:10,870 --> 00:19:09,049
life inside of it if we found that do

495
00:19:13,450 --> 00:19:10,880
you think that really changed our search

496
00:19:14,980 --> 00:19:13,460
for extraterrestrial life do you think

497
00:19:17,080 --> 00:19:14,990
we'd start honing in then on one of

498
00:19:18,730 --> 00:19:17,090
those worlds we find potential bio

499
00:19:21,450 --> 00:19:18,740
signatures in an atmosphere and really

500
00:19:23,830 --> 00:19:21,460
try to figure out if it is life or not

501
00:19:25,419 --> 00:19:23,840
yeah certainly if we saw something that

502
00:19:27,580 --> 00:19:25,429
was really indicative of life I think

503
00:19:30,730 --> 00:19:27,590
that that target would get a lot of

504
00:19:35,289 --> 00:19:30,740
observations we would pull a lot into

505
00:19:37,389 --> 00:19:35,299
that particular target and and yeah I

506
00:19:39,760 --> 00:19:37,399
mean one issue is that when we first

507
00:19:40,659 --> 00:19:39,770
find bio signatures they probably will

508
00:19:43,389 --> 00:19:40,669
be a bit

509
00:19:45,310 --> 00:19:43,399
biggis people are always thinking of new

510
00:19:46,799 --> 00:19:45,320
ways that we might say hey that's that's

511
00:19:49,930 --> 00:19:46,809
a bio signature you see for instance

512
00:19:52,029 --> 00:19:49,940
methane and oxygen in the same planetary

513
00:19:56,229 --> 00:19:52,039

atmosphere and on earth that only

514
00:19:58,119 --> 00:19:56,239
happens because of life but then we'll

515
00:20:00,070 --> 00:19:58,129
always be able to dream up not always we

516
00:20:01,330 --> 00:20:00,080
will often be able to tree mop abiotic

517
00:20:03,039 --> 00:20:01,340
ways to produce that particular

518
00:20:04,930 --> 00:20:03,049
signature and these are going to be very

519
00:20:07,330 --> 00:20:04,940
challenging detectives the first time we

520
00:20:10,060 --> 00:20:07,340
detect it if we low signal-to-noise the

521
00:20:11,409 --> 00:20:10,070
data will be ready it'll be us but it'll

522
00:20:13,029 --> 00:20:11,419
be intriguing enough that we'll try

523
00:20:15,609 --> 00:20:13,039
harder to make a better measurement and

524
00:20:17,169 --> 00:20:15,619
really understand what we're looking and

525
00:20:20,019 --> 00:20:17,179
so depending on what we find depending

526
00:20:22,029 --> 00:20:20,029
on what it was that intrigued us that'll

527
00:20:23,379 --> 00:20:22,039
you know dictate how we follow up on

528
00:20:25,269 --> 00:20:23,389
those instruments and it might be a long

529
00:20:29,799 --> 00:20:25,279
time before everybody concurs yeah you

530
00:20:32,109 --> 00:20:29,809
know that's life on another planet so

531
00:20:35,470 --> 00:20:32,119
it's hard to say how long it'll take

532
00:20:38,169 --> 00:20:35,480
remember when 51 pegasi the first planet

533
00:20:40,060 --> 00:20:38,179
around a sun-like star was discovered in

534
00:20:41,349 --> 00:20:40,070
retrospect that was a watershed moment

535
00:20:43,479 --> 00:20:41,359
it certainly there was a lot of

536
00:20:45,190 --> 00:20:43,489
excitement when that was announced but

537
00:20:46,509 --> 00:20:45,200
it wasn't universally accepted that that

538
00:20:48,519 --> 00:20:46,519

was an exoplanet it was such a

539
00:20:51,460 --> 00:20:48,529
surprising discovery it was not what we

540
00:20:53,200 --> 00:20:51,470
thought we would see and so it took a

541
00:20:54,700 --> 00:20:53,210
few years for things to shake out and

542
00:20:56,919 --> 00:20:54,710
everyone to agree yeah you know the

543
00:20:58,749 --> 00:20:56,929
exoplanet revolution has actually begun

544
00:21:02,200 --> 00:20:58,759
and I suspect that's what it will be

545
00:21:04,029 --> 00:21:02,210
with biosignatures - you know 20 years

546
00:21:05,950 --> 00:21:04,039
after the first one is detected that'll

547
00:21:07,389 --> 00:21:05,960
go down is the watershed moment but

548
00:21:09,869 --> 00:21:07,399
actually that following five or ten

549
00:21:13,330 --> 00:21:09,879
years there will be a lot of discussion

550
00:21:14,769 --> 00:21:13,340
and incredibly hope so any nice if that

551
00:21:17,769 --> 00:21:14,779
happens kind of soon so that's all

552
00:21:20,649 --> 00:21:17,779
that's gonna see it that's right

553
00:21:23,680 --> 00:21:20,659
absolutely I mentioned that you maintain

554
00:21:25,899 --> 00:21:23,690
the website exoplanet story which is one

555
00:21:27,700 --> 00:21:25,909
great place for people to go and see the

556
00:21:30,580 --> 00:21:27,710
exoplanets we've discovered so far and

557
00:21:32,109 --> 00:21:30,590
learn more about them so how many

558
00:21:35,259 --> 00:21:32,119
exoplanets do we actually have right now

559
00:21:38,019 --> 00:21:35,269
in that database oh the actual number

560
00:21:40,080 --> 00:21:38,029
I'm gonna have to actually cheat and

561
00:21:45,310 --> 00:21:40,090
jump over to see the number okay

562
00:21:47,620 --> 00:21:45,320
so we've kept track of 3237 planets that

563
00:21:52,080 --> 00:21:47,630

have good orbits listed in

564
00:21:54,220 --> 00:21:52,090
database and there are another 26 that

565
00:21:55,600 --> 00:21:54,230
we're pretty sure a real planets have

566
00:21:57,700 --> 00:21:55,610
been in interests or we saw them through

567
00:21:59,440 --> 00:21:57,710
micro lensing where we don't have great

568
00:22:03,700 --> 00:21:59,450
orbits but we know their planets and

569
00:22:05,980 --> 00:22:03,710
another 2485 a candidate planets most of

570
00:22:07,480 --> 00:22:05,990
which are real that were discovered by

571
00:22:10,840 --> 00:22:07,490
Kepler and that's that's where the

572
00:22:14,320 --> 00:22:10,850
database lives today and that's not even

573
00:22:18,130 --> 00:22:14,330
counting the planets that were published

574
00:22:20,230 --> 00:22:18,140
in the last say nine months so it was

575
00:22:21,850 --> 00:22:20,240
about it's about nine months behind that

576
00:22:23,230 --> 00:22:21,860
particular database but that's something

577
00:22:25,510 --> 00:22:23,240
that I've been maintaining since I was a

578
00:22:27,520 --> 00:22:25,520
graduate student I said when I started

579
00:22:29,110 --> 00:22:27,530
there were twenty or thirty planets and

580
00:22:31,540 --> 00:22:29,120
I know because we kept the list Paul

581
00:22:34,210 --> 00:22:31,550
Butler had his list of planets as they

582
00:22:35,950 --> 00:22:34,220
got discovered and that list just grew

583
00:22:38,110 --> 00:22:35,960
and grew and grew and eventually we put

584
00:22:41,680 --> 00:22:38,120
it on a computer and eventually it

585
00:22:44,230 --> 00:22:41,690
became exoplanets org and so it's been a

586
00:22:46,600 --> 00:22:44,240
little blob to keep track of all the

587
00:22:47,980 --> 00:22:46,610
planets coming out and that website has

588
00:22:50,350 --> 00:22:47,990

a great interface if you'd like to

589
00:22:52,690 --> 00:22:50,360
explore the planetary properties well

590
00:22:56,050 --> 00:22:52,700
you can make charts and graphs and see

591
00:22:57,850 --> 00:22:56,060
see what kind of planets we know about

592
00:22:58,090 --> 00:22:57,860
or know about it you know almost a year

593
00:23:00,940 --> 00:22:58,100
ago

594
00:23:03,040 --> 00:23:00,950
truth be told though the the flood is

595
00:23:05,380 --> 00:23:03,050
just too much I can't actually keep up

596
00:23:06,880 --> 00:23:05,390
with all of the planets anymore and

597
00:23:08,440 --> 00:23:06,890
that's why we're behind on that

598
00:23:10,660 --> 00:23:08,450
particular site but it's still a great

599
00:23:13,330 --> 00:23:10,670
place to find about all the extra

600
00:23:15,700 --> 00:23:13,340
planets we know that's incredible I

601
00:23:17,830 --> 00:23:15,710
guess it's a good thing a bad thing it's

602
00:23:19,690 --> 00:23:17,840
a flood of exoplanets that we just can't

603
00:23:21,010 --> 00:23:19,700
keep up with terrain hopefully we can

604
00:23:22,270 --> 00:23:21,020
you know have some undergrads and grad

605
00:23:25,450 --> 00:23:22,280
students come in and start taking over

606
00:23:27,520 --> 00:23:25,460
some of that work and to know we have a

607
00:23:29,710 --> 00:23:27,530
lot of plans to support things over we

608
00:23:32,620 --> 00:23:29,720
are working with the folks at Space

609
00:23:34,870 --> 00:23:32,630
Telescope Science Institute and their

610
00:23:37,510 --> 00:23:34,880
their archive to integrate the data

611
00:23:40,060 --> 00:23:37,520
there into a lot of the products and

612
00:23:42,340 --> 00:23:40,070
we're hoping that we can we can do more

613
00:23:43,930 --> 00:23:42,350

to keep it maintained into the future

614
00:23:46,390 --> 00:23:43,940
and then we can even expand it to

615
00:23:48,460 --> 00:23:46,400
include potentially other databases as

616
00:23:49,870 --> 00:23:48,470
well so that if you study asteroids or

617
00:23:52,150 --> 00:23:49,880
