



tim morley



Steinn



Sean Raymond



Michael New

Attendees (26)

▼ Hosts (1)

Mike Toillion

▼ Presenters (5)

David Lomas

Michael New

Sean Raymond

Steinn

tim morley

▼ Participants (20)

Bob Pappalardo &...

Brian

Damien Woods

Daniel Apai / Univ ...

Dave Johnston

dave lynn

David Des Marais

Emily H

g. Cody

House - PSU

Jocelyne DiRuggie...

JTG

Mike New...

Open Chat (Everyone)

Mike Toillion: All panelists should be on a different telecon than what is shown below. If you need this number, please ask and I will send a private chat message to you.
----- (05/20/2013 13:01) -----

Mike Toillion: Mary, I'm sending you the correct telecon (for panelists it is NOT what is listed below)

Michael New: panelist passcode?
----- (05/20/2013 13:04) -----

Mike Toillion: Please enter any questions/comments here.
----- (05/20/2013 13:06) -----

Marion Dunn: I am not logged in on the telephone line just yet, but thought I was pass on some info. With regards to the second panel question - is anyone familiar with Don Fraser's work at Univ. Oxford? I am an "interested geologist" not an astrobiologist, so don't fully understand it myself, but I think he invokes clay minerals as allowing some form of chemical natural selection of different organic enantiomers. I thought this may be of interest to the participants

Teleconference Instructions (Partic...

Teleconference Line: (866) 692-4538
Passcode: 7496560#
More info:

Live Notes

Planetary Conditions for Life version 2.pptx

Full Screen



Agenda

- Welcome & Opening Remarks
- Overview of Today's Agenda
- Panelist Introductions
- Moderated Panel Discussion
- Open Q&A
- Next Steps

1
00:00:12,310 --> 00:00:11,190
uh good afternoon good morning good

2
00:00:16,870 --> 00:00:12,320
evening

3
00:00:19,510 --> 00:00:16,880
everybody uh this is uh our last um uh

4
00:00:21,029 --> 00:00:19,520
webinar for today uh today we're gonna

5
00:00:23,269 --> 00:00:21,039
be talking about planetary conditions

6
00:00:25,349 --> 00:00:23,279
for life we have a panel here the rest

7
00:00:27,109 --> 00:00:25,359
of the panel will be joining us in a

8
00:00:29,269 --> 00:00:27,119
short while francis will join us

9
00:00:33,030 --> 00:00:29,279
but we can kick off uh the intention is

10
00:00:34,870 --> 00:00:33,040
to talk through um a number of important

11
00:00:37,030 --> 00:00:34,880
questions that the panel have uh have

12
00:00:38,150 --> 00:00:37,040
selected is masso selected together the

13
00:00:40,549 --> 00:00:38,160

questions you can see in the bottom

14

00:00:42,150 --> 00:00:40,559

right hand corner of your window there

15

00:00:43,750 --> 00:00:42,160

while the discussion is happening

16

00:00:46,630 --> 00:00:43,760

amongst the panel we encourage

17

00:00:49,029 --> 00:00:46,640

participants to um join in the

18

00:00:50,549 --> 00:00:49,039

conversation on the open chat window to

19

00:00:52,310 --> 00:00:50,559

the left of your screen

20

00:00:54,549 --> 00:00:52,320

uh you can type into there and you'll

21

00:00:57,189 --> 00:00:54,559

see the chat happening there my

22

00:01:00,069 --> 00:00:57,199

colleague dave lomas david lomas will be

23

00:01:02,150 --> 00:01:00,079

copying and pasting uh uh interesting

24

00:01:04,710 --> 00:01:02,160

and important points from that

25

00:01:05,990 --> 00:01:04,720

uh from that uh discussion into the live

26

00:01:07,830 --> 00:01:06,000

notes

27

00:01:10,149 --> 00:01:07,840

our intention is to run the conversation

28

00:01:12,789 --> 00:01:10,159

for uh for about half an hour across the

29

00:01:15,830 --> 00:01:12,799

questions and then open the floor and

30

00:01:18,390 --> 00:01:15,840

open the mics to uh to all participants

31

00:01:19,830 --> 00:01:18,400

so we can engage everybody in the same

32

00:01:21,830 --> 00:01:19,840

conversation

33

00:01:23,830 --> 00:01:21,840

so while the presenters are talking if

34

00:01:25,030 --> 00:01:23,840

you can keep your microphones closed

35

00:01:27,429 --> 00:01:25,040

with star sticks that would be really

36

00:01:29,910 --> 00:01:27,439

useful so we can all hear each other so

37

00:01:31,749 --> 00:01:29,920

uh thank you very much for coming uh i'd

38

00:01:33,190 --> 00:01:31,759

like to head across to michael new first

39

00:01:36,069 --> 00:01:33,200

to give us a little bit of context if

40

00:01:39,749 --> 00:01:36,079

that's good thank you

41

00:01:41,670 --> 00:01:39,759

so good afternoon evening morning um

42

00:01:43,190 --> 00:01:41,680

i'm michael new those who don't know me

43

00:01:45,270 --> 00:01:43,200

i'm the astrobiology discipline

44

00:01:47,990 --> 00:01:45,280

scientist at nasa headquarters

45

00:01:50,230 --> 00:01:48,000

and nasa is

46

00:01:51,830 --> 00:01:50,240

supporting this activity we'd like

47

00:01:53,830 --> 00:01:51,840

the community to really take an

48

00:01:55,510 --> 00:01:53,840

ownership role in it so we're probably

49

00:01:56,550 --> 00:01:55,520

not going to be very involved in the

50

00:01:58,870 --> 00:01:56,560

sense you're probably not going to hear

51

00:02:02,230 --> 00:01:58,880

me say a lot more than this

52

00:02:04,310 --> 00:02:02,240

um planetary kitchens for life is one of

53

00:02:06,310 --> 00:02:04,320

the areas that we one of the ways we

54

00:02:07,749 --> 00:02:06,320

think about one of the areas of

55

00:02:10,070 --> 00:02:07,759

astrobiology

56

00:02:12,710 --> 00:02:10,080

basically it can be summarized very

57

00:02:14,470 --> 00:02:12,720

easily as how do you make planets and

58

00:02:15,510 --> 00:02:14,480

once you have planets what makes them

59

00:02:17,270 --> 00:02:15,520

habitable

60

00:02:19,830 --> 00:02:17,280

and we can argue a lot about what

61

00:02:21,830 --> 00:02:19,840

habitable means

62

00:02:24,150 --> 00:02:21,840

um that is what we're going to talk

63

00:02:26,150 --> 00:02:24,160

about today uh we start talking about

64

00:02:28,550 --> 00:02:26,160

today and then hopefully everybody will

65

00:02:31,670 --> 00:02:28,560

continue talking about it on the online

66

00:02:34,550 --> 00:02:31,680

discussion forum that we're setting up

67

00:02:36,710 --> 00:02:34,560

um the participating in the on this

68

00:02:38,790 --> 00:02:36,720

discussion and in the online discussions

69

00:02:40,949 --> 00:02:38,800

later on is important for two reasons

70

00:02:43,110 --> 00:02:40,959

first we're capturing everything you

71

00:02:44,070 --> 00:02:43,120

write everything you say everything you

72

00:02:46,229 --> 00:02:44,080

post

73

00:02:48,470 --> 00:02:46,239

and so all that information is going to

74

00:02:50,470 --> 00:02:48,480

indirectly affect the thinking of the

75

00:02:52,070 --> 00:02:50,480

people who are actually writing gonna

76

00:02:54,070 --> 00:02:52,080

write the road map

77

00:02:55,350 --> 00:02:54,080

and secondly and perhaps more more

78

00:02:57,030 --> 00:02:55,360

direct certainly more directly and

79

00:02:58,550 --> 00:02:57,040

possibly

80

00:03:00,710 --> 00:02:58,560

more importantly

81

00:03:02,470 --> 00:03:00,720

we're going to be choosing people to

82

00:03:04,949 --> 00:03:02,480

write the road map

83

00:03:06,790 --> 00:03:04,959

based on people who have active

84

00:03:08,470 --> 00:03:06,800

and interesting things who are active

85

00:03:11,110 --> 00:03:08,480

and have interesting things to say uh

86

00:03:13,430 --> 00:03:11,120

both in this panel and later on

87

00:03:16,309 --> 00:03:13,440

in in the online discussion so i really

88

00:03:18,710 --> 00:03:16,319

do encourage you to uh participate both

89

00:03:20,390 --> 00:03:18,720

in the chat room here um

90

00:03:22,630 --> 00:03:20,400

raise your hand you have a function a

91

00:03:24,550 --> 00:03:22,640

button on the upper left corner of your

92

00:03:26,390 --> 00:03:24,560

screen that lets you draw on the webex

93

00:03:29,670 --> 00:03:26,400

that lets you raise your hand and we'll

94

00:03:30,949 --> 00:03:29,680

call on you and then when we decamp from

95

00:03:33,270 --> 00:03:30,959

this

96

00:03:35,910 --> 00:03:33,280

interactive presentation mode we go on

97

00:03:38,390 --> 00:03:35,920

to the discussion forum um we i

98

00:03:40,390 --> 00:03:38,400

encourage you to start taking up

99

00:03:41,990 --> 00:03:40,400

questions writing answers

100

00:03:44,470 --> 00:03:42,000

commenting

101
00:03:47,670 --> 00:03:44,480
um because that's how we're gonna move

102
00:03:49,030 --> 00:03:47,680
uh forward towards a final roadmap that

103
00:03:50,470 --> 00:03:49,040
will define the direction of

104
00:03:51,589 --> 00:03:50,480
astrobiology research for the next

105
00:03:53,110 --> 00:03:51,599
decade

106
00:03:55,430 --> 00:03:53,120
so this is probably all you're going to

107
00:03:56,630 --> 00:03:55,440
hear from me today um

108
00:03:58,390 --> 00:03:56,640
i'm really interested to hear everyone

109
00:03:59,509 --> 00:03:58,400
else has to say so i'm just going to sit

110
00:04:02,710 --> 00:03:59,519
here and

111
00:04:05,990 --> 00:04:04,070
you do it so well thank you thank you

112
00:04:08,309 --> 00:04:06,000
very much michael and thank you for

113
00:04:10,149 --> 00:04:08,319

pointing out how people can chat through

114

00:04:12,309 --> 00:04:10,159

the chat window and raising hands with

115

00:04:15,030 --> 00:04:12,319

the little icon at the top of the screen

116

00:04:16,310 --> 00:04:15,040

so we'll kick off our conversation uh i

117

00:04:18,789 --> 00:04:16,320

kick off uh

118

00:04:21,030 --> 00:04:18,799

without panel these questions were

119

00:04:23,670 --> 00:04:21,040

raised by the panel as being important

120

00:04:25,670 --> 00:04:23,680

topics for for nasa to consider so what

121

00:04:27,670 --> 00:04:25,680

i'm going to ask them to do is to tell

122

00:04:29,430 --> 00:04:27,680

us why you think these are important

123

00:04:30,710 --> 00:04:29,440

questions let's start with the first

124

00:04:32,550 --> 00:04:30,720

question the fact is that's only the

125

00:04:35,670 --> 00:04:32,560

amount of water delivered to planets in

126

00:04:37,189 --> 00:04:35,680

a star's habitable zone um stein can i

127

00:04:39,030 --> 00:04:37,199

turn to you first to give us your

128

00:04:40,950 --> 00:04:39,040

thoughts on that

129

00:04:42,790 --> 00:04:40,960

okay um

130

00:04:44,629 --> 00:04:42,800

so there's an old question within the

131

00:04:46,550 --> 00:04:44,639

solar system of

132

00:04:48,310 --> 00:04:46,560

uh how exactly water got delivered to

133

00:04:52,070 --> 00:04:48,320

the earth uh there are these isotopic

134

00:04:54,790 --> 00:04:53,590

water on the surface of the earth at

135

00:04:56,310 --> 00:04:54,800

least and

136

00:04:58,310 --> 00:04:56,320

there's the question of what happened to

137

00:05:00,230 --> 00:04:58,320

the lunar impact and

138

00:05:02,070 --> 00:05:00,240

the water reservoir and the mantle

139

00:05:04,230 --> 00:05:02,080

and i think the bottom line is we don't

140

00:05:06,230 --> 00:05:04,240

know within a factor of 10

141

00:05:07,830 --> 00:05:06,240

uh what the true

142

00:05:09,590 --> 00:05:07,840

water content of the earth is or the

143

00:05:11,510 --> 00:05:09,600

history of its delivery

144

00:05:13,830 --> 00:05:11,520

and clearly the water content is

145

00:05:16,390 --> 00:05:13,840

critical at least for life as we know it

146

00:05:19,749 --> 00:05:16,400

so it seems reasonable we should

147

00:05:21,990 --> 00:05:19,759

try to understand in detail

148

00:05:24,469 --> 00:05:22,000

water delivery in general for the solar

149

00:05:27,990 --> 00:05:24,479

system in particular but then also

150

00:05:31,510 --> 00:05:29,350

we now understand there's a huge

151

00:05:33,189 --> 00:05:31,520

diversity of planetary systems

152

00:05:35,430 --> 00:05:33,199

we need to understand

153

00:05:38,629 --> 00:05:35,440

the variability in water delivery in

154

00:05:39,670 --> 00:05:38,639

different contexts and with different

155

00:05:41,430 --> 00:05:39,680

um

156

00:05:44,310 --> 00:05:41,440

scenarios of planet formation for

157

00:05:45,590 --> 00:05:44,320

different classes of planetary systems

158

00:05:47,350 --> 00:05:45,600

and we've done a little bit of work on

159

00:05:49,510 --> 00:05:47,360

that sean and i in fact wrote a couple

160

00:05:50,710 --> 00:05:49,520

of papers together and there's several

161

00:05:54,550 --> 00:05:50,720

other papers that have been done last

162

00:05:56,870 --> 00:05:54,560

few years on on both the astro dynamical

163

00:05:58,390 --> 00:05:56,880

problem of transporting volatiles within

164

00:05:59,270 --> 00:05:58,400

a hot disk

165

00:06:01,990 --> 00:05:59,280

and

166

00:06:04,710 --> 00:06:02,000

a little bit on the um

167

00:06:06,230 --> 00:06:04,720

geology and and the

168

00:06:07,830 --> 00:06:06,240

details of delivering water through

169

00:06:08,870 --> 00:06:07,840

impact there's a huge amount of work to

170

00:06:09,990 --> 00:06:08,880

be done

171

00:06:11,430 --> 00:06:10,000

and

172

00:06:12,469 --> 00:06:11,440

i think even astronomy when you don't

173

00:06:14,230 --> 00:06:12,479

understand things within orders of

174

00:06:16,230 --> 00:06:14,240

magnitude

175

00:06:17,909 --> 00:06:16,240

and we know they're critical things and

176

00:06:19,510 --> 00:06:17,919

it's a pretty good

177

00:06:22,390 --> 00:06:19,520

starting point to really get into some

178

00:06:24,790 --> 00:06:22,400

details and try to understand this

179

00:06:26,390 --> 00:06:24,800

uh properly and really try to nail this

180

00:06:27,749 --> 00:06:26,400

question down and then of course we have

181

00:06:28,950 --> 00:06:27,759

to go and get some data and test our

182

00:06:33,350 --> 00:06:28,960

ideas

183

00:06:37,590 --> 00:06:35,510

okay i think i'm unmuted now

184

00:06:40,710 --> 00:06:37,600

um yeah i agree this is uh it's an

185

00:06:42,390 --> 00:06:40,720

interesting question and one thing

186

00:06:43,029 --> 00:06:42,400

uh that i find particularly interesting

187

00:06:45,749 --> 00:06:43,039

is

188

00:06:48,469 --> 00:06:45,759

we don't know that well

189

00:06:49,909 --> 00:06:48,479

where earth's water came from so there

190

00:06:51,270 --> 00:06:49,919

have been a variety of models of where

191

00:06:53,590 --> 00:06:51,280

earth's water came from like stein

192

00:06:55,670 --> 00:06:53,600

mentioned and uh

193

00:06:57,749 --> 00:06:55,680

the the source of earth's water has even

194

00:07:00,230 --> 00:06:57,759

changed over the last 10 20 years you

195

00:07:02,390 --> 00:07:00,240

know the the presumed source

196

00:07:03,830 --> 00:07:02,400

and when we try to extrapolate this to

197

00:07:05,990 --> 00:07:03,840

extrasolar planets because that's kind

198

00:07:07,749 --> 00:07:06,000

of where the next big step is we want to

199

00:07:10,390 --> 00:07:07,759

think about life around

200

00:07:13,350 --> 00:07:10,400

other planets uh i don't think we even

201
00:07:14,870 --> 00:07:13,360
have a good sense of which step in the

202
00:07:16,790 --> 00:07:14,880
in the process

203
00:07:18,629 --> 00:07:16,800
is the one that would control how much

204
00:07:21,430 --> 00:07:18,639
water a planet like earth

205
00:07:24,150 --> 00:07:21,440
received for example uh does it depend

206
00:07:25,909 --> 00:07:24,160
more on the composition of the disk

207
00:07:28,150 --> 00:07:25,919
from which the planets form for example

208
00:07:30,950 --> 00:07:28,160
the it's been argued that the carbon to

209
00:07:31,909 --> 00:07:30,960
oxygen ratio within the disc is a key

210
00:07:34,550 --> 00:07:31,919