binary stars or something you could have

618
00:23:53,890 --> 00:23:52,160
your own version of the interface that's

619
00:23:55,450 --> 00:23:53,900
really cool yeah I mean right now we

620
00:23:57,220 --> 00:23:55,460
have spacecraft at two different

621
00:23:58,870 --> 00:23:57,230
asteroids in our solar system like they

622
00:24:00,130 --> 00:23:58,880
do in Rio and so

623
00:24:01,780 --> 00:24:00,140
pretty cool what's going on in solar

624
00:24:03,850 --> 00:24:01,790
system exploration right now as well

625
00:24:04,720 --> 00:24:03,860
that's the better understand the worlds

626
00:24:07,330 --> 00:24:04,730
of our solar system

627
00:24:10,660 --> 00:24:07,340
I do wanna switch gears and men that you

628
00:24:12,220 --> 00:24:10,670
are project scientists with Nexus I'm

629
00:24:13,120 --> 00:24:12,230
wondering if you can mention or your PI

630
00:24:14,830 --> 00:24:13,130
sorry

631
00:24:17,790 --> 00:24:14,840
we have Nexus and one of you mention

632
00:24:20,920 --> 00:24:17,800
what your role is in Nexus with NASA

633
00:24:24,250 --> 00:24:20,930
so Nexus is interesting it's it's this

634
00:24:26,740 --> 00:24:24,260
research collaboration network where

635
00:24:28,980 --> 00:24:26,750
NASA picked people that were working on

636
00:24:32,080 --> 00:24:28,990
interesting projects of NASA grants

637
00:24:35,320 --> 00:24:32,090
across a range of disciplines that

638
00:24:38,620 --> 00:24:35,330

relate to exoplanets and we get together

639
00:24:41,800 --> 00:24:38,630
in face-to-face meetings about once a

640
00:24:45,190 --> 00:24:41,810
year or a little less and and we just

641
00:24:47,110 --> 00:24:45,200
talk about how we can cross pollinate

642
00:24:48,760 --> 00:24:47,120
each other's research so we have people

643
00:24:50,280 --> 00:24:48,770
that think about healing or physics

644
00:24:53,320 --> 00:24:50,290
people who think about geophysics

645
00:24:55,780 --> 00:24:53,330
planetary science stellar astrophysics

646
00:25:01,000 --> 00:24:55,790
and X exoplanets and just trying to

647
00:25:02,320 --> 00:25:01,010
think of planetary systems in terms of

648
00:25:04,330 --> 00:25:02,330
all of these things because you know

649
00:25:06,370 --> 00:25:04,340
when we study when we go looking for

650
00:25:09,430 --> 00:25:06,380
exoplanets we're really staring at stars

651
00:25:10,930 --> 00:25:09,440
stars give us all the light exoplanets

652
00:25:13,390 --> 00:25:10,940
convert a little light compared to the

653
00:25:16,690 --> 00:25:13,400
star in some cases you know we're not

654
00:25:18,370 --> 00:25:16,700
studying any planetary light at all and

655
00:25:20,530 --> 00:25:18,380
so we have to understand the stars super

656
00:25:21,610 --> 00:25:20,540
well to find the planets and then we

657
00:25:23,320 --> 00:25:21,620
want to know what the planets are like

658
00:25:26,050 --> 00:25:23,330
so we need to understand the stars again

659
00:25:27,670 --> 00:25:26,060
how are they illuminating their planets

660
00:25:29,020 --> 00:25:27,680
and what's that like and then we want to

661
00:25:30,190 --> 00:25:29,030
know the planets are made up then we

662
00:25:31,870 --> 00:25:30,200
know they're made at the same stuff as

663
00:25:34,420 --> 00:25:31,880

the star so now again we're studying the

664
00:25:35,860 --> 00:25:34,430
star to learn about the planet and of

665
00:25:38,860 --> 00:25:35,870
course we have a star in our backyard

666
00:25:41,350 --> 00:25:38,870
the Sun hanging out there that we know

667
00:25:44,080 --> 00:25:41,360
extremely well and yet there's not a lot

668
00:25:46,030 --> 00:25:44,090
of discussion among helium physicists

669
00:25:48,130 --> 00:25:46,040
who know that star really well and

670
00:25:49,960 --> 00:25:48,140
exoplanetary astronomers who are trying

671
00:25:52,480 --> 00:25:49,970
to stand there their planets really well

672
00:25:54,310 --> 00:25:52,490
and then we discover things that we

673
00:25:56,080 --> 00:25:54,320
think are locky and we're trying to

674
00:25:57,370 --> 00:25:56,090
discover what a rocky exoplanet might be

675
00:25:59,440 --> 00:25:57,380
like but what do you know we've got

676
00:26:01,600 --> 00:25:59,450
these geophysicists who know this rocky

677
00:26:03,940 --> 00:26:01,610
planet you sit on really really well so

678
00:26:05,140 --> 00:26:03,950
it's a nexus for us all to learn what

679
00:26:06,430 --> 00:26:05,150
the other people know and what we're

680
00:26:07,780 --> 00:26:06,440
trying to figure out so we're not

681
00:26:09,500 --> 00:26:07,790
reinventing wheels it's a really

682
00:26:10,820 --> 00:26:09,510
productive way to work to go

683
00:26:12,920 --> 00:26:10,830
these meetings and here what people are

684
00:26:16,960 --> 00:26:12,930
working on it and think about the big

685
00:26:18,980 --> 00:26:16,970
picture you might call planetary systems

686
00:26:20,330 --> 00:26:18,990
that's wonderful yeah having that kind

687
00:26:22,070 --> 00:26:20,340
of level of collaboration to bring

688
00:26:23,120 --> 00:26:22,080

people together from kind of different

689
00:26:26,180 --> 00:26:23,130
backgrounds to approach those problems

690
00:26:27,440 --> 00:26:26,190
together so do you have a graduate

691
00:26:28,880 --> 00:26:27,450
students undergraduate students working

692
00:26:30,530 --> 00:26:28,890
in your laboratory as well who are

693
00:26:32,000 --> 00:26:30,540
involved in some of this work that

694
00:26:33,620 --> 00:26:32,010
you've been doing looking at stars

695
00:26:36,130 --> 00:26:33,630
looking at exoplanets involved with

696
00:26:39,770 --> 00:26:36,140
Nexus and these various instruments

697
00:26:43,520 --> 00:26:39,780
absolutely yeah so in terms of Nexus one

698
00:26:47,240 --> 00:26:43,530
of the benefits of being a PI of Nexus

699
00:26:50,690 --> 00:26:47,250
is that we can ask NASA to sponsor

700
00:26:52,640 --> 00:26:50,700
postdoctoral fellows and so the catch is

701
00:26:54,910 --> 00:26:52,650
that it has to be two Nexus POS that

702
00:26:58,760 --> 00:26:54,920
work on different things that color buys

703
00:27:01,730 --> 00:26:58,770
postdoctoral scholar to attack a problem

704
00:27:04,580 --> 00:27:01,740
you know from both angles at once so we

705
00:27:07,190 --> 00:27:04,590
work so our postdoctoral scholar that I

706
00:27:10,160 --> 00:27:07,200
work with is Eva Bodmin at Arizona State

707
00:27:14,450 --> 00:27:10,170
University what our primary adviser is

708
00:27:16,190 --> 00:27:14,460
Steve - another nexus PI and Steve's

709
00:27:18,080 --> 00:27:16,200
group is really diverse it's hard to

710
00:27:19,580 --> 00:27:18,090
contain exactly what he works on but

711
00:27:21,710 --> 00:27:19,590
they think about planets and planetary

712
00:27:23,720 --> 00:27:21,720
atmospheres they think about the solar

713
00:27:25,520 --> 00:27:23,730

system I'm and I bring the stellar

714
00:27:27,620 --> 00:27:25,530
astrophysics angle which is my primary

715
00:27:29,630 --> 00:27:27,630
background and so he has worked on a

716
00:27:31,930 --> 00:27:29,640
bunch of interesting projects she

717
00:27:34,160 --> 00:27:31,940
studied the light curve of tabi star

718
00:27:36,020 --> 00:27:34,170
which is this star that Kepler

719
00:27:38,450 --> 00:27:36,030
discovered that has something blocking

720
00:27:40,160 --> 00:27:38,460
its light it's very confusing hard to

721
00:27:42,440 --> 00:27:40,170
understand exactly what's going on

722
00:27:45,680 --> 00:27:42,450
making the star gets suddenly dimmer for

723
00:27:48,590 --> 00:27:45,690
like a week at a time and Eva working

724
00:27:51,680 --> 00:27:48,600
with Tali Boyajian at Louisiana State

725
00:27:53,390 --> 00:27:51,690
University and me and Steve has put

726
00:27:54,800 --> 00:27:53,400
together all the data we have on it and

727
00:27:57,200 --> 00:27:54,810
shown that whatever is blocking the

728
00:27:59,540 --> 00:27:57,210
Starlight is dust its disaster physical

729
00:28:01,040 --> 00:27:59,550
stuff that feels fills the galaxy and

730
00:28:03,080 --> 00:28:01,050
often orbit stars although we don't know

731
00:28:04,610 --> 00:28:03,090
why it's around this star and try to

732
00:28:07,370 --> 00:28:04,620
study its properties so we can figure

733
00:28:09,320 --> 00:28:07,380
out what's going on with that star she's

734
00:28:12,860 --> 00:28:09,330
also looking at how we can study

735
00:28:14,810 --> 00:28:12,870
exoplanet interiors there are there's a

736
00:28:18,860 --> 00:28:14,820
rare class of exoplanet discovered by

737
00:28:20,720 --> 00:28:18,870
Kepler that orbits its star in less than

738
00:28:21,960 --> 00:28:20,730

a day so these things are not far from

739
00:28:24,090 --> 00:28:21,970
their star in August if you

740
00:28:27,900 --> 00:28:24,100
stellar radii and they can go around in

741
00:28:30,750 --> 00:28:27,910
like 8 to 15 hours and when a planet is