factor

211
00:07:36,230 --> 00:07:34,560
to determine whether uh how much water

212
00:07:39,029 --> 00:07:36,240
you actually end up with due to various

213
00:07:41,350 --> 00:07:39,039

chemical reactions within the disk or is

214

00:07:43,350 --> 00:07:41,360

it the viscous evolution of the disk

215

00:07:45,749 --> 00:07:43,360

some people have argued that in many

216

00:07:48,150 --> 00:07:45,759

discs if you have a very cold passive

217

00:07:50,710 --> 00:07:48,160

disc it's possible that water would

218

00:07:53,110 --> 00:07:50,720

condense in as close as one a year for a

219

00:07:55,189 --> 00:07:53,120

solar like a sun-like star and then you

220

00:07:57,189 --> 00:07:55,199

could end up having an earth be a water

221

00:07:59,350 --> 00:07:57,199

world type planet typically

222

00:08:01,510 --> 00:07:59,360

uh then there's there's various other

223

00:08:03,350 --> 00:08:01,520

processes at play such as short-lived

224

00:08:05,510 --> 00:08:03,360

radionuclides which have an interesting

225

00:08:07,589 --> 00:08:05,520

story in the solar system you know

226

00:08:08,710 --> 00:08:07,599

there's there's a large amount of heat

227

00:08:09,830 --> 00:08:08,720

injected

228

00:08:11,510 --> 00:08:09,840

into the

229

00:08:13,510 --> 00:08:11,520

solar system at early times by things

230

00:08:15,909 --> 00:08:13,520

like aluminum 26 that would have dried

231

00:08:18,230 --> 00:08:15,919

out a lot of planetesimals and is that a

232

00:08:20,469 --> 00:08:18,240

common process or a rare one and how

233

00:08:22,469 --> 00:08:20,479

important is it and then finally there's

234

00:08:25,430 --> 00:08:22,479

the kind of the the real formation of

235

00:08:27,830 --> 00:08:25,440

the earth-like planets uh you know giant

236

00:08:30,869 --> 00:08:27,840

collisions are involved that presumably

237

00:08:33,750 --> 00:08:30,879

uh release a lot of water uh you know is

238

00:08:35,509 --> 00:08:33,760

is is it that the earth tried to form

239

00:08:37,589 --> 00:08:35,519

with a hundred times more water than we

240

00:08:39,430 --> 00:08:37,599

have now and only one percent remained

241

00:08:41,750 --> 00:08:39,440

or did we only lose a factor of two in

242

00:08:43,509 --> 00:08:41,760

water that we don't really know the

243

00:08:45,990 --> 00:08:43,519

answer to those type of questions so

244

00:08:48,310 --> 00:08:46,000

even just kind of narrowing down which

245

00:08:50,070 --> 00:08:48,320

chain along there uh

246

00:08:51,910 --> 00:08:50,080

governed you know is the most important

247

00:08:53,269 --> 00:08:51,920

factor in determining the water content

248

00:08:57,269 --> 00:08:53,279

uh would be an interesting starting

249

00:08:57,279 --> 00:09:01,350

that's that's my thoughts for now

250

00:09:04,550 --> 00:09:03,430

thank you

251
00:09:06,870 --> 00:09:04,560
um

252
00:09:08,949 --> 00:09:06,880
the uh francis will probably come back

253
00:09:10,150 --> 00:09:08,959
and give us his thoughts on this in a

254
00:09:12,550 --> 00:09:10,160
short while

255
00:09:13,910 --> 00:09:12,560
um but um

256
00:09:16,630 --> 00:09:13,920
before we move on to our next question

257
00:09:19,350 --> 00:09:16,640
just just to come back to stein and to

258
00:09:21,190 --> 00:09:19,360
sean uh this may sound like a very naive

259
00:09:24,310 --> 00:09:21,200
question but but what what's stopping

260
00:09:25,990 --> 00:09:24,320
you uh making this progress already why

261
00:09:27,670 --> 00:09:26,000
why is this important

262
00:09:29,190 --> 00:09:27,680
uh to be done why have you not made

263
00:09:30,790 --> 00:09:29,200

progress with this so far why should

264

00:09:34,630 --> 00:09:30,800

nasa be putting their money into this

265

00:09:42,150 --> 00:09:37,350

okay i'll start again um

266

00:09:46,070 --> 00:09:42,160

pure answer is um time money and people

267

00:09:48,150 --> 00:09:46,080

each of these separate problems is a

268

00:09:50,550 --> 00:09:48,160

somewhere between a difficult problem

269

00:09:52,230 --> 00:09:50,560

and a near intractable problem uh

270

00:09:53,590 --> 00:09:52,240

they're computationally hard in case of

271

00:09:55,910 --> 00:09:53,600

the modeling

272

00:09:57,590 --> 00:09:55,920

geochemistry is

273

00:10:00,070 --> 00:09:57,600

complex

274

00:10:03,269 --> 00:10:00,080

and so this chemistry is worse because

275

00:10:04,630 --> 00:10:03,279

the multi-phase chemistry and and in

276

00:10:06,389 --> 00:10:04,640

conditions where we don't always have

277

00:10:09,269 --> 00:10:06,399

lab data to

278

00:10:11,430 --> 00:10:09,279

get through reaction rates and

279

00:10:16,310 --> 00:10:11,440

kinetic equilibria etc

280

00:10:20,949 --> 00:10:18,870

progress isn't fit and start you you do

281

00:10:22,630 --> 00:10:20,959

what you can when you can and then you

282

00:10:23,829 --> 00:10:22,640

hit a barrier and

283

00:10:25,590 --> 00:10:23,839

you have to pause and wait for the

284

00:10:28,069 --> 00:10:25,600

technology to catch up or someone to put

285

00:10:29,269 --> 00:10:28,079

the work in to figure out the next step

286

00:10:30,870 --> 00:10:29,279

um

287

00:10:33,190 --> 00:10:30,880

and it's not just water i see daniel

288

00:10:35,750 --> 00:10:33,200

just denoted that it's

289

00:10:37,590 --> 00:10:35,760

the whole shawn or peachon

290

00:10:38,550 --> 00:10:37,600

group of elements that you need to worry

291

00:10:41,030 --> 00:10:38,560

about

292

00:10:43,190 --> 00:10:41,040

water is more sort of a tracer it's got

293

00:10:45,030 --> 00:10:43,200

a nice

294

00:10:47,190 --> 00:10:45,040

moderate

295

00:10:49,110 --> 00:10:47,200

uh heat of a temperature which is the

296

00:10:49,829 --> 00:10:49,120

vaporizer or the critical triple point

297

00:10:52,949 --> 00:10:49,839

so

298

00:10:55,269 --> 00:10:52,959

are

299

00:10:56,389 --> 00:10:55,279

uh it's not that it's the only unique uh

300

00:10:58,230 --> 00:10:56,399

uh

301

00:11:00,150 --> 00:10:58,240

chemical for for life

302

00:11:02,230 --> 00:11:00,160

uh it's more than the tracker for it but

303

00:11:07,269 --> 00:11:02,240

um

304

00:11:08,790 --> 00:11:07,279

personally i find that that uh

305

00:11:10,310 --> 00:11:08,800

it's literally

306

00:11:13,350 --> 00:11:10,320

we need to be able to have more people

307

00:11:15,350 --> 00:11:13,360

working on it we need to have

308

00:11:16,870 --> 00:11:15,360

groups of overlapping researchers where

309

00:11:18,710 --> 00:11:16,880

there's continuity in the research where

310

00:11:20,389 --> 00:11:18,720

it doesn't stop all the time

311

00:11:21,590 --> 00:11:20,399

and it just

312

00:11:26,069 --> 00:11:21,600

it

313

00:11:27,750 --> 00:11:26,079

resources are money and people

314

00:11:29,509 --> 00:11:27,760

and we're short on that we're critically

315

00:11:31,590 --> 00:11:29,519

short in all these areas of people with

316

00:11:32,790 --> 00:11:31,600

an exterior critical skills and the and

317

00:11:36,310 --> 00:11:32,800

the amount of money to pay to people

318

00:11:40,550 --> 00:11:38,870

i would add one small uh detail

319

00:11:42,470 --> 00:11:40,560

which is that uh

320

00:11:43,910 --> 00:11:42,480

it's a it's a very interdisciplinary

321

00:11:46,470 --> 00:11:43,920

question which why is why it's so

322

00:11:47,990 --> 00:11:46,480

relevant to astrobiology and so for

323

00:11:49,110 --> 00:11:48,000

example when we think just about water

324

00:11:51,509 --> 00:11:49,120

on earth

325

00:11:53,750 --> 00:11:51,519

uh even to even address that problem you

326

00:11:55,590 --> 00:11:53,760

have to be up to date in several

327

00:11:57,670 --> 00:11:55,600

different fields so you don't just need

328

00:11:59,670 --> 00:11:57,680

kind of a background in geology and

329

00:12:01,590 --> 00:11:59,680

astronomy and dynamics and such you

330

00:12:03,110 --> 00:12:01,600

actually need to be up to date because

331

00:12:05,670 --> 00:12:03,120

for example there was a new paper last

332

00:12:07,110 --> 00:12:05,680

year revising earth's bulk water content

333

00:12:08,790 --> 00:12:07,120

changing it by about a factor of three

334

00:12:10,470 --> 00:12:08,800

from what we saw before

335

00:12:11,350 --> 00:12:10,480

there's new dynamical models all the

336

00:12:13,190 --> 00:12:11,360

time

337

00:12:14,949 --> 00:12:13,200

there's new all sorts of new discoveries

338

00:12:16,629 --> 00:12:14,959

and exoplanets that influence how we

339

00:12:19,269 --> 00:12:16,639

think they formed and even how we think

340

00:12:21,350 --> 00:12:19,279

the solar system forms so to really put

341

00:12:22,629 --> 00:12:21,360

the pieces together you don't just need

342

00:12:23,910 --> 00:12:22,639

people who have kind of a background in

343

00:12:25,430 --> 00:12:23,920

one field who are now doing another

344

00:12:27,430 --> 00:12:25,440

field you need people who are at the

345

00:12:29,030 --> 00:12:27,440

forefront of each different field kind

346

00:12:31,509 --> 00:12:29,040

of working together

347

00:12:36,389 --> 00:12:31,519

which is i think the the advantage of

348

00:12:39,509 --> 00:12:37,350

and

349

00:12:43,030 --> 00:12:39,519

just to chime in on this

350

00:12:45,990 --> 00:12:43,040

one of the problems you run into is

351

00:12:48,150 --> 00:12:46,000

even if you get going on this

352

00:12:49,910 --> 00:12:48,160

the research is quantized you get maybe

353

00:12:51,990 --> 00:12:49,920

a three-year grant

354

00:12:53,030 --> 00:12:52,000

and then it's currently essentially a

355

00:12:54,710 --> 00:12:53,040

lottery whether you're going to get a

356

00:12:56,150 --> 00:12:54,720

renewal on the ground or not

357

00:12:59,670 --> 00:12:56,160

and that makes it really difficult to

358

00:13:01,430 --> 00:12:59,680

keep a continuous research theme going

359

00:13:02,790 --> 00:13:01,440

this is not specific to this problem

360

00:13:04,550 --> 00:13:02,800

this is the general

361

00:13:07,910 --> 00:13:04,560

i think nasa is perfectly well aware of

362

00:13:13,190 --> 00:13:09,910

it makes it harder to maintain progress

363

00:13:13,200 --> 00:13:18,470

try again

364

00:13:21,750 --> 00:13:19,590

well thank you thank you for the

365

00:13:22,710 --> 00:13:21,760

response there does that

366

00:13:24,870 --> 00:13:22,720

does that

367

00:13:28,069 --> 00:13:24,880

apply also to our second question on our

368

00:13:28,949 --> 00:13:28,079

list here about organic molecules

369

00:13:31,990 --> 00:13:28,959

um

370

00:13:33,829 --> 00:13:32,000

is uh could you again explain to us uh

371

00:13:36,310 --> 00:13:33,839

something as to why you think this

372

00:13:38,710 --> 00:13:36,320

question is is important for nasa to

373

00:13:42,710 --> 00:13:40,550

you want to go first

374

00:13:45,509 --> 00:13:42,720

um sure well this this particular

375

00:13:48,870 --> 00:13:45,519

question about the organic molecules

376

00:13:50,310 --> 00:13:48,880

and such is really not my specialty uh

377

00:13:53,670 --> 00:13:50,320

but

378

00:13:55,670 --> 00:13:53,680

i mean i think the the general idea of

379

00:13:57,269 --> 00:13:55,680

of understanding

380

00:14:00,949 --> 00:13:57,279

where these molecules that that are key

381

00:14:02,470 --> 00:14:00,959

for life on earth come from how you can

382

00:14:04,150 --> 00:14:02,480

you know how they're preserved and what

383

00:14:05,990 --> 00:14:04,160

you really need is is really important

384

00:14:08,230 --> 00:14:06,000

and also multi-disciplinary because it

385

00:14:10,790 --> 00:14:08,240

should connect naturally uh between kind

386

00:14:12,310 --> 00:14:10,800

of planetary science and geology

387

00:14:14,470 --> 00:14:12,320

and even astrophysics when you think of

388

00:14:15,990 --> 00:14:14,480

the abundances of different elements in

389

00:14:19,990 --> 00:14:16,000

the interstellar medium or in clouds

390

00:14:23,750 --> 00:14:20,710

so

391

00:14:25,590 --> 00:14:23,760

question i don't know too much about the

392

00:14:28,829 --> 00:14:25,600

details of it personally but uh it's

393

00:14:33,110 --> 00:14:30,710

so um

394

00:14:34,870 --> 00:14:33,120

again i'm an astronomer not a not a

395

00:14:36,629 --> 00:14:34,880

biologist or a uh

396

00:14:38,230 --> 00:14:36,639

chemist

397

00:14:39,829 --> 00:14:38,240

we know in the interstellar media we get

398

00:14:41,590 --> 00:14:39,839

part of the way there at least

399

00:14:43,750 --> 00:14:41,600

we get

400

00:14:46,790 --> 00:14:43,760

moderately complex molecules forming in

401
00:14:49,910 --> 00:14:46,800
the gas phase and on solid surfaces

402
00:14:51,829 --> 00:14:49,920
on planetary in the solar nebula

403
00:14:54,470 --> 00:14:51,839
and these are clearly delivered to the

404
00:14:55,590 --> 00:14:54,480
earth and other planets in general so we

405
00:14:58,310 --> 00:14:55,600
start off

406
00:15:01,350 --> 00:14:58,320
halfway there there are moderately

407
00:15:02,790 --> 00:15:01,360
complex organic compounds there are

408
00:15:03,910 --> 00:15:02,800
compounds we know are biologically

409
00:15:07,990 --> 00:15:03,920
interesting

410
00:15:12,470 --> 00:15:09,910
amino acids and sugars

411
00:15:14,870 --> 00:15:12,480
we see directly in space

412
00:15:23,030 --> 00:15:19,829
what we don't know is the big step from

413
00:15:25,110 --> 00:15:23,040

how we get to through prebiotic or

414

00:15:26,870 --> 00:15:25,120

protobiotic conditions

415

00:15:28,790 --> 00:15:26,880

and there are some really interesting

416

00:15:30,949 --> 00:15:28,800

ideas out there

417

00:15:33,590 --> 00:15:30,959

uh the classic title pool idea

418

00:15:37,629 --> 00:15:33,600

hydrothermal van

419

00:15:42,470 --> 00:15:41,110

plays um there are a number of places

420

00:15:43,990 --> 00:15:42,480

where things could be happening maybe

421

00:15:45,750 --> 00:15:44,000

you need all of them maybe you need some

422