742
00:28:32,490 --> 00:28:30,760
that close to a star apparently it can

743
00:28:34,440 --> 00:28:32,500
evaporate or something's going on that

744
00:28:36,720 --> 00:28:34,450
they're losing a lot of materials so we

745
00:28:39,300 --> 00:28:36,730
can't actually see the planet block the

746
00:28:41,280 --> 00:28:39,310
Starlight but we do see this huge plume

747
00:28:44,130 --> 00:28:41,290
of material coming off of a planet

748
00:28:46,050 --> 00:28:44,140
blocking the Starlight and so she's been

749
00:28:48,540 --> 00:28:46,060
studying how we can use the James Webb

750
00:28:50,640 --> 00:28:48,550
Space Telescope to analyze the

751
00:28:52,740 --> 00:28:50,650
mineralogical properties of that

752
00:28:54,270 --> 00:28:52,750
material coming off of these exoplanets

753
00:28:57,090 --> 00:28:54,280
which would actually allow us to

754
00:28:59,580 --> 00:28:57,100
understand the mineralogical properties

755
00:29:02,040 --> 00:28:59,590
of an exoplanet interior directly will

756
00:29:04,170 --> 00:29:02,050
have a spectrum of the material of the

757
00:29:06,240 --> 00:29:04,180
inside of an exoplanet which is

758
00:29:08,970 --> 00:29:06,250
extraordinary because we don't even have

759
00:29:11,370 --> 00:29:08,980
that for solar system planets we really

760
00:29:13,110 --> 00:29:11,380
don't have that very well understood for

761
00:29:15,330 --> 00:29:13,120
the earth itself with very few samples

762
00:29:17,280 --> 00:29:15,340
of the deep earth interior and we don't

763
00:29:18,840 --> 00:29:17,290

know how representative they are so it's

764
00:29:21,120 --> 00:29:18,850
a pretty extraordinary opportunity to

765
00:29:22,770 --> 00:29:21,130
study what rocky exoplanets are made of

766
00:29:24,450 --> 00:29:22,780
so that's that's what she's working on

767
00:29:26,880 --> 00:29:24,460
the speed for instance you know it

768
00:29:28,230 --> 00:29:26,890
sounds incredible just to see inside of

769
00:29:30,030 --> 00:29:28,240
a planet like that I know we've I've

770
00:29:32,040 --> 00:29:30,040
heard people talk about Jupiter possibly

771
00:29:34,140 --> 00:29:32,050
having liquid and metallic hydrogen

772
00:29:36,150 --> 00:29:34,150
layers down inside of it but we really

773
00:29:37,500 --> 00:29:36,160
don't know if it's there or not and so

774
00:29:38,970 --> 00:29:37,510
it'd be so cool if we could see you know

775
00:29:41,010 --> 00:29:38,980
inside a world like that to better

776
00:29:43,590 --> 00:29:41,020
understand it before we do open it up to

777
00:29:46,560 --> 00:29:43,600
audience questions though dr. ray

778
00:29:47,850 --> 00:29:46,570
I want chatted a bit about SETI and what

779
00:29:50,580 --> 00:29:47,860
you've done so far in your work with

780
00:29:52,800 --> 00:29:50,590
study and this quest to understand if

781
00:29:54,720 --> 00:29:52,810
there is excess rescue intelligence out

782
00:29:55,710 --> 00:29:54,730
there in the universe what your mind

783
00:29:58,530 --> 00:29:55,720
speaking about what you've what you've

784
00:30:00,090 --> 00:29:58,540
been involved is so far sure so it's

785
00:30:01,980 --> 00:30:00,100
only been the last couple of years that

786
00:30:03,020 --> 00:30:01,990
I've been working on this I kind of fell

787
00:30:04,820 --> 00:30:03,030
into it

788
00:30:07,350 --> 00:30:04,830

the search for extraterrestrial

789
00:30:09,150 --> 00:30:07,360
intelligences is really a broad field

790
00:30:10,770 --> 00:30:09,160
those people in they when they hear the

791
00:30:13,410 --> 00:30:10,780
term they think about Jodie Foster on

792
00:30:16,620 --> 00:30:13,420
her car the headphones right the large

793
00:30:18,060 --> 00:30:16,630
array in the background and that is I

794
00:30:20,190 --> 00:30:18,070
mean except for the headphones using

795
00:30:22,380 --> 00:30:20,200
using radio telescopes to look for

796
00:30:27,060 --> 00:30:22,390
deliberate signals or even or even leak

797
00:30:28,950 --> 00:30:27,070
signals from other civilizations is is

798
00:30:31,800 --> 00:30:28,960
where a lot of the work in this field

799
00:30:33,990 --> 00:30:31,810
has happened and indeed if you want a

800
00:30:34,380 --> 00:30:34,000
nearby star looking back at the Sun and

801
00:30:38,940 --> 00:30:34,390
you want

802
00:30:42,270 --> 00:30:38,950
No is there life orbiting that star the

803
00:30:45,420 --> 00:30:42,280
easiest way to tell that there was using

804
00:30:47,460 --> 00:30:45,430
earth mm technology will be listen for

805
00:30:51,020 --> 00:30:47,470
our radio transmissions things like

806
00:30:53,220 --> 00:30:51,030
radar here on earth is loud enough

807
00:30:54,870 --> 00:30:53,230
strong enough signal said if you knew

808
00:30:56,400 --> 00:30:54,880
what you were looking for you can in

809
00:30:59,460 --> 00:30:56,410
principle detect them at interstellar

810
00:31:01,410 --> 00:30:59,470
distances with LA to earth technology so

811
00:31:03,870 --> 00:31:01,420
there's a strong argument that this is a

812
00:31:05,580 --> 00:31:03,880
really good way to go looking for not

813
00:31:08,010 --> 00:31:05,590

just life but technological life and

814
00:31:10,050 --> 00:31:08,020
then that the signals that you might get

815
00:31:12,480 --> 00:31:10,060
from technological life might be much

816
00:31:16,140 --> 00:31:12,490
easier to detect and much more

817
00:31:18,120 --> 00:31:16,150
unambiguous then science from just

818
00:31:20,280 --> 00:31:18,130
biology or something like that so we

819
00:31:22,260 --> 00:31:20,290
call these techno signatures Jill tarter

820
00:31:26,880 --> 00:31:22,270
coined this term techno signatures it's

821
00:31:29,250 --> 00:31:26,890
a signature of technology and technology

822
00:31:30,930 --> 00:31:29,260
presumably would therefore mean life so

823
00:31:34,530 --> 00:31:30,940
in some sense they're also a bio

824
00:31:36,570 --> 00:31:34,540
signature but there are a lot of ideas

825
00:31:38,550 --> 00:31:36,580
for how you might go about finding life

826
00:31:41,100 --> 00:31:38,560
they might send lasers instead of radio

827
00:31:43,650 --> 00:31:41,110
signals and so there are a couple of

828
00:31:47,460 --> 00:31:43,660
nascent projects getting going to really

829
00:31:51,330 --> 00:31:47,470
do a large ball sky surveys to look for

830
00:31:53,700 --> 00:31:51,340
laser signals instead of radio we'd also

831
00:31:55,650 --> 00:31:53,710
know like to look for you know any other

832
00:31:57,320 --> 00:31:55,660
sign because we don't know how we're

833
00:31:59,190 --> 00:31:57,330
eventually going to succeed to find

834
00:32:01,200 --> 00:31:59,200
technological life in the universe and

835
00:32:02,790 --> 00:32:01,210
there's a lot of potential signals that

836
00:32:04,650 --> 00:32:02,800
we might look for and that's kind of

837
00:32:06,420 --> 00:32:04,660
where I live

838
00:32:08,100 --> 00:32:06,430

I sometimes distinguish between

839
00:32:10,140 --> 00:32:08,110
communication city where we're looking

840
00:32:14,880 --> 00:32:10,150
for deliberately communicative signals

841
00:32:17,430 --> 00:32:14,890
and artifact cities when we look for the

842
00:32:19,740 --> 00:32:17,440
the signs of Technology that aren't

843
00:32:21,990 --> 00:32:19,750
necessarily designed to transmit or

844
00:32:23,820 --> 00:32:22,000
broadcast to get our attention so just

845
00:32:25,650 --> 00:32:23,830
as one example if you build something in

846
00:32:29,370 --> 00:32:25,660
space it's generally gonna need energy

847
00:32:31,110 --> 00:32:29,380
and and if you're out floating around in

848
00:32:33,630 --> 00:32:31,120
space what you'd like for energy is

849
00:32:35,220 --> 00:32:33,640
something like fusion reactors that

850
00:32:38,760 --> 00:32:35,230
would just create huge amounts of energy

851
00:32:40,560 --> 00:32:38,770
for you and wonderfully if you're out in

852
00:32:42,030 --> 00:32:40,570
space anywhere in a style you've got one

853
00:32:43,740 --> 00:32:42,040
you've got a gigantic fusion reactor

854
00:32:44,730 --> 00:32:43,750
sitting right there steadily stable even

855
00:32:47,340 --> 00:32:44,740
for billions of years

856
00:32:49,380 --> 00:32:47,350
just throwing energy at you and so if

857
00:32:50,910 --> 00:32:49,390
put up some solar panels you can collect

858
00:32:53,610 --> 00:32:50,920
the starlight from this giant fusion

859
00:32:55,800 --> 00:32:53,620
reactor called the star and power

860
00:32:57,360 --> 00:32:55,810
whatever it is you're doing up in space

861
00:32:59,250 --> 00:32:57,370
but there's a consequence to collecting

862
00:33:00,510 --> 00:32:59,260
all that energy which is that if you

863
00:33:02,820 --> 00:33:00,520

collect energy at some point you have to

864
00:33:04,380 --> 00:33:02,830
get rid of it you never destroy energy

865
00:33:06,060 --> 00:33:04,390
you never use it up so when your