00:15:47,030 --> 00:15:45,760

of them maybe just one of them will do

423

00:15:48,150 --> 00:15:47,040

or maybe you're completely on the wrong

424

00:15:51,350 --> 00:15:48,160

track and there's something else going

425

00:15:52,870 --> 00:15:51,360

on but something somewhere

426

00:15:55,110 --> 00:15:52,880

gave us conditions where the

427

00:15:56,710 --> 00:15:55,120

concentration and the thermodynamic

428

00:15:59,030 --> 00:15:56,720

conditions existed

429

00:16:00,710 --> 00:15:59,040

or prebiotic molecules become probiotics

430

00:16:01,509 --> 00:16:00,720

become biotic

431

00:16:04,790 --> 00:16:01,519

and

432

00:16:06,389 --> 00:16:04,800

raw catalysis presumably you're more or

433

00:16:08,629 --> 00:16:06,399

less safe unless you're contingently

434

00:16:10,550 --> 00:16:08,639

sterilized by the ionized impact

435

00:16:11,749 --> 00:16:10,560

or volcano opening up right underneath

436

00:16:13,749 --> 00:16:11,759

the tidal pool

437

00:16:15,590 --> 00:16:13,759

but um

438

00:16:17,430 --> 00:16:15,600

and then you do it again

439

00:16:19,829 --> 00:16:17,440

but there's no reason we can't

440

00:16:22,629 --> 00:16:19,839

understand this this is not a

441

00:16:24,550 --> 00:16:22,639

inconceivably difficult problem

442

00:16:25,749 --> 00:16:24,560

uh and in fact one of the things i've

443

00:16:27,509 --> 00:16:25,759

been most impressed with in the last

444

00:16:30,150 --> 00:16:27,519

decade with the biology is how how

445

00:16:32,150 --> 00:16:30,160

strongly we've converged from both ends

446

00:16:35,350 --> 00:16:32,160

and understanding this problem

447

00:16:38,870 --> 00:16:35,360

and it seems to me that this is a

448

00:16:40,790 --> 00:16:38,880

very large question in science in fact

449

00:16:42,629 --> 00:16:40,800

in a lot of surveys this is one of the

450

00:16:45,189 --> 00:16:42,639

two big questions

451
00:16:46,470 --> 00:16:45,199
that we must understand the the origin

452
00:16:48,470 --> 00:16:46,480
of life question where you how you

453
00:16:50,949 --> 00:16:48,480
transit from a

454
00:16:53,509 --> 00:16:50,959
prebiotic biotic and

455
00:16:54,710 --> 00:16:53,519
we seem to be praying to answer it

456
00:16:57,110 --> 00:16:54,720
unless we're missing something really

457
00:16:58,870 --> 00:16:57,120
subtle i think we are very close to

458
00:17:00,069 --> 00:16:58,880
really understanding step by step what's

459
00:17:01,670 --> 00:17:00,079
going on

460
00:17:03,430 --> 00:17:01,680
uh even possibly down to the point of

461
00:17:06,150 --> 00:17:03,440
replicating it and there have been some

462
00:17:08,470 --> 00:17:06,160
class plastic lab experiments that have

463
00:17:09,429 --> 00:17:08,480

elucidated some of the steps in this i

464

00:17:11,909 --> 00:17:09,439

really wish for instance we're here to

465

00:17:14,069 --> 00:17:11,919

talk about this um

466

00:17:16,069 --> 00:17:14,079

but um can i

467

00:17:17,510 --> 00:17:16,079

say can i bring david david into the

468

00:17:20,069 --> 00:17:17,520

conversation he's raising his hand here

469

00:17:20,079 --> 00:17:23,429

david yeah um

470

00:17:27,270 --> 00:17:25,750

can you hear me

471

00:17:28,549 --> 00:17:27,280

we can

472

00:17:30,150 --> 00:17:28,559

yes okay

473

00:17:32,470 --> 00:17:30,160

yeah it seems to me that this is the

474

00:17:34,150 --> 00:17:32,480

hardest question of the four i think it

475

00:17:35,909 --> 00:17:34,160

seems to me that this is really origins

476

00:17:36,950 --> 00:17:35,919

of life in fact shouldn't that question

477

00:17:38,789 --> 00:17:36,960

end

478

00:17:46,310 --> 00:17:38,799

complexification of organics towards

479

00:17:50,150 --> 00:17:48,390

can you hear me

480

00:17:53,590 --> 00:17:50,160

yeah so what

481

00:17:55,830 --> 00:17:53,600

can you clarify the distinction

482

00:17:59,029 --> 00:17:55,840

well biogenesis is the origin of life

483

00:18:00,950 --> 00:17:59,039

abiogenesis is the order of

484

00:18:02,630 --> 00:18:00,960

something that's not life

485

00:18:04,710 --> 00:18:02,640

so i just thought maybe the a should go

486

00:18:05,750 --> 00:18:04,720

away on that last word

487

00:18:12,710 --> 00:18:05,760

but

488

00:18:13,510 --> 00:18:12,720

that um

489

00:18:15,029 --> 00:18:13,520

you know

490

00:18:16,789 --> 00:18:15,039

a lot of our laboratory models can

491

00:18:18,950 --> 00:18:16,799

figure out parts of this puzzle but it

492

00:18:21,350 --> 00:18:18,960

seems to me that the key

493

00:18:23,669 --> 00:18:21,360

part of the puzzle is how can we channel

494

00:18:25,190 --> 00:18:23,679

energy into the formation of complexity

495

00:18:27,750 --> 00:18:25,200

in terms of function

496

00:18:29,430 --> 00:18:27,760

and so it's this coupling of the energy

497

00:18:31,350 --> 00:18:29,440

that's in the environment towards the

498

00:18:32,950 --> 00:18:31,360

increase in information content of what

499

00:18:35,430 --> 00:18:32,960

it is that you're trying to do that is

500

00:18:36,870 --> 00:18:35,440

the crux of the problem and so i think

501
00:18:38,150 --> 00:18:36,880
whereas many

502
00:18:40,630 --> 00:18:38,160
studies have

503
00:18:43,350 --> 00:18:40,640
shown progress in some of the sub areas

504
00:18:45,110 --> 00:18:43,360
about this challenge of origin of life

505
00:18:47,029 --> 00:18:45,120
life is the system where you have the

506
00:18:49,350 --> 00:18:47,039
energy coupled to these complex

507
00:18:51,270 --> 00:18:49,360
molecules and processes and

508
00:18:52,470 --> 00:18:51,280
that seems to be a tough one to me and i

509
00:18:54,710 --> 00:18:52,480
don't know that there's been a lot of

510
00:18:56,230 --> 00:18:54,720
work done on that so um

511
00:18:58,470 --> 00:18:56,240
anyway i just thought i'd say that it's

512
00:18:59,669 --> 00:18:58,480
how does the system come about

513
00:19:03,029 --> 00:18:59,679

um

514

00:19:07,590 --> 00:19:04,789

so i think a related question and that

515

00:19:09,110 --> 00:19:07,600

takes us down to question four as well

516

00:19:10,789 --> 00:19:09,120

is not just

517

00:19:13,430 --> 00:19:10,799

how do you couple the free energy that's

518

00:19:14,630 --> 00:19:13,440

flowing through the system into driving

519

00:19:16,230 --> 00:19:14,640

uh

520

00:19:17,510 --> 00:19:16,240

the complexification i guess is the word

521

00:19:19,750 --> 00:19:17,520

we're using here

522

00:19:20,789 --> 00:19:19,760

but also how little can you get away

523

00:19:22,070 --> 00:19:20,799

with

524

00:19:24,070 --> 00:19:22,080

uh it is

525

00:19:25,750 --> 00:19:24,080

it sort of becomes another goldilocks

526

00:19:27,350 --> 00:19:25,760

problem because if you put too much

527

00:19:27,990 --> 00:19:27,360

energy through the system you vaporize

528

00:19:29,590 --> 00:19:28,000

it

529

00:19:31,029 --> 00:19:29,600

that does not seem to be conducive to

530

00:19:32,070 --> 00:19:31,039

biogenesis

531

00:19:33,990 --> 00:19:32,080

um

532

00:19:35,830 --> 00:19:34,000

vaporizing i

533

00:19:38,070 --> 00:19:35,840

could go to ions plasma if you would

534

00:19:40,230 --> 00:19:38,080

really huge amount of energy through but

535

00:19:42,710 --> 00:19:40,240

there is presumably some minimum amount

536

00:19:44,789 --> 00:19:42,720

of free energy flow where you just never

537

00:19:46,630 --> 00:19:44,799

get the gradients and the interesting

538

00:19:48,870 --> 00:19:46,640

chemistry going to

539

00:19:50,230 --> 00:19:48,880

where you actually get to origin of life

540

00:19:51,430 --> 00:19:50,240

and

541

00:19:52,870 --> 00:19:51,440

again this seems to be the sort of

542

00:19:54,549 --> 00:19:52,880

question where we can squeeze down to

543

00:19:57,669 --> 00:19:54,559

the answer and

544

00:20:01,110 --> 00:19:59,669

lower bound of energy flow where you're

545

00:20:02,789 --> 00:20:01,120

just you're just not going to get there

546

00:20:03,990 --> 00:20:02,799

in a finite time

547

00:20:06,710 --> 00:20:04,000

and

548

00:20:08,710 --> 00:20:06,720

is

549

00:20:10,789 --> 00:20:08,720

are you then relying on contingent or

550

00:20:12,789 --> 00:20:10,799

stochastic events or is this really

551
00:20:14,390 --> 00:20:12,799
inevitable once you get free life free

552
00:20:15,430 --> 00:20:14,400
energy flowing through

553
00:20:17,350 --> 00:20:15,440
a

554
00:20:18,630 --> 00:20:17,360
motor my old system for long enough is

555
00:20:20,070 --> 00:20:18,640
rich enough of a chemistry are you

556
00:20:21,990 --> 00:20:20,080
always going to get life

557
00:20:23,430 --> 00:20:22,000
that's that's i think the question we

558
00:20:28,390 --> 00:20:23,440
want to know

559
00:20:30,549 --> 00:20:28,400
or or at least a mechanism

560
00:20:32,149 --> 00:20:30,559
conceivably of course there could be

561
00:20:32,870 --> 00:20:32,159
several different metabolic channels or

562
00:20:37,430 --> 00:20:32,880
or

563
00:20:38,950 --> 00:20:37,440

and we may be very strongly biased here

564

00:20:41,990 --> 00:20:38,960

in terms of what we're looking for but

565

00:20:46,630 --> 00:20:44,070

we just point out here that as michael

566

00:20:48,950 --> 00:20:46,640

points out uh we're not just necessarily

567

00:20:51,590 --> 00:20:48,960

discussing the origin of life here but

568

00:20:53,830 --> 00:20:51,600

how habitable planets are made

569

00:20:56,230 --> 00:20:53,840

uh and how how once formerly inhabitable

570

00:20:57,270 --> 00:20:56,240

so just just to keep that on topic for

571

00:21:00,630 --> 00:20:57,280

the moment

572

00:21:03,350 --> 00:21:00,640

um can we can we sort of have a look

573

00:21:04,310 --> 00:21:03,360

towards um our third question here we'll

574

00:21:06,070 --> 00:21:04,320

probably come backwards and forwards

575

00:21:08,390 --> 00:21:06,080

across these when francis comes back in

576

00:21:10,149 --> 00:21:08,400

to join us but um i just want a big

577

00:21:12,310 --> 00:21:10,159

thing about the uniquely identifying

578

00:21:14,870 --> 00:21:12,320

fossils um

579

00:21:16,710 --> 00:21:14,880

it's um i wonder if sean could you give

580

00:21:17,909 --> 00:21:16,720

us a little bit of background as to why

581

00:21:22,630 --> 00:21:17,919

you think that was an important question

582

00:21:26,549 --> 00:21:24,950

um sorry what

583

00:21:28,630 --> 00:21:26,559

this is another area that i'm afraid i'm

584

00:21:30,710 --> 00:21:28,640

not super specialized in i've i know a

585

00:21:32,470 --> 00:21:30,720

little bit about the the fossil kind of

586

00:21:34,950 --> 00:21:32,480

problem like from the the

587

00:21:38,149 --> 00:21:34,960

reported mars uh fossils in the mars

588

00:21:39,909 --> 00:21:38,159

meteorite but uh again

589

00:21:42,310 --> 00:21:39,919

i mean this is a hugely important

590

00:21:43,669 --> 00:21:42,320

question of whether even

591

00:21:45,750 --> 00:21:43,679

if you have a chunk of life in your hand

592

00:21:47,190 --> 00:21:45,760

whether you can identify it or not

593

00:21:49,110 --> 00:21:47,200

um

594

00:21:50,549 --> 00:21:49,120

so exactly

595

00:21:52,070 --> 00:21:50,559

more details than that i'm gonna have to

596

00:21:55,270 --> 00:21:52,080

pass to someone else

597

00:21:57,669 --> 00:21:55,280

uh given my background

598

00:21:59,110 --> 00:21:57,679

okay thank you stein did you have it or

599

00:22:06,310 --> 00:21:59,120

should i bring in david david's got a

600

00:22:11,110 --> 00:22:07,990

oh do you want david

601
00:22:13,590 --> 00:22:11,120
oh okay well you know i'm on the science

602
00:22:14,870 --> 00:22:13,600
definition team for the mars 2020 rover

603
00:22:16,470 --> 00:22:14,880
so i have to be a little careful about

604
00:22:17,669 --> 00:22:16,480
what i say here

605
00:22:20,070 --> 00:22:17,679
but um

606
00:22:22,230 --> 00:22:20,080
you know this this is a challenge uh to

607
00:22:24,390 --> 00:22:22,240
really get at this question you need to

608
00:22:26,070 --> 00:22:24,400
figure out how to collect samples and

609
00:22:27,510 --> 00:22:26,080
then quite frankly in the long run get

610
00:22:29,750 --> 00:22:27,520
them back to earth

611
00:22:31,669 --> 00:22:29,760
uh and so the real challenge is how do

612
00:22:33,110 --> 00:22:31,679
we intelligently select samples and of

613
00:22:34,149 --> 00:22:33,120

course what do we do with them once we

614

00:22:36,390 --> 00:22:34,159

get back

615

00:22:38,149 --> 00:22:36,400

um i think i would take a little issue

616

00:22:39,909 --> 00:22:38,159

with the latter part of that question

617

00:22:42,390 --> 00:22:39,919

it's it's so implying the absence of

618

00:22:44,310 --> 00:22:42,400

biologically exclusive chemical

619

00:22:46,470 --> 00:22:44,320

signatures and i would think many would

620

00:22:48,549 --> 00:22:46,480

argue that certainly in terms of organic

621

00:22:49,990 --> 00:22:48,559

chemicals uh there would be bio

622

00:22:51,110 --> 00:22:50,000

signatures that could be quite

623

00:22:53,750 --> 00:22:51,120

definitive

624

00:22:55,190 --> 00:22:53,760

so um yeah i think but then of course

625

00:22:56,950 --> 00:22:55,200

there's the question as to whether we

626

00:23:00,310 --> 00:22:56,960

could ever determine them as being

627

00:23:03,029 --> 00:23:00,320

biological using a remote spacecraft and

628

00:23:04,789 --> 00:23:03,039

i think in that case uh there is reason

629

00:23:07,110 --> 00:23:04,799

to be um

630

00:23:10,070 --> 00:23:07,120

skeptical that we could achieve that but

631

00:23:12,310 --> 00:23:10,080

i think at least for mars uh a key part

632

00:23:14,470 --> 00:23:12,320

of addressing this is the issue of

633

00:23:15,669 --> 00:23:14,480

sample return i'll try to answer this

634

00:23:16,630 --> 00:23:15,679

question

635

00:23:18,070 --> 00:23:16,640

um

636

00:23:35,430 --> 00:23:18,080

a lot of people would argue that that's

637

00:23:38,549 --> 00:23:36,870

thank you about that damn it's got to

638