866
00:33:07,440 --> 00:33:06,070
computer gets energy from the wall it

867
00:33:10,080 --> 00:33:07,450
does all that interesting stuff like

868
00:33:12,090 --> 00:33:10,090
watching videos on the internet and when

869
00:33:13,380 --> 00:33:12,100
it's done with the energy it radiates it

870
00:33:15,600 --> 00:33:13,390
away is heat and that's why your

871
00:33:16,380 --> 00:33:15,610
computer warms up when you use it that's

872
00:33:17,970 --> 00:33:16,390
true of anything

873
00:33:19,770 --> 00:33:17,980
so anything orbiting a star is gonna

874
00:33:22,740 --> 00:33:19,780
absorb light and then it's gonna be

875
00:33:24,780 --> 00:33:22,750
radiated away as heat and so in 1960

876
00:33:25,800 --> 00:33:24,790
Freeman Dyson had the idea that we

877
00:33:28,440 --> 00:33:25,810
should look to see if there are any

878
00:33:30,240 --> 00:33:28,450
stars giving up too much heat stars are

879
00:33:32,640 --> 00:33:30,250
so hot most of their energy stars like

880
00:33:35,430 --> 00:33:32,650
the Sun anyway or wavelengths you can

881
00:33:37,470 --> 00:33:35,440
see with your eyes and so the cooler

882
00:33:41,400 --> 00:33:37,480
things around them like planets or dust

883
00:33:42,900 --> 00:33:41,410
or big solar panels would rule 88 absorb

884
00:33:45,180 --> 00:33:42,910
and then reradiates that emission away

885
00:33:47,130 --> 00:33:45,190
at infrared wavelengths and so my first

886
00:33:49,830 --> 00:33:47,140
project my first foray into this field

887
00:33:51,600 --> 00:33:49,840
was just sort of pick up that ball that

888
00:33:52,980 --> 00:33:51,610

almost no one had worked on since he

889
00:33:54,390 --> 00:33:52,990
proposed it there were a couple of

890
00:33:58,530 --> 00:33:54,400
projects when my did Kerrigan at

891
00:34:01,410 --> 00:33:58,540
Fermilab and and see what we could do

892
00:34:03,090 --> 00:34:01,420
with the new NASA satellites that have

893
00:34:05,340 --> 00:34:03,100
gone up and looked at and measured the

894
00:34:07,350 --> 00:34:05,350
infrared emission of basically every

895
00:34:12,510 --> 00:34:07,360
starts at night so that was my very

896
00:34:14,490 --> 00:34:12,520
first my very first project yeah since

897
00:34:16,890 --> 00:34:14,500
then I've just been getting involved in

898
00:34:18,870 --> 00:34:16,900
more and more angles more and more ways

899
00:34:22,380 --> 00:34:18,880
that we can go about looking for

900
00:34:23,460 --> 00:34:22,390
technological signals and one of the

901
00:34:24,840 --> 00:34:23,470
things we've done is developed a

902
00:34:26,370 --> 00:34:24,850
graduate course here because I realize

903
00:34:27,630 --> 00:34:26,380
there's no textbook I can't go to the

904
00:34:30,900 --> 00:34:27,640
library and get a book on all the ways

905
00:34:32,490 --> 00:34:30,910
to do this so I developed a graduate

906
00:34:34,890 --> 00:34:32,500
course that we teach is part of our

907
00:34:36,840 --> 00:34:34,900
astrobiology dual title degree here at

908
00:34:38,730 --> 00:34:36,850
Penn State University so this can be

909
00:34:40,470 --> 00:34:38,740
taken by astronomers or biologists

910
00:34:43,560 --> 00:34:40,480
geophysicists anyone who's going to be

911
00:34:46,230 --> 00:34:43,570
an astrobiologist as part of their

912
00:34:47,850 --> 00:34:46,240
astrobiology PhD and learn about the

913
00:34:49,980 --> 00:34:47,860

history of SETI when there were all the

914
00:34:51,630 --> 00:34:49,990
ways to do it we went down to Green Bank

915
00:34:54,450 --> 00:34:51,640
and conducted our own radio observations

916
00:34:56,640 --> 00:34:54,460
around planet baring stars discovered by

917
00:34:59,250 --> 00:34:56,650
Kepler we learned about looking at waste

918
00:35:00,570 --> 00:34:59,260
heat we learned about lasers

919
00:35:02,100 --> 00:35:00,580
looking in the solar system for

920
00:35:03,960 --> 00:35:02,110
potential artifacts and all the things

921
00:35:06,390 --> 00:35:03,970
that can be done and the students were

922
00:35:08,670 --> 00:35:06,400
amazing we've already had we've already

923
00:35:10,980 --> 00:35:08,680
had one paper published based on a final

924
00:35:12,780 --> 00:35:10,990
project the students did and we have one

925
00:35:14,760 --> 00:35:12,790
more submitted to a journal and we have

926
00:35:16,590 --> 00:35:14,770
one more ready to submit so it was a

927
00:35:18,870 --> 00:35:16,600
real big success up before to teaching

928
00:35:19,980 --> 00:35:18,880
it again next year that's awesome I want

929
00:35:23,400 --> 00:35:19,990
you to get back to grad school and take

930
00:35:24,750 --> 00:35:23,410
that course I do have to jump over to

931
00:35:26,180 --> 00:35:24,760
our questions from audience now as much

932
00:35:28,530 --> 00:35:26,190
as I'd like to keep chatting about that

933
00:35:31,050 --> 00:35:28,540
so let's jump into our audience

934
00:35:33,240 --> 00:35:31,060
questions from the hashtag ask Astro bio

935
00:35:35,520 --> 00:35:33,250
on Twitter as well as second net and

936
00:35:38,760 --> 00:35:35,530
Facebook our first question comes from

937
00:35:40,710 --> 00:35:38,770
Twitter from Marianne Denton she asks in

938
00:35:43,380 --> 00:35:40,720

addition to active research you've had

939
00:35:45,030 --> 00:35:43,390
not many students and she says that grad

940
00:35:48,360 --> 00:35:45,040
students might struggle with research

941
00:35:50,400 --> 00:35:48,370
and with advisors and mentorship so what

942
00:35:53,360 --> 00:35:50,410
are your expectations of your graduate

943
00:35:56,520 --> 00:35:53,370
students and of yourself as an advisor

944
00:35:59,580 --> 00:35:56,530
and how do you support them to become

945
00:36:02,040 --> 00:35:59,590
independent researchers themselves yeah

946
00:36:04,440 --> 00:36:02,050
mentorship for me is an important part

947
00:36:07,490 --> 00:36:04,450
of being an advisor I really appreciate

948
00:36:09,870 --> 00:36:07,500
all of the advisers I had through my

949
00:36:13,230 --> 00:36:09,880
schooling my undergraduate advisor Dan

950
00:36:14,580 --> 00:36:13,240
Clemens at Boston University although

951
00:36:18,030 --> 00:36:14,590
through my PhD work and postdoctoral

952
00:36:22,710 --> 00:36:18,040
work all my all my advisers were really

953
00:36:24,240 --> 00:36:22,720
strong mentors they they did more than

954
00:36:28,380 --> 00:36:24,250
just gave me good projects and give me

955
00:36:30,780 --> 00:36:28,390
advice they they're friends and they

956
00:36:33,900 --> 00:36:30,790
they cared about my career development

957
00:36:36,480 --> 00:36:33,910
so I try to I try to do that with all of

958
00:36:38,580 --> 00:36:36,490
my students to really support their

959
00:36:42,270 --> 00:36:38,590
career aspirations whatever those are

960
00:36:44,760 --> 00:36:42,280
and and provide as much support for

961
00:36:48,360 --> 00:36:44,770
their their their studies and

962
00:36:50,600 --> 00:36:48,370
professional development that I can and

963
00:36:52,950 --> 00:36:50,610

then in terms of independence I mean

964
00:36:55,170 --> 00:36:52,960
most of most students want to go on to

965
00:37:00,210 --> 00:36:55,180
become independent researchers and so

966
00:37:02,400 --> 00:37:00,220
that's a matter of believing in their

967
00:37:05,250 --> 00:37:02,410
abilities to do those things and giving

968
00:37:07,500 --> 00:37:05,260
them aspirational goals and having high

969
00:37:10,620 --> 00:37:07,510
expectations but also making sure that

970
00:37:10,910 --> 00:37:10,630
they understand that I I know they can

971
00:37:12,170 --> 00:37:10,920
read

972
00:37:14,630 --> 00:37:12,180
and that I'll give them the support they

973
00:37:17,029 --> 00:37:14,640
need to do that and so it's it's always

974
00:37:18,559 --> 00:37:17,039
wonderful to watch the arc of a student

975
00:37:19,819 --> 00:37:18,569
go from you know eating a lot of

976
00:37:22,250 --> 00:37:19,829
hand-holding and not being sure what

977
00:37:24,710 --> 00:37:22,260
they're doing to becoming you know much

978
00:37:26,809 --> 00:37:24,720
more of an expert in their fields than I

979
00:37:29,210 --> 00:37:26,819
am and having their own ideas then

980
00:37:31,970 --> 00:37:29,220
heading off to go do postdoc do

981
00:37:35,450 --> 00:37:31,980
postdoctoral work that I may any more

982
00:37:37,880 --> 00:37:35,460
support for me so yeah I'd like to

983
00:37:40,759 --> 00:37:37,890
foster that independence and and think

984
00:37:41,990 --> 00:37:40,769
of it as a mentorship that's great

985
00:37:44,150 --> 00:37:42,000
yeah it's good to see you know the

986
00:37:45,769 --> 00:37:44,160
people are actually really invested in

987
00:37:47,420 --> 00:37:45,779
helping their students you know become

988
00:37:49,400 --> 00:37:47,430

their own people there are scientists

989
00:37:52,099 --> 00:37:49,410
and learn for themselves how to do these

990
00:37:53,359 --> 00:37:52,109
things our next question is actually a

991
00:37:56,120 --> 00:37:53,369
combo question which we've never had

992
00:37:57,589 --> 00:37:56,130
before but these two users asks the

993
00:38:00,289 --> 00:37:57,599
question they were almost exactly the

994
00:38:02,900 --> 00:38:00,299
same we put them together from dr. Jim

995
00:38:06,200 --> 00:38:02,910
pass on Twitter and from Bruno Pavle

996
00:38:07,970 --> 00:38:06,210
touch on second net the question is what

997
00:38:11,120 --> 00:38:07,980
is the status of the search for

998
00:38:13,519 --> 00:38:11,130
potentially habitable exomoons have you

999
00:38:16,910 --> 00:38:13,529
discovered any and is there any emphasis

1000
00:38:18,259 --> 00:38:16,920
yet on doing on finding exit moons or do

1001
00:38:21,009 --> 00:38:18,269
we need better telescopes that are

1002
00:38:24,650 --> 00:38:21,019
really made for finding X eminence yeah

1003
00:38:26,690 --> 00:38:24,660
so it's interesting the first habitable

1004
00:38:27,620 --> 00:38:26,700
zone planets were discovered kind of

1005
00:38:29,509 --> 00:38:27,630
early haand

1006
00:38:31,700 --> 00:38:29,519
and the planet searched the first time

1007
00:38:34,370 --> 00:38:31,710
that we found giant planets orbiting

1008
00:38:37,609 --> 00:38:34,380
stars at sort of one astronomical unit

1009
00:38:39,710 --> 00:38:37,619
the typical Earth's Sun distance was

1010
00:38:41,509 --> 00:38:39,720
just in the first few years of exoplanet

1011
00:38:43,009 --> 00:38:41,519
discovery and those first like 20 or 30

1012
00:38:45,710 --> 00:38:43,019
or 40 planets I remember which one the

1013
00:38:47,299 --> 00:38:45,720

first one was and these are giant

1014
00:38:48,859 --> 00:38:47,309
planets they're far enough from the star

1015
00:38:50,480 --> 00:38:48,869
they could have moons and all the giant

1016
00:38:52,130 --> 00:38:50,490
planets in Luke and Saturn they both

1017
00:38:55,130 --> 00:38:52,140
they both have lots of lots of moons

1018
00:38:57,019 --> 00:38:55,140
so presumably those planets too - so in

1019
00:38:58,999 --> 00:38:57,029
some sense the first exomoons we know

1020
00:39:03,349 --> 00:38:59,009
you know we knew where they were decades

1021
00:39:05,720 --> 00:39:03,359
ago now actually finding those moons and

1022
00:39:07,910 --> 00:39:05,730
knowing they're there is a much much

1023
00:39:11,029 --> 00:39:07,920
harder problem today we still do not

1024
00:39:14,210 --> 00:39:11,039
have a confirmed detection of a moon

1025
00:39:16,160 --> 00:39:14,220
around an exoplanet we have these young

1026
00:39:18,620 --> 00:39:16,170
exoplanets with gigantic ring systems

1027
00:39:20,029 --> 00:39:18,630
that can wear the inner man eject found

1028
00:39:24,190 --> 00:39:20,039
one of those systems and there's

1029
00:39:27,220 --> 00:39:24,200
probably many more and there is a tent

1030
00:39:30,190 --> 00:39:27,230
detection of a large EXO moon by David

1031
00:39:31,450 --> 00:39:30,200
Kings team at Columbia University using

1032
00:39:34,060 --> 00:39:31,460
capital R now the Hubble Space Telescope

1033
00:39:36,520 --> 00:39:34,070
to try and and verify that it's there

1034
00:39:38,020 --> 00:39:36,530
and it's it looks pretty good but even

1035
00:39:38,980 --> 00:39:38,030
there they're not ready to say we found

1036
00:39:41,490 --> 00:39:38,990
a minute but that would not be a

1037
00:39:44,470 --> 00:39:41,500
habitable xmin that'll be very hot one

1038
00:39:47,260 --> 00:39:44,480

the prospects for finding an extra moon

1039
00:39:48,819 --> 00:39:47,270
in the habitable zone of a star are much

1040
00:39:51,069 --> 00:39:48,829
harder because they're just it's hard

1041
00:39:52,569 --> 00:39:51,079
enough to find planets to find a tiny

1042
00:39:54,460 --> 00:39:52,579
little moon next to them is extremely

1043
00:39:57,190 --> 00:39:54,470
difficult so there are some prospects

1044
00:39:59,260 --> 00:39:57,200
that we might find moon-forming discs

1045
00:40:01,569 --> 00:39:59,270
around very young planets I'm hopeful

1046
00:40:04,329 --> 00:40:01,579
that that we'll be able to do that soon

1047
00:40:07,300 --> 00:40:04,339
and there's prospects that the tests and

1048
00:40:09,790 --> 00:40:07,310
follow-up instruments we can find very

1049
00:40:12,160 --> 00:40:09,800
hot EXO moons around close in planets

1050
00:40:14,530 --> 00:40:12,170
but I don't think the you know that

1051
00:40:16,480 --> 00:40:14,540
Endor is gonna be something that we find

1052
00:40:19,990 --> 00:40:16,490
in the very near future it's just it's

1053
00:40:22,390 --> 00:40:20,000
too challenging okay no I mean our

1054
00:40:24,069 --> 00:40:22,400
planet has a fairly large moon compared

1055
00:40:33,270 --> 00:40:24,079
to the size of our planet and it's a

1056
00:40:37,930 --> 00:40:35,410
it'll be very hard to tell that you've

1057
00:40:40,150 --> 00:40:37,940
got a binary planets because we're not

1058
00:40:41,950 --> 00:40:40,160
it we're a long way from resolving

1059
00:40:44,260 --> 00:40:41,960
seeing a dot of light and saying that's

1060
00:40:46,599 --> 00:40:44,270
a that's a rocky planet and oh look

1061
00:40:48,370 --> 00:40:46,609
there's a little dot next to it but the

1062
00:40:49,930 --> 00:40:48,380
resolution you need from your telescopes

1063
00:40:51,579 --> 00:40:49,940

to accomplish that it's not something

1064
00:40:53,140 --> 00:40:51,589
that's in the you know in the planning

1065
00:40:55,109 --> 00:40:53,150
right now that we'll be able to do soon

1066
00:40:57,760 --> 00:40:55,119
and actually people worry a lot about

1067
00:41:00,250 --> 00:40:57,770
binary planets as false positives for

1068
00:41:02,079 --> 00:41:00,260
biosignatures so I mentioned before one

1069
00:41:04,630 --> 00:41:02,089
potential bio signature to be seeing

1070
00:41:07,450 --> 00:41:04,640
oxygen and methane in the atmosphere of

1071
00:41:08,800 --> 00:41:07,460
a single planet and when you can do that

1072
00:41:10,510 --> 00:41:08,810
without life the most natural

1073
00:41:12,250 --> 00:41:10,520
explanation is that you have an oxygen

1074
00:41:14,950 --> 00:41:12,260
atmosphere and the life is producing the

1075
00:41:18,700 --> 00:41:14,960
methane the other way around but imagine

1076
00:41:20,680 --> 00:41:18,710
if the moon had a methane atmosphere so

1077
00:41:22,540 --> 00:41:20,690
you've got earth with its oxygen and the

1078
00:41:25,240 --> 00:41:22,550
moon with its methane and when you look

1079
00:41:27,220 --> 00:41:25,250
at this system from another star you

1080
00:41:29,620 --> 00:41:27,230
don't know it's two objects and you see

1081
00:41:30,760 --> 00:41:29,630
oxygen and methane and you'd get it

1082
00:41:32,079 --> 00:41:30,770
wrong you'd think there was a lot of

1083
00:41:33,339 --> 00:41:32,089
methane and oxygen in the same

1084
00:41:36,040 --> 00:41:33,349
atmosphere and it was really different

1085
00:41:37,710 --> 00:41:36,050
so we worry about binary planets as a

1086
00:41:38,850 --> 00:41:37,720
false positive before

1087
00:41:41,400 --> 00:41:38,860
that's a great point yeah I think they

1088
00:41:42,750 --> 00:41:41,410

could be like the worst way for us to

1089
00:41:44,250 --> 00:41:42,760
start thinking we found life is by

1090
00:41:46,500 --> 00:41:44,260
finding lots and lots of really awesome

1091
00:41:47,580 --> 00:41:46,510
planetary systems that I've trained it's

1092
00:41:50,490 --> 00:41:47,590
something entirely different than what

1093
00:41:51,840 --> 00:41:50,500
we think it's gonna be a long road to

1094
00:41:53,520 --> 00:41:51,850
plow yeah

1095
00:41:55,680 --> 00:41:53,530
well talking about the methane in an

1096
00:41:58,170 --> 00:41:55,690
atmosphere and about moons altogether

1097
00:42:00,810 --> 00:41:58,180
our next question comes from space nerd

1098
00:42:02,340 --> 00:42:00,820
on Twitter they want to know what's the

1099
00:42:05,040 --> 00:42:02,350
place that you would most want to

1100
00:42:06,210 --> 00:42:05,050
explore for existing or former life in

1101
00:42:09,300 --> 00:42:06,220
our solar system

1102
00:42:11,070 --> 00:42:09,310
so like Mars and solidus Europa yeah

1103
00:42:13,380 --> 00:42:11,080
we're outside of earth do you think is

1104
00:42:14,970 --> 00:42:13,390
the best place to look I guess that

1105
00:42:17,730 --> 00:42:14,980
depends on whether you're looking for

1106
00:42:20,010 --> 00:42:17,740
life that's still around so you know I

1107
00:42:22,080 --> 00:42:20,020
think it's even money on whether we'll

1108
00:42:25,860 --> 00:42:22,090
first discover extraterrestrial life in

1109
00:42:27,300 --> 00:42:25,870
the solar system or or elsewhere of

1110
00:42:28,350 --> 00:42:27,310
course it depends on whether it exists

1111
00:42:30,060 --> 00:42:28,360
and elsewhere in the solar system