00:23:41,350 --> 00:23:38,559

mute that line for now but you want to

639

00:23:43,990 --> 00:23:41,360

take it over again tim

640

00:23:46,149 --> 00:23:44,000

thank you um so

641

00:23:47,909 --> 00:23:46,159

just coming back then to um stein i

642

00:23:49,190 --> 00:23:47,919

think you were about to you're about to

643

00:23:51,110 --> 00:23:49,200

say something before david came in there

644

00:23:52,470 --> 00:23:51,120

were you

645

00:23:54,789 --> 00:23:52,480

yeah i thought sort of

646

00:23:55,909 --> 00:23:54,799

that that was part of my job but um

647

00:23:57,430 --> 00:23:55,919

so i think the answer to that question

648

00:23:59,270 --> 00:23:57,440

is yes

649

00:24:00,549 --> 00:23:59,280

we will we will at some point be able to

650

00:24:02,070 --> 00:24:00,559

uniquely identify fossils and

651
00:24:04,310 --> 00:24:02,080
microorganisms

652
00:24:06,310 --> 00:24:04,320
uh whether that'll be on the time scale

653
00:24:07,750 --> 00:24:06,320
that's useful to this roadmap is uh the

654
00:24:11,110 --> 00:24:07,760
hard question

655
00:24:15,590 --> 00:24:12,630
clearly if we can bring rocks back and

656
00:24:18,390 --> 00:24:15,600
see morphological uh signatures of rock

657
00:24:22,710 --> 00:24:18,400
of fossils that are that everybody

658
00:24:26,149 --> 00:24:25,029
unfortunately people are very clever in

659
00:24:28,549 --> 00:24:26,159
coming up with alternative

660
00:24:31,510 --> 00:24:28,559
interpretations of

661
00:24:32,549 --> 00:24:31,520
such things as we've already experienced

662
00:24:34,149 --> 00:24:32,559
um

663
00:24:36,789 --> 00:24:34,159

so

664

00:24:39,350 --> 00:24:36,799

a unique identifier will probably

665

00:24:41,430 --> 00:24:39,360

require cumulative evidence of multiple

666

00:24:43,590 --> 00:24:41,440

lines of evidence

667

00:24:45,990 --> 00:24:43,600

not a a

668

00:24:46,950 --> 00:24:46,000

eureka moment of wow you know here's

669

00:24:49,190 --> 00:24:46,960

here's the

670

00:24:50,630 --> 00:24:49,200

the definitive single proof of life on

671

00:24:52,950 --> 00:24:50,640

another planet

672

00:24:57,029 --> 00:24:52,960

our past life on our planet

673

00:24:58,230 --> 00:24:57,039

um in particular um

674

00:25:00,070 --> 00:24:58,240

between

675

00:25:03,909 --> 00:25:00,080

looking for like biosignatures and

676
00:25:06,149 --> 00:25:03,919
isotope ratios and signature metabolism

677
00:25:08,230 --> 00:25:06,159
and uh morphology

678
00:25:10,230 --> 00:25:08,240
we should be thinking about

679
00:25:11,669 --> 00:25:10,240
what else is there

680
00:25:13,590 --> 00:25:11,679
um

681
00:25:16,149 --> 00:25:13,600
is is there a is it something we're

682
00:25:18,070 --> 00:25:16,159
overlooking where we can pick up if not

683
00:25:21,510 --> 00:25:18,080
a conclusive unique identifying

684
00:25:23,350 --> 00:25:21,520
signature supporting evidence or

685
00:25:25,029 --> 00:25:23,360
or little things that when they go

686
00:25:26,870 --> 00:25:25,039
together with another

687
00:25:29,190 --> 00:25:26,880
strong but not conclusive signature do

688
00:25:30,310 --> 00:25:29,200

they cumulatively add up to a unique

689

00:25:32,630 --> 00:25:30,320

signature

690

00:25:34,230 --> 00:25:32,640

or a convincing enough that everybody

691

00:25:36,070 --> 00:25:34,240

more or less can agree okay we really

692

00:25:37,909 --> 00:25:36,080

got got something here

693

00:25:39,110 --> 00:25:37,919

um

694

00:25:40,630 --> 00:25:39,120

i don't know

695

00:25:42,390 --> 00:25:40,640

i suspect we're going to find out the

696

00:25:43,909 --> 00:25:42,400

hard way by going and trying and failing

697

00:25:46,070 --> 00:25:43,919

a few times and then keep doing it again

698

00:25:48,230 --> 00:25:46,080

and again and again

699

00:25:49,750 --> 00:25:48,240

but it's clearly possible and it's

700

00:25:53,110 --> 00:25:49,760

interesting

701

00:25:56,870 --> 00:25:55,430

i'd like to know the answer

702

00:25:59,669 --> 00:25:56,880

thank you stein

703

00:26:01,750 --> 00:25:59,679

we have a hand raised from david

704

00:26:04,310 --> 00:26:01,760

david all right

705

00:26:05,830 --> 00:26:04,320

uh a useful concept in this right my

706

00:26:08,310 --> 00:26:05,840

regard might be something called a

707

00:26:09,590 --> 00:26:08,320

potential biosignature as opposed to

708

00:26:11,990 --> 00:26:09,600

what you might call a definitive

709

00:26:14,310 --> 00:26:12,000

biosignature and and the value of this

710

00:26:16,230 --> 00:26:14,320

concept of a potential biosignature is

711

00:26:18,070 --> 00:26:16,240

that this is going to be an iterative

712

00:26:20,390 --> 00:26:18,080

process we first had to go to mars to

713

00:26:22,710 --> 00:26:20,400

establish the extent of water activity

714

00:26:25,190 --> 00:26:22,720

now we're sort of at the level of trying

715

00:26:27,190 --> 00:26:25,200

to make a more complete uh investigation

716

00:26:28,789 --> 00:26:27,200

with respect to what it is required for

717

00:26:30,630 --> 00:26:28,799

habitability and of course as you know

718

00:26:31,990 --> 00:26:30,640

that's more than just water

719

00:26:33,830 --> 00:26:32,000

uh and then the same thing really

720

00:26:34,630 --> 00:26:33,840

applies to bio signatures we need to

721

00:26:37,750 --> 00:26:34,640

know

722

00:26:39,590 --> 00:26:37,760

go to get the best chance for

723

00:26:40,789 --> 00:26:39,600

preservation of bio signatures and the

724

00:26:42,149 --> 00:26:40,799

first things we're going to see that are

725

00:26:44,230 --> 00:26:42,159

interesting will be potential this

726

00:26:45,909 --> 00:26:44,240

certainly will not be proven

727

00:26:47,590 --> 00:26:45,919

but then that helps narrow the search

728

00:26:49,990 --> 00:26:47,600

and so how do we set up sort of an

729

00:26:51,510 --> 00:26:50,000

iterative approach to this problem to

730

00:26:54,390 --> 00:26:51,520

break it down into

731

00:26:56,710 --> 00:26:54,400

tractable steps and so this concept of a

732

00:26:58,710 --> 00:26:56,720

potential bio signature just like the

733

00:27:01,510 --> 00:26:58,720

allen hill stuff was before we came down

734

00:27:10,950 --> 00:27:01,520

with a more definitive determination i i

735

00:27:16,070 --> 00:27:13,029

what i'd like to do now is open the

736

00:27:17,990 --> 00:27:16,080

question uh to to the floor really we

737

00:27:19,669 --> 00:27:18,000

have a number of questions here which i

738

00:27:21,830 --> 00:27:19,679

think francis had something to

739

00:27:23,510 --> 00:27:21,840

contribute to as well but then hopefully

740

00:27:26,549 --> 00:27:23,520

he'll join us surely

741

00:27:27,830 --> 00:27:26,559

but uh the um the attendees we have 27

742

00:27:29,909 --> 00:27:27,840

attendees here

743

00:27:32,630 --> 00:27:29,919

um what are your opinions on these

744

00:27:34,789 --> 00:27:32,640

questions here why why do you think

745

00:27:37,830 --> 00:27:34,799

these questions may be important for

746

00:27:41,510 --> 00:27:37,840

nasa to pursue why should they be on the

747

00:27:43,590 --> 00:27:41,520

astrobiology roadmap

748

00:27:47,350 --> 00:27:43,600

if you can raise your hands

749

00:27:49,669 --> 00:27:47,360

daniel thank you first and thank you

750

00:27:51,269 --> 00:27:49,679

okay so i would like to address the

751

00:27:53,269 --> 00:27:51,279

first question

752

00:27:55,269 --> 00:27:53,279

i hope you can hear me now

753

00:27:56,230 --> 00:27:55,279

um i think that's an important question

754

00:27:58,470 --> 00:27:56,240

because

755

00:28:00,389 --> 00:27:58,480

exoplanets have been growing in

756

00:28:02,630 --> 00:28:00,399

importance and they are very likely

757

00:28:05,430 --> 00:28:02,640

going to play an important role in next

758

00:28:06,950 --> 00:28:05,440

decades nasa space missions

759

00:28:09,430 --> 00:28:06,960

this question is very important because

760

00:28:10,549 --> 00:28:09,440

it helps answering this question helps

761

00:28:11,669 --> 00:28:10,559

to figure out which are the right

762

00:28:13,350 --> 00:28:11,679

targets

763

00:28:17,190 --> 00:28:13,360

and

764

00:28:18,710 --> 00:28:17,200

planet we can better characterize them

765

00:28:20,470 --> 00:28:18,720

and understand their

766

00:28:21,990 --> 00:28:20,480

potential for

767

00:28:23,190 --> 00:28:22,000

hosting life

768

00:28:27,190 --> 00:28:23,200

i think

769

00:28:29,590 --> 00:28:27,200

extend the question from water to also

770

00:28:31,029 --> 00:28:29,600

other biocritical elements

771

00:28:33,029 --> 00:28:31,039

and because the processes are very

772

00:28:34,549 --> 00:28:33,039

complex and

773

00:28:37,269 --> 00:28:34,559

some of them are stochastic that can

774

00:28:38,389 --> 00:28:37,279

deliver volatiles and organics it's

775

00:28:40,789 --> 00:28:38,399

important to

776

00:28:43,029 --> 00:28:40,799

study trends and recognize

777

00:28:44,470 --> 00:28:43,039

the combination of these processes

778

00:28:55,909 --> 00:28:44,480

that needs to be

779

00:28:55,919 --> 00:28:59,590

thank you

780

00:29:04,230 --> 00:29:01,990

i understand that uh george cody may

781

00:29:05,830 --> 00:29:04,240

also have an opinion on some of these

782

00:29:08,149 --> 00:29:05,840

george can i ask you

783

00:29:17,909 --> 00:29:08,159

if you could uh give us your thoughts on

784

00:29:17,919 --> 00:29:34,149

foreign

785

00:29:38,070 --> 00:29:35,590

george

786

00:29:39,510 --> 00:29:38,080

isn't there what well i would uh i'd

787

00:29:46,070 --> 00:29:39,520

also draw

788

00:29:49,750 --> 00:29:47,590

yes hello

789

00:29:51,990 --> 00:29:49,760

can you hear me hello

790

00:29:53,990 --> 00:29:52,000

yes we can

791

00:29:56,789 --> 00:29:54,000

yes hi i'm tim zweer from purdue

792

00:30:00,070 --> 00:29:56,799

university and uh i'm a chemist physical

793

00:30:02,389 --> 00:30:00,080

chemist uh here at purdue and uh so i've

794

00:30:04,870 --> 00:30:02,399

been thinking particularly about this

795

00:30:06,149 --> 00:30:04,880

second question here about the organic

796

00:30:08,870 --> 00:30:06,159

molecules

797

00:30:11,029 --> 00:30:08,880

and how they can be produced and

798

00:30:12,230 --> 00:30:11,039

it seems to me um

799

00:30:15,430 --> 00:30:12,240

that

800

00:30:18,630 --> 00:30:15,440

there may be a need for some new types

801
00:30:20,549 --> 00:30:18,640
of laboratory based experiments um

802
00:30:22,149 --> 00:30:20,559
i think this is one of the regions in

803
00:30:26,070 --> 00:30:22,159
which actual laboratory-based

804
00:30:28,070 --> 00:30:26,080
experiments could be particularly useful

805
00:30:30,870 --> 00:30:28,080
because you know of course chemists have

806
00:30:34,549 --> 00:30:30,880
built up over time an extraordinarily

807
00:30:36,950 --> 00:30:34,559
sophisticated set of techniques for

808
00:30:39,269 --> 00:30:36,960
exciting molecules rating irradiating

809
00:30:41,110 --> 00:30:39,279
them in various ways and then following

810
00:30:43,110 --> 00:30:41,120
reaction pathways

811
00:30:44,710 --> 00:30:43,120
to specific products

812
00:30:46,950 --> 00:30:44,720
when when i think about some of the work

813
00:30:48,710 --> 00:30:46,960

that's that's been done over the years

814

00:30:51,669 --> 00:30:48,720

of course much of it takes a quite

815

00:30:54,870 --> 00:30:51,679

different tactic where

816

00:30:57,510 --> 00:30:54,880

you take a a pretty generic reaction

817

00:30:59,190 --> 00:30:57,520

mixture and a radiate irradiated over

818

00:31:02,070 --> 00:30:59,200

long period of time

819

00:31:05,430 --> 00:31:02,080

you know either with uv or vuv radiation

820

00:31:06,630 --> 00:31:05,440

or a discharge or whatever it might be

821

00:31:08,789 --> 00:31:06,640

and then

822

00:31:10,950 --> 00:31:08,799

after the fact when the end products are

823

00:31:13,350 --> 00:31:10,960

formed in a film or some sort of thing

824

00:31:14,789 --> 00:31:13,360

you try to characterize the the final

825

00:31:17,110 --> 00:31:14,799

end products

826

00:31:19,590 --> 00:31:17,120

but as a chemist you know i would be

827

00:31:21,830 --> 00:31:19,600

very interested in asking specific

828

00:31:24,149 --> 00:31:21,840

questions about particular types of

829

00:31:26,870 --> 00:31:24,159

organic functional groups that are known

830

00:31:28,710 --> 00:31:26,880

to be present in space and pervasive say

831

00:31:30,230 --> 00:31:28,720

for instance the nitrils or something

832

00:31:34,389 --> 00:31:30,240

like that

833

00:31:36,710 --> 00:31:34,399

and then trying to engage in specific uh

834

00:31:39,590 --> 00:31:36,720

photochemical or radiation

835

00:31:42,310 --> 00:31:39,600

uh chemistry that you could follow in

836

00:31:44,470 --> 00:31:42,320

time and specifically detect the

837

00:31:47,110 --> 00:31:44,480

products that are being formed to try to

838

00:31:49,430 --> 00:31:47,120

actually build up mechanisms then that

839

00:31:51,430 --> 00:31:49,440

that could be hopefully

840

00:31:53,909 --> 00:31:51,440

general enough to be

841

00:32:01,590 --> 00:31:53,919

applicable in in different circumstances

842

00:32:06,630 --> 00:32:04,070

stein sean do you have a response to

843

00:32:06,640 --> 00:32:09,029

um

844

00:32:13,190 --> 00:32:10,789

yeah i think for participants who might

845

00:32:16,389 --> 00:32:13,200

want to respond to that

846

00:32:18,870 --> 00:32:16,399

you know who you are you got one time

847

00:32:20,549 --> 00:32:18,880

while we wait for those hands to go up

848

00:32:26,149 --> 00:32:20,559

i wonder if

849

00:32:32,070 --> 00:32:27,029

let me

850

00:32:33,750 --> 00:32:32,080

again for the for all attendees here

851
00:32:35,509 --> 00:32:33,760
we're uh we're talking about planetary

852
00:32:37,430 --> 00:32:35,519
conditions for life and we're we're

853
00:32:39,990 --> 00:32:37,440
wondering amongst ourselves here what

854
00:32:42,710 --> 00:32:40,000