1112
00:42:32,580 --> 00:42:30,070
whether it exists elsewhere around the

1113
00:42:34,350 --> 00:42:32,590

nearby stars we study but it's also we

1114
00:42:38,610 --> 00:42:34,360
can look a lot harder in the solar

1115
00:42:41,280 --> 00:42:38,620
system then we can around other stars so

1116
00:42:43,230 --> 00:42:41,290
Mars looks pretty dead right now there's

1117
00:42:45,060 --> 00:42:43,240
not a ton of evidence for biology

1118
00:42:46,410 --> 00:42:45,070
although there are these cool these

1119
00:42:49,680 --> 00:42:46,420
called methane detections that are

1120
00:42:51,510 --> 00:42:49,690
really tantalizing and so Mars is

1121
00:42:54,600 --> 00:42:51,520
probably the best bet on both counts

1122
00:42:56,700 --> 00:42:54,610
that it we know it was wet life is easy

1123
00:42:59,010 --> 00:42:56,710
to form then there's probably some kind

1124
00:43:00,840 --> 00:42:59,020
of evidence of life back when it was wet

1125
00:43:04,200 --> 00:43:00,850
but we might have to dig to find that

1126
00:43:06,480 --> 00:43:04,210
it's not obvious how we'll find that no

1127
00:43:07,980 --> 00:43:06,490
life likes to hang on and subterranean

1128
00:43:09,540 --> 00:43:07,990
life and Mars maybe it's been able to

1129
00:43:12,090 --> 00:43:09,550
hang on for billions of years since it

1130
00:43:13,890 --> 00:43:12,100
was wet in which case you know we might

1131
00:43:18,330 --> 00:43:13,900
even find living life right there on

1132
00:43:21,030 --> 00:43:18,340
Mars in terms of other spots I think and

1133
00:43:23,580 --> 00:43:21,040
sell it us in Europa still feel still

1134
00:43:25,500 --> 00:43:23,590
feel like the best bets because we know

1135
00:43:28,440 --> 00:43:25,510
that they've got at least slush if not

1136
00:43:30,450 --> 00:43:28,450
water that we can explore and Enceladus

1137
00:43:33,060 --> 00:43:30,460
hallway all the way it's sadder it's

1138
00:43:34,830 --> 00:43:33,070

hard to get to but man it's just spewing

1139
00:43:36,690 --> 00:43:34,840
that water out into space and those

1140
00:43:38,550 --> 00:43:36,700
geysers which means you don't have to

1141
00:43:40,110 --> 00:43:38,560
land and drill you don't have to have

1142
00:43:42,270 --> 00:43:40,120
like this submarine to go down and

1143
00:43:45,780 --> 00:43:42,280
explore you can actually sample the

1144
00:43:47,970 --> 00:43:45,790
seawater in principle and see see what's

1145
00:43:50,440 --> 00:43:47,980
in there so depending on how quickly you

1146
00:43:52,809 --> 00:43:50,450
think it is that a planet like

1147
00:43:54,849 --> 00:43:52,819
and solidus would have life in the first

1148
00:43:57,609 --> 00:43:54,859
place that might be the best bet so I

1149
00:43:59,319 --> 00:43:57,619
don't know why I try not to have really

1150
00:44:01,690 --> 00:43:59,329
strong personal priors on these things

1151
00:44:04,059 --> 00:44:01,700
because I have no way of knowing which

1152
00:44:05,680 --> 00:44:04,069
the best one is and so I try to be kind

1153
00:44:09,010 --> 00:44:05,690
of flat from all that and say you know

1154
00:44:10,390 --> 00:44:09,020
which is easiest to explore it Mars is

1155
00:44:12,970 --> 00:44:10,400
easiest because it's closest we should

1156
00:44:15,039 --> 00:44:12,980
do that if and so it is easiest because

1157
00:44:17,799 --> 00:44:15,049
we fly by it let's do that let's let's

1158
00:44:19,690 --> 00:44:17,809
try lots of options and not put all our

1159
00:44:22,000 --> 00:44:19,700
eggs in one basket it's something good

1160
00:44:23,260 --> 00:44:22,010
ROI kind of plan and to get a lot of

1161
00:44:25,720 --> 00:44:23,270
return because you know it is hard to

1162
00:44:26,920 --> 00:44:25,730
get things funded through NASA you know

1163
00:44:29,410 --> 00:44:26,930

we have a mission you going back to your

1164
00:44:30,670 --> 00:44:29,420
episode with your epic clipper but no

1165
00:44:35,410 --> 00:44:30,680
plans in the works to go back to the

1166
00:44:37,559 --> 00:44:35,420
solidus so NASA is a big beast it takes

1167
00:44:40,780 --> 00:44:37,569
a long time to sort of turn that train

1168
00:44:42,880 --> 00:44:40,790
turn that ship but the discovery of

1169
00:44:45,370 --> 00:44:42,890
those plumes has created lots and lots

1170
00:44:47,109 --> 00:44:45,380
of discussion it's how it really

1171
00:44:48,640 --> 00:44:47,119
surprised me if things go there and I

1172
00:44:50,500 --> 00:44:48,650
know that the brakes are shot people

1173
00:44:51,220 --> 00:44:50,510
have been talking about a quick trip to

1174
00:44:53,049 --> 00:44:51,230
go busy

1175
00:45:00,250 --> 00:44:53,059
Enceladus if they can figure out how to

1176
00:45:02,710 --> 00:45:00,260
get that gigantic laser working lets

1177
00:45:05,559 --> 00:45:02,720
another question here Mellie Howard on

1178
00:45:08,380 --> 00:45:05,569
Facebook asks as a student who's looking

1179
00:45:11,440 --> 00:45:08,390
to go into astrobiology what kinds of

1180
00:45:14,109 --> 00:45:11,450
majors or minors or even courses should

1181
00:45:15,789 --> 00:45:14,119
they look for and is a masters enough or

1182
00:45:19,120 --> 00:45:15,799
do you really need a doctorate to become

1183
00:45:21,819 --> 00:45:19,130
an astrobiologist yeah so there's a lot

1184
00:45:23,589 --> 00:45:21,829
of injuries into astrobiology so here at

1185
00:45:26,109 --> 00:45:23,599
Penn State I was mentioning we have a

1186
00:45:28,270 --> 00:45:26,119
ph.d program and you can come into

1187
00:45:29,230 --> 00:45:28,280
astrobiology from biology we have a lot

1188
00:45:31,690 --> 00:45:29,240

of people that come through with the

1189
00:45:35,799 --> 00:45:31,700
earth sciences or you can come through

1190
00:45:37,960 --> 00:45:35,809
an astronomy so I mean it's a broad

1191
00:45:39,460 --> 00:45:37,970
field and when you're doing an

1192
00:45:41,410 --> 00:45:39,470
undergraduate work you should pick you

1193
00:45:43,359 --> 00:45:41,420
know what your entry into it is and that

1194
00:45:44,920 --> 00:45:43,369
doesn't limit you you can still go any

1195
00:45:47,349 --> 00:45:44,930
other stuff especially in graduate

1196
00:45:49,000 --> 00:45:47,359
school but you really want to excel at

1197
00:45:51,490 --> 00:45:49,010
something at the undergraduate level so

1198
00:45:53,829 --> 00:45:51,500
that you can have a really strong start

1199
00:45:55,510 --> 00:45:53,839
to your graduate career so if you wanted

1200
00:45:58,720 --> 00:45:55,520
to go into astronomy which is the one I

1201
00:46:00,370 --> 00:45:58,730
can advise best then you want to have a

1202
00:46:01,780 --> 00:46:00,380
really good physics background and

1203
00:46:05,380 --> 00:46:01,790
mathematics

1204
00:46:06,910 --> 00:46:05,390
when we admit people to our program we

1205
00:46:08,559 --> 00:46:06,920
can teach astronomy you can teach

1206
00:46:10,630 --> 00:46:08,569
quickly get you up to speed on

1207
00:46:13,150 --> 00:46:10,640
magnitudes and how telescopes work and

1208
00:46:15,339 --> 00:46:13,160
stuff but it's it's hard to get people

1209
00:46:16,450 --> 00:46:15,349
up to speed on mathematical physics and

1210
00:46:18,819 --> 00:46:16,460
stuff if you don't have a strong

1211
00:46:21,190 --> 00:46:18,829
background on it so that's what I would

1212
00:46:24,010 --> 00:46:21,200
recommend for that angle and then if you

1213
00:46:25,359 --> 00:46:24,020

wanted to come in from the biology or

1214
00:46:28,020 --> 00:46:25,369
the sciences then you would want to

1215
00:46:30,400 --> 00:46:28,030
major in something like geophysics or

1216
00:46:33,760 --> 00:46:30,410
microbiology or something like that

1217
00:46:35,170 --> 00:46:33,770
to get him on that angle so depending on

1218
00:46:36,670 --> 00:46:35,180
where your interests lie you should

1219
00:46:38,380 --> 00:46:36,680
contact a faculty member at an

1220
00:46:40,329 --> 00:46:38,390
astrobiology program like ours at Penn

1221
00:46:42,849 --> 00:46:40,339
State or the folks at University of

1222
00:46:45,819 --> 00:46:42,859
Washington for instance and ask them

1223
00:46:48,010 --> 00:46:45,829
what prep would be looked upon most

1224
00:46:52,569 --> 00:46:48,020
favorably in their department for for

1225
00:46:53,380 --> 00:46:52,579
graduate studies awesome oh and a PhD is

1226
00:46:56,799 --> 00:46:53,390
what you're after

1227
00:46:59,530 --> 00:46:56,809
most most you know scientists in all of

1228
00:47:00,970 --> 00:46:59,540
those disciplines are PhD scientists and

1229
00:47:02,349 --> 00:47:00,980
if I can be a little selfish also

1230
00:47:04,120 --> 00:47:02,359
mention the University of Colorado in

1231
00:47:05,950 --> 00:47:04,130
Boulder where we're gonna live in

1232
00:47:07,750 --> 00:47:05,960
Boulder right now that's where I got my

1233
00:47:09,730 --> 00:47:07,760
PhD from and it's also a dual

1234