things should be on this astrobiology

855
00:32:44,950 --> 00:32:42,720
road what should nasa be funding where

856
00:32:46,950 --> 00:32:44,960
if they have a huge pot of money where

857
00:32:48,870 --> 00:32:46,960
should that money be focused

858
00:32:51,590 --> 00:32:48,880
and we're trying to

859
00:32:53,029 --> 00:32:51,600
ascertain from from the community

860
00:32:56,070 --> 00:32:53,039
what might be the best things to be

861
00:32:58,470 --> 00:32:56,080
having on that roadmap so

862
00:33:00,149 --> 00:32:58,480
these questions here are designed

863
00:33:01,110 --> 00:33:00,159

to prompt

864

00:33:04,789 --> 00:33:01,120

thoughts

865

00:33:05,830 --> 00:33:04,799

uh you can agree or disagree in any way

866

00:33:07,830 --> 00:33:05,840

you like

867

00:33:09,350 --> 00:33:07,840

but all your thoughts here will be much

868

00:33:12,549 --> 00:33:09,360

appreciated

869

00:33:14,950 --> 00:33:12,559

so um raise hands throw in your your

870

00:33:15,909 --> 00:33:14,960

thoughts um and we can sort of discuss

871

00:33:17,750 --> 00:33:15,919

those

872

00:33:19,430 --> 00:33:17,760

further

873

00:33:21,590 --> 00:33:19,440

i think that david has raised his hand

874

00:33:23,830 --> 00:33:21,600

oh sorry stein carry on

875

00:33:25,430 --> 00:33:23,840

the david has andre

876

00:33:27,830 --> 00:33:25,440

thank you very much indeed david i see

877

00:33:33,509 --> 00:33:30,310

okay uh two two comments about

878

00:33:35,430 --> 00:33:33,519

habitability one which we got into at

879

00:33:38,149 --> 00:33:35,440

the last time with this road map

880

00:33:40,789 --> 00:33:38,159

was you have a habitable planet that can

881

00:33:42,710 --> 00:33:40,799

support life as we know it and then you

882

00:33:45,590 --> 00:33:42,720

have the kind of planet that's habitable

883

00:33:47,909 --> 00:33:45,600

that could foster the origin of life and

884

00:33:49,190 --> 00:33:47,919

are those two necessarily the same in

885

00:33:51,590 --> 00:33:49,200

other words could you say that the

886

00:33:53,110 --> 00:33:51,600

habitability of our current planet would

887

00:33:55,190 --> 00:33:53,120

have been the type of

888

00:33:56,950 --> 00:33:55,200

environment where life could have begun

889

00:33:59,750 --> 00:33:56,960

and it's not clear to me at all that

890

00:34:01,669 --> 00:33:59,760

that's the same kind of environment so

891

00:34:04,389 --> 00:34:01,679

and especially if you believe in plants

892

00:34:06,310 --> 00:34:04,399

panspermia between planets in one system

893

00:34:07,909 --> 00:34:06,320

uh you know this is this becomes sort of

894

00:34:09,190 --> 00:34:07,919

an interesting question so that's one

895

00:34:11,829 --> 00:34:09,200

little distinction i thought you might

896

00:34:14,470 --> 00:34:11,839

want to consider in your deliberations

897

00:34:16,310 --> 00:34:14,480

um and the other thing which for mars is

898

00:34:17,990 --> 00:34:16,320

a big issue is how long did these

899

00:34:19,750 --> 00:34:18,000

conditions persist

900

00:34:21,829 --> 00:34:19,760

it's much easier to say that there was

901
00:34:24,230 --> 00:34:21,839
water at some time or that all the magic

902
00:34:25,829 --> 00:34:24,240
components that you need uh were present

903
00:34:28,389 --> 00:34:25,839
at a time but how long do they have to

904
00:34:30,389 --> 00:34:28,399
be present uh to really make it truly

905
00:34:33,190 --> 00:34:30,399
habitable and especially for life to

906
00:34:35,750 --> 00:34:33,200
begin so that's to me a key key question

907
00:34:37,669 --> 00:34:35,760
how can we quantify stability of the

908
00:34:39,990 --> 00:34:37,679
environment and persistence

909
00:34:41,669 --> 00:34:40,000
that's it

910
00:34:43,750 --> 00:34:41,679
thank you very much dude i think michael

911
00:34:45,829 --> 00:34:43,760
do you have a response to that i have a

912
00:34:47,990 --> 00:34:45,839
comment um we've been talking a little

913
00:34:49,030 --> 00:34:48,000

bit about habitability and origin of

914

00:34:51,510 --> 00:34:49,040

life

915

00:34:55,349 --> 00:34:51,520

and mars and i i think that's really

916

00:34:57,430 --> 00:34:55,359

gotten us off track pretty far away from

917

00:34:59,750 --> 00:34:57,440

what i wanted us or thought we would be

918

00:35:02,150 --> 00:34:59,760

talking about which are things like

919

00:35:04,550 --> 00:35:02,160

before you have a planet uh how do you

920

00:35:05,990 --> 00:35:04,560

make it how once you've got a planet or

921

00:35:08,470 --> 00:35:06,000

planetary system

922

00:35:10,710 --> 00:35:08,480

what makes planets habitable in that

923

00:35:14,150 --> 00:35:10,720

system so for example you know we have

924

00:35:16,230 --> 00:35:14,160

jupiter and jupiter does two things it

925

00:35:17,670 --> 00:35:16,240

deflects away some material from coming

926

00:35:19,270 --> 00:35:17,680

into the inner solar system but it also

927

00:35:22,230 --> 00:35:19,280

directs some material into the inner

928

00:35:24,710 --> 00:35:22,240

solar system and that that outer solar

929

00:35:27,109 --> 00:35:24,720

system structure of having a big giant

930

00:35:28,950 --> 00:35:27,119

jupiter sitting there may be important

931

00:35:32,790 --> 00:35:28,960

for the habitability of the inner

932

00:35:36,550 --> 00:35:34,310

i also thought we'd be talking more

933

00:35:38,150 --> 00:35:36,560

about how organic molecules get made

934

00:35:40,870 --> 00:35:38,160

where they get made now

935

00:35:43,349 --> 00:35:40,880

in space do they get made on dust grains

936

00:35:45,270 --> 00:35:43,359

do they get made in ices

937

00:35:47,190 --> 00:35:45,280

how do they get delivered to the earth

938

00:35:48,710 --> 00:35:47,200

too once they've been made

939

00:35:50,950 --> 00:35:48,720

so um

940

00:35:53,430 --> 00:35:50,960

those are the kind and that's built into

941

00:35:55,349 --> 00:35:53,440

these questions and i i think i would

942

00:35:56,630 --> 00:35:55,359

like to see more conversations

943

00:35:59,270 --> 00:35:56,640

particularly

944

00:36:01,750 --> 00:35:59,280

you know oral conversation you can hear

945

00:36:03,670 --> 00:36:01,760

not just typed in the chat window about

946

00:36:07,109 --> 00:36:03,680

these topics and less about mars and

947

00:36:08,710 --> 00:36:07,119

habitability we have an entire uh

948

00:36:11,430 --> 00:36:08,720

kickoff webinar

949

00:36:14,069 --> 00:36:11,440

last week on astrobiology for solar

950

00:36:16,950 --> 00:36:14,079

systems exploration that touched on

951

00:36:19,270 --> 00:36:16,960

those areas and and um i

952

00:36:21,510 --> 00:36:19,280

i think post questions comments on that

953

00:36:24,390 --> 00:36:21,520

should go to that area on the website

954

00:36:28,470 --> 00:36:24,400

astrobiologyfuture.org

955

00:36:35,190 --> 00:36:30,790

thank you michael and i see that uh

956

00:36:38,550 --> 00:36:36,710

yeah just to follow up on michael's

957

00:36:41,109 --> 00:36:38,560

point that uh one of the interesting

958

00:36:42,550 --> 00:36:41,119

questions i think within the plant

959

00:36:46,310 --> 00:36:42,560

formation

960

00:36:48,950 --> 00:36:46,320

topic is how do stellar mass and binary

961

00:36:49,910 --> 00:36:48,960

to influence the initial volatile and

962

00:36:51,670 --> 00:36:49,920

organic

963

00:36:52,790 --> 00:36:51,680

budget of plants that form in certain

964

00:36:54,710 --> 00:36:52,800

systems

965

00:36:56,710 --> 00:36:54,720

we know that ant wars and m dwarf

966

00:36:58,950 --> 00:36:56,720

planets can be very important targets in

967

00:37:00,950 --> 00:36:58,960

the near future nasa missions but it's

968

00:37:03,109 --> 00:37:00,960

really unclear how

969

00:37:06,230 --> 00:37:03,119

this chemistry and the planets

970

00:37:09,109 --> 00:37:06,240

volatile and organic inventory change

971

00:37:11,349 --> 00:37:09,119

with the stellar mass

972

00:37:12,790 --> 00:37:11,359

so i think that should be part of the

973

00:37:17,990 --> 00:37:12,800

road map and one of the questions we

974

00:37:22,150 --> 00:37:21,109

right so thank you daniel stein

975

00:37:25,190 --> 00:37:22,160

joan do you want to comment at this

976

00:37:30,470 --> 00:37:27,750

um yeah let me comment on this

977

00:37:33,030 --> 00:37:30,480

so so you make some good points i mean

978

00:37:34,630 --> 00:37:33,040

in terms of planet formation it's being

979

00:37:37,190 --> 00:37:34,640

appreciated more and more that there are

980

00:37:37,910 --> 00:37:37,200

a lot of steps to get to

981

00:37:42,870 --> 00:37:37,920

a

982

00:37:44,790 --> 00:37:42,880

some little dust screens you got to form

983

00:37:46,790 --> 00:37:44,800

your planetesimals

984

00:37:48,150 --> 00:37:46,800

you got to make those into bigger things

985

00:37:49,190 --> 00:37:48,160

that are maybe the size of the moon or

986

00:37:50,790 --> 00:37:49,200

mars

987

00:37:53,030 --> 00:37:50,800

those are still you know where they're

988

00:37:55,349 --> 00:37:53,040

still early on and there's a gas disk

989

00:37:57,510 --> 00:37:55,359

around they can migrate around due to

990

00:37:59,990 --> 00:37:57,520

the presence of the gas disk

991

00:38:01,990 --> 00:38:00,000

and the gas goes away

992

00:38:04,150 --> 00:38:02,000

uh and then you have this kind of final

993

00:38:05,990 --> 00:38:04,160

sweep up phase where you form uh you

994

00:38:08,390 --> 00:38:06,000

know kind of last formation phase where

995

00:38:10,390 --> 00:38:08,400

you have giant impacts and form planets

996

00:38:11,910 --> 00:38:10,400

that are really kind of we think look

997

00:38:12,790 --> 00:38:11,920

sort of like earth well at least in our

998

00:38:13,589 --> 00:38:12,800

case

999

00:38:15,589 --> 00:38:13,599

and

1000

00:38:17,510 --> 00:38:15,599

if you want to form a planet like earth

1001

00:38:19,430 --> 00:38:17,520

or a planet that could be habitable and

1002

00:38:21,670 --> 00:38:19,440

that's the end point

1003

00:38:24,069 --> 00:38:21,680

you know how many ways are there to make

1004

00:38:26,310 --> 00:38:24,079

it through the chain and end up there

1005

00:38:28,390 --> 00:38:26,320

and and that's kind of a broad view of

1006

00:38:30,710 --> 00:38:28,400

you know how planet formation connects

1007

00:38:33,109 --> 00:38:30,720

to astrobiology because we don't know if

1008

00:38:34,550 --> 00:38:33,119

you need to follow a very specific path

1009

00:38:36,230 --> 00:38:34,560

or whether you could almost follow

1010

00:38:37,910 --> 00:38:36,240

almost any path and still get you know

1011

00:38:39,510 --> 00:38:37,920

within this kind of window of a

1012

00:38:41,750 --> 00:38:39,520

habitable plan

1013

00:38:43,430 --> 00:38:41,760

and uh and there's all sorts of

1014

00:38:45,670 --> 00:38:43,440

parameters in there and daniel mentioned

1015

00:38:47,990 --> 00:38:45,680

many of them there like uh the the

1016

00:38:49,030 --> 00:38:48,000

properties of the of the protoplanetary

1017

00:38:51,510 --> 00:38:49,040

disk

1018

00:38:52,790 --> 00:38:51,520

the presence of binaries the composition

1019

00:38:54,870 --> 00:38:52,800

of the disk

1020

00:38:55,910 --> 00:38:54,880

uh how fast it evolves these kind of

1021

00:39:00,310 --> 00:38:55,920

questions

1022

00:39:01,670 --> 00:39:00,320

each one is being looked at individually

1023

00:39:04,470 --> 00:39:01,680

and some are not even being looked at

1024

00:39:07,190 --> 00:39:04,480

yet and connecting the dots between them

1025

00:39:09,510 --> 00:39:07,200

with a specific endpoint i think is is

1026
00:39:13,990 --> 00:39:09,520
you know kind of a an interesting way to

1027
00:39:16,790 --> 00:39:15,030
so to

1028
00:39:17,670 --> 00:39:16,800
continue that theme

1029
00:39:20,230 --> 00:39:17,680
um

1030
00:39:22,069 --> 00:39:20,240
there are two issues here one is knowing

1031
00:39:23,990 --> 00:39:22,079
the microphysics of each step and i

1032
00:39:25,990 --> 00:39:24,000
think we're a long way

1033
00:39:27,750 --> 00:39:26,000
along there and that we

1034
00:39:29,030 --> 00:39:27,760
think we understand a lot of the physics

1035
00:39:31,270 --> 00:39:29,040
involved although there may be a couple

1036
00:39:33,190 --> 00:39:31,280
places where a little

1037
00:39:35,430 --> 00:39:33,200
there's still some physical processes

1038
00:39:37,430 --> 00:39:35,440

where it's not clear which are dominant

1039

00:39:39,030 --> 00:39:37,440

and which are important and which are

1040

00:39:41,670 --> 00:39:39,040

uh irrelevant and can be left out of the

1041

00:39:42,470 --> 00:39:41,680

simulations but then even once we know

1042

00:39:44,230 --> 00:39:42,480

that

1043

00:39:46,630 --> 00:39:44,240

we're now talking about a very large

1044

00:39:48,470 --> 00:39:46,640

parameter space and we've kind of

1045

00:39:49,990 --> 00:39:48,480

sampled it sparsely

1046

00:39:51,990 --> 00:39:50,000

we initially were totally focused on

1047

00:39:53,910 --> 00:39:52,000

solar system like

1048

00:39:55,349 --> 00:39:53,920

systems because that's what we had and

1049

00:39:57,270 --> 00:39:55,359

then as we discovered different kinds of

1050

00:39:58,630 --> 00:39:57,280

systems we sort of tried a few things

1051
00:40:00,710 --> 00:39:58,640
here and there

1052
00:40:02,310 --> 00:40:00,720
and there's been some broad surveys

1053
00:40:03,750 --> 00:40:02,320
trying to do a sort of core sampling of

1054
00:40:05,349 --> 00:40:03,760
the parameter space

1055
00:40:06,790 --> 00:40:05,359
but we really haven't explored all these

1056
00:40:08,150 --> 00:40:06,800
different channels

1057
00:40:12,230 --> 00:40:08,160
and and that's

1058
00:40:15,430 --> 00:40:12,240
it's perfectly doable uh it requires

1059
00:40:16,950 --> 00:40:15,440
a fairly modest by by

1060
00:40:20,230 --> 00:40:16,960
modern research standards effort in

1061
00:40:21,750 --> 00:40:20,240
terms of and and i think computationally

1062
00:40:22,870 --> 00:40:21,760