00:47:13,180 --> 00:47:09,740
certificate in astrobiology at CU

1235
00:47:16,150 --> 00:47:13,190
Boulder as well great all right they're

1236
00:47:17,559 --> 00:47:16,160
offering some of these dual degrees I'm

1237
00:47:21,039 --> 00:47:17,569
not sure if we actually have any degrees

1238
00:47:25,930 --> 00:47:21,049

in astrobiology offered currently but

1239
00:47:28,930 --> 00:47:25,940
maybe in the future this one's from

1240
00:47:32,530 --> 00:47:28,940
pritho Jay Paul one second net Preetha

1241
00:47:34,859 --> 00:47:32,540
asks supposing if there is a possibility

1242
00:47:37,539 --> 00:47:34,869
for silicon-based life in the universe

1243
00:47:39,789 --> 00:47:37,549
does it then still make sense to look

1244
00:47:42,700 --> 00:47:39,799
for earth-like conditions in exoplanets

1245
00:47:44,740 --> 00:47:42,710
right so this gets back to the issue of

1246
00:47:47,500 --> 00:47:44,750
you know you know why limit ourselves to

1247
00:47:50,559 --> 00:47:47,510
earth-like planets and the best the two

1248
00:47:51,730 --> 00:47:50,569
best reasons are we know it works in

1249
00:47:54,579 --> 00:47:51,740
earth-like environments because it

1250
00:47:57,579 --> 00:47:54,589
worked here and it was robust here and

1251
00:47:59,799 --> 00:47:57,589
we have to look somewhere so the farther

1252
00:48:03,400 --> 00:47:59,809
afield of those conditions we get for

1253
00:48:05,890 --> 00:48:03,410
instance silicon-based life the the less

1254
00:48:07,450 --> 00:48:05,900
sure our footing is and again I try not

1255
00:48:09,430 --> 00:48:07,460
to have strong personal priors I think

1256
00:48:12,160 --> 00:48:09,440
it's a great idea to look for those

1257
00:48:12,660 --> 00:48:12,170
unexpected kinds of life or those more

1258
00:48:14,010 --> 00:48:12,670
unusual

1259
00:48:18,030 --> 00:48:14,020
would expect the kinds of lifelike

1260
00:48:20,160 --> 00:48:18,040
silicon-based life but it's hard to

1261
00:48:22,260 --> 00:48:20,170
define a program to look for life as we

1262
00:48:23,880 --> 00:48:22,270
don't know it because they don't know in

1263
00:48:28,470 --> 00:48:23,890

part means we don't know exactly what

1264
00:48:31,200 --> 00:48:28,480
we're looking for so fortunately you

1265
00:48:33,000 --> 00:48:31,210
know the planets we're looking for that

1266
00:48:34,650 --> 00:48:33,010
are most like the earth are some of the

1267
00:48:36,420 --> 00:48:34,660
hardest to find and the stepping stones

1268
00:48:38,339 --> 00:48:36,430
to finding those planets and studying

1269
00:48:40,319 --> 00:48:38,349
them are the find planets that are a

1270
00:48:43,680 --> 00:48:40,329
little hotter and a little more massive

1271
00:48:45,210 --> 00:48:43,690
and around the rock kind of stronger and

1272
00:48:47,640 --> 00:48:45,220
so those won't necessarily be the

1273
00:48:50,099 --> 00:48:47,650
planets that we're looking at first on

1274
00:48:53,460 --> 00:48:50,109
our way for that you know Holy Grail or

1275
00:48:55,980 --> 00:48:53,470
2.0 or something like that so I'm not

1276
00:48:58,109 --> 00:48:55,990
too concerned that we will neglect the

1277
00:49:00,450 --> 00:48:58,119
other kinds of planets will necessarily

1278
00:49:07,260 --> 00:49:00,460
be looking at the planets where we can

1279
00:49:08,789 --> 00:49:07,270
learn the most first very cool just a

1280
00:49:09,870 --> 00:49:08,799
few more questions yet we have some time

1281
00:49:13,140 --> 00:49:09,880
from our audience

1282
00:49:17,160 --> 00:49:13,150
user Brian Collins on Facebook has asked

1283
00:49:19,410 --> 00:49:17,170
if there is a plan in place for what we

1284
00:49:21,839 --> 00:49:19,420
do if we find an extraterrestrial

1285
00:49:24,900 --> 00:49:21,849
species that's more advanced than just a

1286
00:49:28,710 --> 00:49:24,910
microbe say is there a plan so this is

1287
00:49:31,260 --> 00:49:28,720
called post detection protocol so what

1288
00:49:32,940 --> 00:49:31,270

do you do when SETI succeeds and you get

1289
00:49:34,650 --> 00:49:32,950
that signal from outer space that means

1290
00:49:37,680 --> 00:49:34,660
we're not alone as a technological

1291
00:49:39,089 --> 00:49:37,690
species in the galaxy or in the universe

1292
00:49:42,420 --> 00:49:39,099
and yeah there's a been a lot of thought

1293
00:49:44,910 --> 00:49:42,430
of this on this I mean the pioneers of

1294
00:49:49,109 --> 00:49:44,920
this program of the SETI programs like

1295
00:49:50,609 --> 00:49:49,119
Frank Drake and Jill tarter have always

1296
00:49:52,710 --> 00:49:50,619
thought about you know what is that

1297
00:49:54,210 --> 00:49:52,720
protocol the first protocol is you

1298
00:49:57,120 --> 00:49:54,220
confirm it you don't want to be wrong

1299
00:49:58,650 --> 00:49:57,130
and and so the first thing you do is you

1300
00:50:00,240 --> 00:49:58,660
make sure other telescopes see the same

1301
00:50:01,799 --> 00:50:00,250
signal everyone agrees where it is

1302
00:50:04,530 --> 00:50:01,809
everyone agrees on its strengths its

1303
00:50:06,510 --> 00:50:04,540
frequencies and and what's in there and

1304
00:50:09,809 --> 00:50:06,520
then what follows after that depends a

1305
00:50:12,359 --> 00:50:09,819
lot on what you found if what you found

1306
00:50:14,640 --> 00:50:12,369
is some sort of simple communicative

1307
00:50:17,430 --> 00:50:14,650
signal that you know you know what it's

1308
00:50:20,339 --> 00:50:17,440
saying like in Carl Sagan's contact or

1309
00:50:23,490 --> 00:50:20,349
something like that you know things are

1310
00:50:25,500 --> 00:50:23,500
gonna move really fast and and but if

1311
00:50:26,200 --> 00:50:25,510
what you find is kind of ambiguous or

1312
00:50:27,490 --> 00:50:26,210
you know

1313
00:50:28,839 --> 00:50:27,500

you can tell us the transmission but

1314
00:50:30,849 --> 00:50:28,849
it's not for us and you don't know how

1315
00:50:32,500 --> 00:50:30,859
to decode it and things like that then

1316
00:50:34,540 --> 00:50:32,510
the implications maybe aren't so strong

1317
00:50:36,970 --> 00:50:34,550
if what we're finding is a star on the

1318
00:50:38,859 --> 00:50:36,980
other side of the galaxy well you know

1319
00:50:40,270 --> 00:50:38,869
there's not really any opportunity for a

1320
00:50:42,040 --> 00:50:40,280
back and forth in that case so the

1321
00:50:44,260 --> 00:50:42,050
consequences aren't as strong as if it's

1322
00:50:45,760 --> 00:50:44,270
the next star over where you know they

1323
00:50:47,109 --> 00:50:45,770
probably know we're here if we send a

1324
00:50:51,240 --> 00:50:47,119
signal now we'll get an answer in our

1325
00:50:53,170 --> 00:50:51,250
lifetimes um I've been convinced by

1326
00:50:57,220 --> 00:50:53,180
anthropologists that study this stuff

1327
00:51:00,849 --> 00:50:57,230
like Katherine Denning and at York that

1328
00:51:03,609 --> 00:51:00,859
that we're not really prepared to handle

1329
00:51:06,820 --> 00:51:03,619
this properly to communicate a discovery

1330
00:51:10,120 --> 00:51:06,830
to the public in a way that that the

1331
00:51:11,470 --> 00:51:10,130
world public will will appreciate what

1332
00:51:14,010 --> 00:51:11,480
we do know and what we don't know

1333
00:51:17,109 --> 00:51:14,020
there's a lot of preconceived notions

1334
00:51:18,640 --> 00:51:17,119
people have about what kind of life is

1335
00:51:21,070 --> 00:51:18,650
out there and what it means to have

1336
00:51:24,250 --> 00:51:21,080
contacted them and so this is something

1337
00:51:26,440 --> 00:51:24,260
where I think we need to do more work to

1338
00:51:28,540 --> 00:51:26,450

be ready for what we find but I also

1339
00:51:30,250 --> 00:51:28,550
think like you know all the best plans

1340
00:51:32,470 --> 00:51:30,260
as soon as they need contact with

1341
00:51:33,730 --> 00:51:32,480
reality will go this isn't what we

1342
00:51:35,680 --> 00:51:33,740
planned for this is not what we thought

1343
00:51:37,810 --> 00:51:35,690
we would see I think we're going to be

1344
00:51:39,790 --> 00:51:37,820
surprised but hopefully it will be a

1345
00:51:43,930 --> 00:51:39,800
sufficiently ambitious signal then we'll

1346
00:51:45,760 --> 00:51:43,940
have some time to figure it out coming

1347
00:51:50,589 --> 00:51:45,770
to say hi with gigantic military

1348
00:51:52,930 --> 00:51:50,599
warships or thing like that really

1349
00:51:54,359 --> 00:51:52,940
intriguing it's a little scary to think

1350
00:51:57,579 --> 00:51:54,369
that we wouldn't have the plan in place

1351
00:51:59,380 --> 00:51:57,589
necessarily dance for like who you talk

1352
00:52:00,730 --> 00:51:59,390
to right the first you have you have to

1353
00:52:02,589 --> 00:52:00,740
you know communicate with other

1354
00:52:04,930 --> 00:52:02,599
astronomers do you see this as well you

1355
00:52:06,339 --> 00:52:04,940
get the confirmation you know you do all

1356
00:52:07,930 --> 00:52:06,349
of this stuff and then you make an

1357
00:52:10,980 --> 00:52:07,940
announcement about what it is you found

1358
00:52:13,780 --> 00:52:10,990
so I mean that that protocol is set up

1359
00:52:15,550 --> 00:52:13,790
but that's just that's just how do the

1360
00:52:17,800 --> 00:52:15,560
astronomers make sure they haven't made

1361
00:52:19,660 --> 00:52:17,810
a mistake and how do they do the press

1362
00:52:21,180 --> 00:52:19,670
concerts and stuff yeah

1363
00:52:23,920 --> 00:52:21,190

but then after that you know is right

1364
00:52:25,480 --> 00:52:23,930
yeah I mean cancer it's gonna become so

1365
00:52:26,980 --> 00:52:25,490
much I wanted we found

1366
00:52:29,410 --> 00:52:26,990
yeah truth always stranger than the

1367
00:52:31,359 --> 00:52:29,420
fiction let's end with a more technical

1368
00:52:33,790 --> 00:52:31,369
question from user Tom Caruso on

1369
00:52:36,430 --> 00:52:33,800
Facebook first off he said congrats on

1370
00:52:38,830 --> 00:52:36,440
your award thank you and then secondly

1371
00:52:40,840 --> 00:52:38,840
he says can you elaborate on how we

1372
00:52:42,460 --> 00:52:40,850
started to sort out the different

1373
00:52:45,610 --> 00:52:42,470
molecules that we find in the

1374
00:52:47,140 --> 00:52:45,620
atmospheres of exoplanets so so for

1375
00:52:49,840 --> 00:52:47,150
instance how can our observation is let

1376
00:52:52,630 --> 00:52:49,850
us see ocean versus land versus

1377
00:52:55,390 --> 00:52:52,640
atmosphere can we see circulation in an

1378
00:52:57,430 --> 00:52:55,400
atmosphere and you know it could be

1379
00:52:59,590 --> 00:52:57,440
actually tell that there are signs of

1380
00:53:01,660 --> 00:52:59,600
life in that mysterious

1381
00:53:05,080 --> 00:53:01,670
right it depends a lot on how it is

1382
00:53:07,840 --> 00:53:05,090
we're measuring the planet so the the

1383
00:53:09,220 --> 00:53:07,850
methods that seem the most right the

1384
00:53:10,270 --> 00:53:09,230
ones that are gonna happen first are

1385
00:53:14,440 --> 00:53:10,280
when the James Webb Space Telescope

1386
00:53:16,840 --> 00:53:14,450
launches it will be able to analyze as I

1387
00:53:18,730 --> 00:53:16,850
discussed the the Starlight filtering

1388
00:53:21,430 --> 00:53:18,740

through a planetary atmosphere in

1389
00:53:25,210 --> 00:53:21,440
transmission and so we'll be able to

1390
00:53:27,400 --> 00:53:25,220
learn about that atmosphere clouds will

1391
00:53:30,730 --> 00:53:27,410
make things hard to measure and and

1392
00:53:32,050 --> 00:53:30,740
it'll be really very challenging but

1393
00:53:34,330 --> 00:53:32,060
we'll be able they will immediately

1394
00:53:37,300 --> 00:53:34,340
recognize certain chemical species like

1395
00:53:39,310 --> 00:53:37,310
hydrogen or you know carbon monoxide

1396
00:53:41,230 --> 00:53:39,320
carbon dioxide and things like that and

1397
00:53:44,620 --> 00:53:41,240
hopefully methane there will be a

1398
00:53:46,060 --> 00:53:44,630
challenge of interpretation to we know

1399
00:53:47,560 --> 00:53:46,070
what the chemical fingerprints of all

1400
00:53:49,030 --> 00:53:47,570
these gases look like but we're gonna be

1401
00:53:51,340 --> 00:53:49,040
seeing them all piled on top of each

1402
00:53:55,110 --> 00:53:51,350
other which is gonna make disentangling

1403
00:53:57,580 --> 00:53:55,120
everything kind of challenging and so

1404
00:53:59,410 --> 00:53:57,590
we'll find something with the James Webb

1405
00:54:01,210 --> 00:53:59,420
Space Telescope it's possible it'll be a

1406
00:54:02,890 --> 00:54:01,220
whopping ly large signal and surprise us

1407
00:54:04,740 --> 00:54:02,900
and we'll just know I think it's more

1408
00:54:07,150 --> 00:54:04,750
likely it's gonna be kind of ambiguous

1409
00:54:09,040 --> 00:54:07,160
it's good and and there aren't very many

1410
00:54:11,080 --> 00:54:09,050
planets we know of hopefully we'll find

1411
00:54:13,480 --> 00:54:11,090
some more soon that we'll be able to do

1412
00:54:17,050 --> 00:54:13,490
this work on but the bottom line answer

1413
00:54:18,490 --> 00:54:17,060

is that we'll see the missing patterns

1414
00:54:21,280 --> 00:54:18,500
of light that are characteristic of

1415
00:54:23,200 --> 00:54:21,290
those of those chemical species in the

1416
00:54:25,240 --> 00:54:23,210
atmosphere and that's how we'll know

1417
00:54:28,180 --> 00:54:25,250
what the atmosphere is made of now if we

1418
00:54:30,520 --> 00:54:28,190
detect a planet in reflected light so

1419
00:54:34,120 --> 00:54:30,530
use a coronagraph on some future mission

1420
00:54:36,550 --> 00:54:34,130
and actually image that little ball of

1421
00:54:38,560 --> 00:54:36,560
rock that is a planet reflecting its

1422
00:54:41,080 --> 00:54:38,570
Starlight that's a little bit different

1423
00:54:42,520 --> 00:54:41,090
we'd be looking at reflected light and

1424
00:54:45,250 --> 00:54:42,530
would be other able to study other

1425
00:54:46,450 --> 00:54:45,260
things about the planet as it rotated so

1426
00:54:48,280 --> 00:54:46,460
if you just think about looking at a

1427
00:54:50,230 --> 00:54:48,290
globe of the earth sometimes you looking

1428
00:54:52,089 --> 00:54:50,240
at the Pacific Ocean sometimes you're

1429
00:54:54,309 --> 00:54:52,099
looking at you know Siberia

1430
00:54:56,170 --> 00:54:54,319
sometimes you're seeing a lot of clouds

1431
00:54:57,699 --> 00:54:56,180
and sometimes it's pretty clear on that

1432
00:55:00,160 --> 00:54:57,709
hemisphere and as the planet rotates

1433
00:55:01,839 --> 00:55:00,170
these things all change and so by

1434
00:55:03,249 --> 00:55:01,849
monitoring those changes we'll learn

1435
00:55:05,410 --> 00:55:03,259
things like how quickly the planet

1436
00:55:07,180 --> 00:55:05,420
rotates and you might be able to infer

1437
00:55:09,549 --> 00:55:07,190
things like you know how much of it is

1438
00:55:12,009 --> 00:55:09,559

covered in in oceans and whether it has

1439
00:55:13,870 --> 00:55:12,019
clouds and then we'll take spectra in

1440
00:55:15,519 --> 00:55:13,880
that reflected light and similar to the

1441
00:55:17,349 --> 00:55:15,529
atmospheric thing you can hopefully

1442
00:55:19,689 --> 00:55:17,359
figure out what that what the

1443
00:55:22,180 --> 00:55:19,699
atmospheric constituents are that's

1444
00:55:24,459 --> 00:55:22,190
awesome unfortunately we only have a few

1445
00:55:26,799 --> 00:55:24,469
minutes left so I think we're just gonna

1446
00:55:29,229 --> 00:55:26,809
end with just asking you dr. right if

1447
00:55:33,130 --> 00:55:29,239
you have some final words of wisdom for

1448
00:55:37,930 --> 00:55:33,140
up-and-coming astrobiologists Oh for

1449
00:55:40,420 --> 00:55:37,940
up-and-coming astrobiologists well for

1450
00:55:43,839 --> 00:55:40,430
me I've I've followed problems that I

1451
00:55:46,749 --> 00:55:43,849
find really interesting like um work on

1452
00:55:49,209 --> 00:55:46,759
things that inspire you I've

1453
00:55:51,609 --> 00:55:49,219
occasionally signed on to projects that

1454
00:55:54,400 --> 00:55:51,619
didn't really inspire me that I wasn't

1455
00:55:57,999 --> 00:55:54,410
really motivated on and I've always

1456
00:56:00,729 --> 00:55:58,009
regretted it you should you should stick

1457
00:56:01,989 --> 00:56:00,739
to what you what gets you up out of bed

1458
00:56:03,219 --> 00:56:01,999
and you're like wow I really want to

1459
00:56:05,170 --> 00:56:03,229
work on this problem thank you

1460
00:56:06,670 --> 00:56:05,180
you can animate it when people ask you

1461
00:56:08,109 --> 00:56:06,680
about it you're like yes let me tell you

1462
00:56:09,880 --> 00:56:08,119
what I'm working on that's a good

1463
00:56:12,189 --> 00:56:09,890

indicator of what you should what you

1464
00:56:14,709 --> 00:56:12,199
should chase down and then you know a

1465
00:56:16,630 --> 00:56:14,719
lot of this work is a slog like working

1466
00:56:19,329 --> 00:56:16,640
through Jackson homework problems in the

1467
00:56:21,189 --> 00:56:19,339
a.m. or you know debugging that piece of

1468
00:56:22,689 --> 00:56:21,199
code but you've just been working on for

1469
00:56:25,299 --> 00:56:22,699
weeks that never seems to work there is

1470
00:56:26,650 --> 00:56:25,309
a slog that you have to get through but

1471
00:56:28,029 --> 00:56:26,660
the reward at the other end is nice

1472
00:56:30,640 --> 00:56:28,039
because you get to talk about your great

1473
00:56:32,410 --> 00:56:30,650
skirts no it's wonderful well thank you

1474
00:56:34,599 --> 00:56:32,420
so much for your time dr. Jason and

1475
00:56:36,309 --> 00:56:34,609
right thank you everyone for watching

1476
00:56:38,620 --> 00:56:36,319
ask and ask your biologist for this one

1477
00:56:41,740 --> 00:56:38,630
so so look forward to seeing you all