it's we're at the point where it is

1063
00:40:25,670 --> 00:40:22,880

doable

1064

00:40:27,270 --> 00:40:25,680

um but there's not been a coherent

1065

00:40:29,270 --> 00:40:27,280

effort to do that

1066

00:40:30,470 --> 00:40:29,280

rather there have been

1067

00:40:31,829 --> 00:40:30,480

people here and they're doing it for a

1068

00:40:34,069 --> 00:40:31,839

bit and

1069

00:40:35,670 --> 00:40:34,079

making some progress and

1070

00:40:37,190 --> 00:40:35,680

it's just getting there

1071

00:40:38,870 --> 00:40:37,200

the

1072

00:40:40,950 --> 00:40:38,880

i mean a lot of different paths that

1073

00:40:43,510 --> 00:40:40,960

people have been working on this for

1074

00:40:47,030 --> 00:40:43,520

decades in some cases it's all coming

1075

00:40:48,470 --> 00:40:47,040

together very nicely but it's

1076

00:40:49,910 --> 00:40:48,480

even at the level of just looking at

1077

00:40:51,829 --> 00:40:49,920

something like the kepler sampler or the

1078

00:40:53,829 --> 00:40:51,839

rv sampler systems which is not complete

1079

00:40:56,069 --> 00:40:53,839

but they're about fire systems we have

1080

00:40:56,870 --> 00:40:56,079

not explored even what we already know

1081

00:40:58,390 --> 00:40:56,880

now

1082

00:41:00,150 --> 00:40:58,400

we have not fully

1083

00:41:02,390 --> 00:41:00,160

probed with implications of various

1084

00:41:03,270 --> 00:41:02,400

different configurations and

1085

00:41:07,589 --> 00:41:03,280

and

1086

00:41:09,670 --> 00:41:07,599

picked up

1087

00:41:11,750 --> 00:41:09,680

what that implies for for delivery of

1088

00:41:14,390 --> 00:41:11,760

organics or or the conditions on the

1089

00:41:16,069 --> 00:41:14,400

planet we haven't been

1090

00:41:17,829 --> 00:41:16,079

in the disorder system we haven't really

1091

00:41:20,550 --> 00:41:17,839

talked about atmospheres yet and what

1092

00:41:21,990 --> 00:41:20,560

they imply for habitability uh we don't

1093

00:41:23,910 --> 00:41:22,000

know yet what the full range of

1094

00:41:25,430 --> 00:41:23,920

planetary radii are that could sustain

1095

00:41:26,950 --> 00:41:25,440

habitability

1096

00:41:29,030 --> 00:41:26,960

um

1097

00:41:29,910 --> 00:41:29,040

so but a lot of these are doable and and

1098

00:41:31,829 --> 00:41:29,920

i think

1099

00:41:34,470 --> 00:41:31,839

we can do them uh what fraction of the

1100

00:41:39,750 --> 00:41:34,480

resources should be allocated to that is

1101

00:41:45,589 --> 00:41:40,630

david

1102

00:41:47,270 --> 00:41:45,599

building on what science has said

1103

00:41:48,950 --> 00:41:47,280

well yeah now that mike has slapped me

1104

00:41:51,190 --> 00:41:48,960

about the head and told me what this

1105

00:41:52,630 --> 00:41:51,200

telecon is really supposed to be about

1106

00:41:53,990 --> 00:41:52,640

let me make something which i think is

1107

00:41:56,230 --> 00:41:54,000

relevant

1108

00:41:57,670 --> 00:41:56,240

and that is that uh you know in terms of

1109

00:41:59,109 --> 00:41:57,680

volatiles being incorporated into

1110

00:42:00,630 --> 00:41:59,119

planetesimals i've gotten this

1111

00:42:02,390 --> 00:42:00,640

impression that you get up to a certain

1112

00:42:05,030 --> 00:42:02,400

size of planetesimal

1113

00:42:07,190 --> 00:42:05,040

and uh and that these things can really

1114

00:42:09,030 --> 00:42:07,200

vary in their volatile content and then

1115

00:42:11,270 --> 00:42:09,040

after that you get into this big cosmic

1116

00:42:12,950 --> 00:42:11,280

billiard game where these planets will

1117

00:42:14,790 --> 00:42:12,960

collide and that you notice need to go

1118

00:42:16,390 --> 00:42:14,800

through that phase really to get up to

1119

00:42:19,030 --> 00:42:16,400

an sized object

1120

00:42:21,510 --> 00:42:19,040

and given the tremendous variety of

1121

00:42:23,030 --> 00:42:21,520

volatile contents in these planetesimals

1122

00:42:25,670 --> 00:42:23,040

it really is a seems like it's a

1123

00:42:27,829 --> 00:42:25,680

stochastic process and so at some point

1124

00:42:29,589 --> 00:42:27,839

you just have to go and look and so i

1125

00:42:31,990 --> 00:42:29,599

think maybe one of the key things to

1126

00:42:33,349 --> 00:42:32,000

consider in this road map is what what

1127

00:42:35,349 --> 00:42:33,359

is that that we can actually do

1128

00:42:37,990 --> 00:42:35,359

experimentally or with models versus

1129

00:42:40,230 --> 00:42:38,000

what the advocacy we would make for for

1130

00:42:42,069 --> 00:42:40,240

astronomical observation missions to

1131

00:42:43,829 --> 00:42:42,079

look at these disks you know in other

1132

00:42:45,910 --> 00:42:43,839

words how how could this roadmap guide

1133

00:42:48,470 --> 00:42:45,920

the balance between astronomical

1134

00:42:50,630 --> 00:42:48,480

observational approaches versus the lab

1135

00:42:52,630 --> 00:42:50,640

or modeling on the other side given that

1136

00:42:54,550 --> 00:42:52,640

there's a stochastic element in there

1137

00:42:55,990 --> 00:42:54,560

and this stochastic aspect was one of

1138

00:42:57,990 --> 00:42:56,000

the major arguments for the kepler

1139

00:42:59,990 --> 00:42:58,000

mission that you know there's there's

1140

00:43:04,950 --> 00:43:00,000

this element in planet formation we just

1141

00:43:04,960 --> 00:43:10,390

that's it

1142

00:43:13,190 --> 00:43:11,430

so

1143

00:43:14,710 --> 00:43:13,200

could i comment on this

1144

00:43:16,150 --> 00:43:14,720

yes um

1145

00:43:17,990 --> 00:43:16,160

uh

1146

00:43:20,069 --> 00:43:18,000

this is it's a good point so so why not

1147

00:43:22,470 --> 00:43:20,079

just go look and see what uh

1148

00:43:24,870 --> 00:43:22,480

these planets are actually made of

1149

00:43:27,349 --> 00:43:24,880

the the trick is with kepler uh you know

1150

00:43:28,870 --> 00:43:27,359

you get a pretty good radius of a planet

1151

00:43:30,630 --> 00:43:28,880

and if you're lucky if you're really

1152

00:43:32,150 --> 00:43:30,640

really lucky then you can get some sort

1153

00:43:33,990 --> 00:43:32,160

of mass estimate

1154

00:43:36,870 --> 00:43:34,000

but there's no way you can

1155

00:43:39,349 --> 00:43:36,880

really constrain the bulk composition

1156

00:43:40,550 --> 00:43:39,359

at the moment to the degree that we need

1157

00:43:42,790 --> 00:43:40,560

to

1158

00:43:44,390 --> 00:43:42,800

or that we're talking about in terms of

1159

00:43:46,470 --> 00:43:44,400

these planet formation models for

1160

00:43:48,710 --> 00:43:46,480

example if you took the earth

1161

00:43:50,630 --> 00:43:48,720

you know the exact earth replica

1162

00:43:52,470 --> 00:43:50,640

and then you gave it either

1163

00:43:54,870 --> 00:43:52,480

zero water or a hundred times the

1164

00:43:57,349 --> 00:43:54,880

earth's current water content its radius

1165

00:43:59,430 --> 00:43:57,359

changes a very small amount

1166

00:44:00,470 --> 00:43:59,440

you know below less than kepler could

1167

00:44:02,470 --> 00:44:00,480

detect

1168

00:44:04,870 --> 00:44:02,480

and so

1169

00:44:06,950 --> 00:44:04,880

so kepler can't really feed back in

1170

00:44:08,390 --> 00:44:06,960

that directly unfortunately it would be

1171

00:44:09,750 --> 00:44:08,400

great if it could

1172

00:44:11,430 --> 00:44:09,760

uh and

1173

00:44:13,510 --> 00:44:11,440

though you know i think it will be able

1174

00:44:15,510 --> 00:44:13,520

to in certain situations

1175

00:44:17,670 --> 00:44:15,520

uh but

1176

00:44:20,150 --> 00:44:17,680

it doesn't give as many answers as we

1177

00:44:21,829 --> 00:44:20,160

would like right now

1178

00:44:23,349 --> 00:44:21,839

can i make a comment this is francis

1179

00:44:27,270 --> 00:44:23,359

mccoven

1180

00:44:31,270 --> 00:44:29,430

please do who's that speaking

1181

00:44:33,030 --> 00:44:31,280

uh francis mcombin

1182

00:44:35,190 --> 00:44:33,040

sorry i'm a bit late

1183

00:44:38,390 --> 00:44:35,200

ah francis hello

1184

00:44:40,150 --> 00:44:38,400

welcome um yes please please uh please

1185

00:44:42,230 --> 00:44:40,160

make a comment yeah

1186

00:44:43,750 --> 00:44:42,240

okay so um

1187

00:44:44,550 --> 00:44:43,760

one way that we might actually be able

1188

00:44:47,190 --> 00:44:44,560

to get

1189

00:44:48,630 --> 00:44:47,200

at the volatiles uh from a distance

1190

00:44:51,270 --> 00:44:48,640

is looking at the

1191

00:44:52,550 --> 00:44:51,280

walk planetary uncompressed density

1192

00:44:53,910 --> 00:44:52,560

um

1193

00:44:55,589 --> 00:44:53,920

because you know things like mercury

1194

00:44:56,630 --> 00:44:55,599

that have very high density high metal

1195

00:44:58,150 --> 00:44:56,640

content

1196

00:45:01,109 --> 00:44:58,160

even if they have a lot of hydrogen that

1197

00:45:02,470 --> 00:45:01,119

hydrogen wouldn't uh make water

1198

00:45:04,630 --> 00:45:02,480

so we're sort of narrowing in on a

1199

00:45:06,150 --> 00:45:04,640

certain core size that correlates with

1200

00:45:08,630 --> 00:45:06,160

oxygen fugacity

1201

00:45:10,230 --> 00:45:08,640

that allows for the stability of water

1202

00:45:12,150 --> 00:45:10,240

the at least the prediction of the

1203

00:45:15,030 --> 00:45:12,160

stability of water versus

1204

00:45:23,990 --> 00:45:15,040

something like h₂ that might not be as

1205

00:45:27,109 --> 00:45:25,750

so there may be creative ways about

1206

00:45:27,910 --> 00:45:27,119

going about

1207

00:45:29,030 --> 00:45:27,920

um

1208

00:45:35,910 --> 00:45:29,040

you know

1209

00:45:39,270 --> 00:45:37,349

thank you very much

1210

00:45:41,430 --> 00:45:39,280

francis how how much of the conversation

1211

00:45:43,670 --> 00:45:41,440

have you been able to hear so far

1212

00:45:45,589 --> 00:45:43,680

about the last 10 minutes

1213

00:45:46,390 --> 00:45:45,599

ah okay

1214

00:45:49,349 --> 00:45:46,400

um

1215

00:45:51,589 --> 00:45:49,359

uh i'm gonna i'm gonna turn to uh daniel

1216

00:45:52,309 --> 00:45:51,599

and david you have some comments to make

1217

00:45:54,309 --> 00:45:52,319

but

1218

00:45:56,150 --> 00:45:54,319

if you uh if you would like to have a

1219

00:45:59,109 --> 00:45:56,160

think about some of the questions that

1220

00:46:00,470 --> 00:45:59,119

we put on the uh on the um on the

1221

00:46:02,950 --> 00:46:00,480

opening slide

1222

00:46:04,710 --> 00:46:02,960

i'll turn to you in a few moments to

1223

00:46:07,030 --> 00:46:04,720

give us your thoughts on why these are

1224

00:46:09,510 --> 00:46:07,040

very important questions and why you

1225

00:46:11,270 --> 00:46:09,520

with stein and sean decided that nasa

1226
00:46:12,630 --> 00:46:11,280
should consider these these questions so

1227
00:46:13,829 --> 00:46:12,640
i'll come back to just a moment but let

1228
00:46:16,550 --> 00:46:13,839
me go first

1229
00:46:18,870 --> 00:46:16,560
daniel um who's got his hand up daniel

1230
00:46:21,670 --> 00:46:18,880
did you just want to build on that

1231
00:46:22,950 --> 00:46:21,680
thanks yeah i just wanted to

1232
00:46:25,670 --> 00:46:22,960
highlight some of the points that were

1233
00:46:27,510 --> 00:46:25,680
raised which like i agree i wanted to

1234
00:46:36,710 --> 00:46:27,520
add that not only we have samples from

1235
00:46:39,589 --> 00:46:38,390
so i'm just gonna mute that telecon real

1236
00:46:42,550 --> 00:46:39,599
quick it sounds like there's a fire

1237
00:46:44,309 --> 00:46:42,560
alarm in someone's building

1238
00:46:46,230 --> 00:46:44,319

that's a good point to bring up we'll

1239

00:46:48,470 --> 00:46:46,240

record this talk so you can

1240

00:46:50,550 --> 00:46:48,480

escape the fire and watch it later if

1241

00:46:52,790 --> 00:46:50,560

you need to

1242

00:46:53,589 --> 00:46:52,800

um i'll try to unmute it if it's beeping

1243

00:46:55,430 --> 00:46:53,599

i'll

1244

00:46:58,630 --> 00:46:55,440

mute it again and send it back to you

1245

00:47:02,870 --> 00:47:00,150

so if we've um

1246

00:47:04,230 --> 00:47:02,880

if we have do we still have daniel

1247

00:47:11,510 --> 00:47:04,240

yeah

1248

00:47:13,270 --> 00:47:11,520

becoming functional now we are seeing

1249

00:47:15,030 --> 00:47:13,280

exciting results and that gives us an

1250

00:47:17,510 --> 00:47:15,040

opportunity to study protoplanetary

1251

00:47:21,270 --> 00:47:17,520

disks banter systems in the making

1252

00:47:23,349 --> 00:47:21,280

and uh there was observations of um

1253

00:47:25,349 --> 00:47:23,359

planetary systems or

1254

00:47:27,510 --> 00:47:25,359

around white dwarfs which gives us

1255

00:47:29,990 --> 00:47:27,520

another interesting perspective into the

1256

00:47:32,550 --> 00:47:30,000

composition of planetary systems so i

1257

00:47:34,470 --> 00:47:32,560

think not only the exoplanets can be

1258

00:47:36,150 --> 00:47:34,480

directly studied but also forming

1259

00:47:37,190 --> 00:47:36,160

planetary systems

1260

00:47:39,430 --> 00:47:37,200

and

1261

00:47:43,670 --> 00:47:39,440

which i think is an important point

1262

00:47:44,710 --> 00:47:43,680

the other issues or opportunity here

1263

00:47:45,589 --> 00:47:44,720

um

1264

00:47:49,829 --> 00:47:45,599

is

1265

00:47:50,790 --> 00:47:49,839

think it's important to focus on trends

1266

00:47:52,790 --> 00:47:50,800

because

1267

00:47:55,190 --> 00:47:52,800

we do expect trends with for example

1268

00:47:56,390 --> 00:47:55,200

stellar mass uv radiation etc in the

1269

00:47:58,870 --> 00:47:56,400

chemistry

1270

00:48:01,589 --> 00:47:58,880

and even if we probably won't be able to

1271

00:48:03,670 --> 00:48:01,599

determine and predict compositions for

1272

00:48:05,910 --> 00:48:03,680

individual plants we should be able to

1273

00:48:07,670 --> 00:48:05,920

come up with a statistical description

1274

00:48:09,750 --> 00:48:07,680

for volatile budgets and that's

1275

00:48:11,910 --> 00:48:09,760

something that i think with the emerging

1276

00:48:13,270 --> 00:48:11,920

new data should be possible in the next

1277

00:48:15,030 --> 00:48:13,280

five to ten

1278

00:48:16,790 --> 00:48:15,040

years

1279

00:48:18,150 --> 00:48:16,800

thanks

1280

00:48:20,150 --> 00:48:18,160

thank you daniel

1281

00:48:21,750 --> 00:48:20,160

david you have you have your hand raised

1282

00:48:23,670 --> 00:48:21,760

as well

1283

00:48:25,270 --> 00:48:23,680

just a quick comment in response to what

1284

00:48:27,349 --> 00:48:25,280

sean had mentioned and that is i wasn't

1285

00:48:29,510 --> 00:48:27,359

so much focusing on what we should do

1286

00:48:31,349 --> 00:48:29,520

with the kepler data but what this group

1287

00:48:33,109 --> 00:48:31,359

could do to advocate for a future

1288

00:48:34,710 --> 00:48:33,119

mission and i think that the comments

1289

00:48:36,470 --> 00:48:34,720

you just heard before mine that got at

1290

00:48:38,390 --> 00:48:36,480

that is you know what can we do to

1291

00:48:40,470 --> 00:48:38,400

influence the next kind of mission that

1292

00:48:41,990 --> 00:48:40,480

would get into the types of observations

1293

00:48:45,910 --> 00:48:42,000

of early disks that would be most

1294

00:48:50,790 --> 00:48:46,829

thank

1295

00:48:53,670 --> 00:48:50,800

you can i can i um come back to francis

1296

00:48:56,150 --> 00:48:53,680

then please francis um thank you for

1297

00:48:58,870 --> 00:48:56,160

joining us uh as well

1298

00:49:00,630 --> 00:48:58,880

still in the airport somewhere um

1299

00:49:02,630 --> 00:49:00,640

we started the conversation going

1300

00:49:05,750 --> 00:49:02,640

through these opening panel questions

1301
00:49:07,670 --> 00:49:05,760
and stein and sean and the participants

1302
00:49:10,549 --> 00:49:07,680
were exploring as to why these are

1303
00:49:12,309 --> 00:49:10,559
important questions for nasa to explore

1304
00:49:14,950 --> 00:49:12,319
i understand you're you're very much

1305
00:49:16,630 --> 00:49:14,960
into the organic side of things we'd be

1306
00:49:18,630 --> 00:49:16,640
very interested to hear your comments on

1307
00:49:19,510 --> 00:49:18,640
why these are important questions in the

1308
00:49:21,750 --> 00:49:19,520
last

1309
00:49:24,549 --> 00:49:21,760
five minutes or so

1310
00:49:28,470 --> 00:49:26,069
so i guess i'll start with the first

1311
00:49:30,069 --> 00:49:28,480
question what factors determine the

1312
00:49:31,430 --> 00:49:30,079
amount of water delivered to planets in

1313
00:49:33,430 --> 00:49:31,440

the stars habitable zone and the

1314

00:49:35,750 --> 00:49:33,440

availability of that water

1315

00:49:37,829 --> 00:49:35,760

for participation in chemical reactions

1316

00:49:40,069 --> 00:49:37,839

um

1317

00:49:42,950 --> 00:49:40,079

so there's abundant hydrogen

1318

00:49:45,430 --> 00:49:42,960

in uh most planetary systems the most

1319

00:49:46,630 --> 00:49:45,440

fun element in all stars really

1320

00:49:48,630 --> 00:49:46,640

um

1321

00:49:50,230 --> 00:49:48,640

but hydrogen alone isn't what we need

1322

00:49:55,109 --> 00:49:50,240

for for life in a lot of organic

1323

00:49:57,670 --> 00:49:55,990

so

1324

00:49:59,829 --> 00:49:57,680

understanding

1325

00:50:01,589 --> 00:49:59,839

the availability of that water and how

1326

00:50:03,589 --> 00:50:01,599

it's able to participate

1327

00:50:04,790 --> 00:50:03,599

uh to make organic molecules is

1328

00:50:06,069 --> 00:50:04,800

fundamentally important for

1329

00:50:07,589 --> 00:50:06,079

understanding

1330

00:50:08,870 --> 00:50:07,599

the origin of life

1331

00:50:12,150 --> 00:50:08,880

um

1332

00:50:13,670 --> 00:50:12,160

you know for example the moon uh

1333

00:50:15,750 --> 00:50:13,680

is now known to have

1334

00:50:17,190 --> 00:50:15,760

a lot more water or hydrogen than we

1335

00:50:19,510 --> 00:50:17,200

previously thought

1336

00:50:21,910 --> 00:50:19,520

but it doesn't necessarily make

1337

00:50:25,349 --> 00:50:21,920

it a higher target for

1338

00:50:39,109 --> 00:50:27,190

so

1339

00:50:42,230 --> 00:50:40,230

you

1340

00:50:43,670 --> 00:50:42,240

yeah

1341

00:50:44,870 --> 00:50:43,680

um what

1342

00:50:48,950 --> 00:50:44,880

tell me more about your what your

1343

00:50:51,510 --> 00:50:48,960

thoughts are on the organic molecules

1344

00:50:53,109 --> 00:50:51,520

well it seems that we you know obvious

1345

00:50:54,470 --> 00:50:53,119

what we observe we find organic

1346

00:50:55,510 --> 00:50:54,480

molecules in

1347

00:50:57,349 --> 00:50:55,520

a lot of

1348

00:50:59,990 --> 00:50:57,359

carbonaceous chondrites we're finding

1349

00:51:01,990 --> 00:51:00,000

organic molecules within

1350

00:51:04,870 --> 00:51:02,000

igneous minerals that seem to form

1351
00:51:06,710 --> 00:51:04,880
during the cooling of magmatic

1352
00:51:10,630 --> 00:51:06,720
magmatic systems on places like the

1353
00:51:16,470 --> 00:51:12,710
so it seems like planets

1354
00:51:17,829 --> 00:51:16,480
uh and and early on in the solar system

1355
00:51:19,910 --> 00:51:17,839
we were able to make a lot of these

1356
00:51:23,349 --> 00:51:19,920
organic molecules but

1357
00:51:24,309 --> 00:51:23,359
most of them are fairly simple

1358
00:51:27,430 --> 00:51:24,319
um

1359
00:51:29,109 --> 00:51:27,440
and uh and they're typically around in

1360
00:51:30,630 --> 00:51:29,119
in minor concentrations i mean

1361
00:51:32,630 --> 00:51:30,640
carbonation chondrites are much higher

1362
00:51:34,309 --> 00:51:32,640
but when we find them in the context of

1363
00:51:36,390 --> 00:51:34,319

planetary bodies

1364

00:51:39,109 --> 00:51:36,400

uh their concentrations seem to be very

1365

00:51:41,510 --> 00:51:39,119

low uh however to get

1366

00:51:42,390 --> 00:51:41,520

you know what geologic processes you

1367

00:51:43,990 --> 00:51:42,400

know we need to understand the

1368

00:51:45,510 --> 00:51:44,000

geological processes they can bring

1369

00:51:47,990 --> 00:51:45,520

these molecules together and help them

1370

00:51:49,430 --> 00:51:48,000

become more complex complex

1371

00:51:51,829 --> 00:51:49,440

so that we can move towards

1372

00:51:53,829 --> 00:51:51,839

understanding you know how and where to

1373

00:51:57,990 --> 00:51:53,839

look for the origins of life

1374

00:52:02,390 --> 00:52:00,790

and i apologize from uh sounding a bit

1375

00:52:06,390 --> 00:52:02,400

out of it i just got off of the

1376

00:52:10,950 --> 00:52:07,990

well thank you for uh thank you for

1377

00:52:12,870 --> 00:52:10,960

joining us um we we are very interested

1378

00:52:15,030 --> 00:52:12,880

in your comments on this so if you if

1379

00:52:18,069 --> 00:52:15,040

you don't mind bearing with us we will

1380

00:52:19,430 --> 00:52:18,079

do i'll also invite attendees and the

1381

00:52:20,950 --> 00:52:19,440

rest of the panel to join in the

1382

00:52:22,790 --> 00:52:20,960

conversation if people want to raise

1383

00:52:23,990 --> 00:52:22,800

their hands they can comment against

1384

00:52:26,630 --> 00:52:24,000

what you're saying

1385

00:52:29,430 --> 00:52:26,640

as i just like to mention to the uh to

1386

00:52:31,190 --> 00:52:29,440

the audience to the attendees uh we're

1387

00:52:33,829 --> 00:52:31,200

coming just up towards the end of this

1388

00:52:35,670 --> 00:52:33,839

conference but as francis has joined us

1389

00:52:37,109 --> 00:52:35,680

in the last few moments and he's put a

1390

00:52:39,190 --> 00:52:37,119

lot of effort into that

1391

00:52:40,630 --> 00:52:39,200

it would be uh i'd be grateful if we

1392

00:52:42,470 --> 00:52:40,640

could just carry on for just a few more

1393

00:52:43,990 --> 00:52:42,480

minutes just just make sure that we've

1394

00:52:45,910 --> 00:52:44,000

covered everything that francis can

1395

00:52:47,430 --> 00:52:45,920

contribute uh

1396

00:52:50,069 --> 00:52:47,440

considering his

1397

00:52:52,309 --> 00:52:50,079

tiredness as well um if people need to

1398

00:52:54,390 --> 00:52:52,319

drop out then please do

1399

00:52:56,630 --> 00:52:54,400

just to make it very clear the

1400

00:52:59,589 --> 00:52:56,640

conversations that we are having here

1401
00:53:00,790 --> 00:52:59,599
will be uh transcribed and put up onto

1402
00:53:02,950 --> 00:53:00,800
the website

1403
00:53:04,710 --> 00:53:02,960
uh in the next few hours so the

1404
00:53:06,790 --> 00:53:04,720
conversation can continue and we

1405
00:53:09,589 --> 00:53:06,800
encourage everybody to come along to the

1406
00:53:11,990 --> 00:53:09,599
website joining the conversations

1407
00:53:14,470 --> 00:53:12,000
and help us build this

1408
00:53:15,910 --> 00:53:14,480
this road map that uh nasa are trying to

1409
00:53:18,630 --> 00:53:15,920
put together with the help of the

1410
00:53:20,230 --> 00:53:18,640
community so please stay engaged

1411
00:53:21,829 --> 00:53:20,240
now having said that i'd like to just

1412
00:53:23,829 --> 00:53:21,839
carry on just for a few more minutes if

1413
00:53:25,670 --> 00:53:23,839

you can bear with us for us to just give

1414

00:53:27,190 --> 00:53:25,680

us a little bit more of your insight and

1415

00:53:28,950 --> 00:53:27,200

i invite other people to join in the

1416

00:53:31,990 --> 00:53:28,960

conversation with you as well one of the

1417

00:53:34,309 --> 00:53:32,000

questions we didn't cover um francis was

1418

00:53:35,829 --> 00:53:34,319

the um the question right

1419

00:53:38,230 --> 00:53:35,839

is life a chemical consequence of

1420

00:53:40,710 --> 00:53:38,240

thermodynamics or did it emerge in spite

1421

00:53:42,150 --> 00:53:40,720

in spite of thermodynamics again why is

1422

00:53:44,069 --> 00:53:42,160

that an important question for nasa to

1423

00:53:45,750 --> 00:53:44,079

consider

1424

00:53:48,710 --> 00:53:45,760

um i think

1425

00:53:50,790 --> 00:53:48,720

that that question kind of ties into the

1426
00:53:52,870 --> 00:53:50,800
you know whether whether life emerges

1427
00:53:54,309 --> 00:53:52,880
from sarcastic processes or whether it's

1428
00:53:56,390 --> 00:53:54,319
an eventuality

1429
00:53:58,790 --> 00:53:56,400
so a planetary body

1430
00:54:00,470 --> 00:53:58,800
uh largely is going to evolve it's a

1431
00:54:03,109 --> 00:54:00,480
very dynamic process but it's going to

1432
00:54:04,870 --> 00:54:03,119
evolve based on thermodynamic principles

1433
00:54:06,470 --> 00:54:04,880
um but every now and then you get these

1434
00:54:08,390 --> 00:54:06,480
stochastic processes things like the

1435
00:54:09,990 --> 00:54:08,400
weight heavy bombardment or things that

1436
00:54:11,990 --> 00:54:10,000
really add a lot of flux to the system

1437
00:54:13,190 --> 00:54:12,000
that that throw it out of equilibrium or

1438
00:54:14,950 --> 00:54:13,200

at least the equilibrium that it was

1439

00:54:17,589 --> 00:54:14,960

heading towards

1440

00:54:19,030 --> 00:54:17,599

and um you know life in general is sort

1441

00:54:21,109 --> 00:54:19,040

of a mix of equilibrium and

1442

00:54:22,230 --> 00:54:21,119

disequilibrium processes

1443

00:54:24,230 --> 00:54:22,240

uh

1444

00:54:25,829 --> 00:54:24,240

and so if if life is a chemical

1445

00:54:28,230 --> 00:54:25,839

consequence of thermodynamics then

1446

00:54:30,390 --> 00:54:28,240

perhaps we should expect to find it uh

1447

00:54:32,470 --> 00:54:30,400

everywhere if it emerges in spite of it

1448

00:54:35,190 --> 00:54:32,480

it may lead more towards you know

1449

00:54:37,270 --> 00:54:35,200

stochastic processes sort of inducing it

1450

00:54:38,870 --> 00:54:37,280

uh because of being drastically out of

1451

00:54:44,710 --> 00:54:38,880

an equilibrium that we were heading

1452

00:54:48,790 --> 00:54:46,630

what is the experiment what is the

1453

00:55:02,069 --> 00:54:48,800

research that needs to be done to answer

1454

00:55:07,510 --> 00:55:04,829

i guess if we could

1455

00:55:09,190 --> 00:55:07,520

produce an experimental laugh that turns

1456

00:55:10,950 --> 00:55:09,200

non-living material into living material

1457

00:55:11,750 --> 00:55:10,960

that would really be it but

1458

00:55:14,549 --> 00:55:11,760

um

1459

00:55:16,309 --> 00:55:14,559

we haven't been able to do that yet

1460

00:55:18,150 --> 00:55:16,319

uh but perhaps we

1461

00:55:19,829 --> 00:55:18,160

you know shouldn't should invest more in

1462

00:55:20,710 --> 00:55:19,839

actually trying to do that and think

1463

00:55:22,230 --> 00:55:20,720

through

1464

00:55:23,750 --> 00:55:22,240

the chemical reactions that would

1465

00:55:26,710 --> 00:55:23,760

actually lead to

1466

00:55:30,390 --> 00:55:28,470

if it is a therm if it is a consequence

1467

00:55:31,790 --> 00:55:30,400

of thermodynamics then we should be able

1468

00:55:35,670 --> 00:55:31,800

to reproduce it in the

1469

00:55:38,470 --> 00:55:35,680

laboratory um given the right chemical

1470

00:55:43,750 --> 00:55:41,589

david i see you have your hand raised

1471

00:55:45,910 --> 00:55:43,760

i'll try to keep it concise i i think

1472

00:55:47,990 --> 00:55:45,920

the thermodynamics plays a role because

1473

00:55:49,109 --> 00:55:48,000

the approach to thermodynamics releases

1474

00:55:50,870 --> 00:55:49,119

energy

1475

00:55:53,190 --> 00:55:50,880

gets it back to that earlier discussion

1476
00:55:54,789 --> 00:55:53,200
we had about coupling energy to these

1477
00:55:56,150 --> 00:55:54,799
processes that we think are essential

1478
00:55:58,069 --> 00:55:56,160
for life so

1479
00:56:00,069 --> 00:55:58,079
yeah it's kinetic and it's that approach

1480
00:56:02,470 --> 00:56:00,079
to thermodynamics that

1481
00:56:03,910 --> 00:56:02,480
is the landscape and so

1482
00:56:05,589 --> 00:56:03,920
experiments that incorporate that i

1483
00:56:08,710 --> 00:56:05,599
think are relevant

1484
00:56:13,430 --> 00:56:10,950
yeah

1485
00:56:15,750 --> 00:56:13,440
stein shawn do you have something to add

1486
00:56:18,789 --> 00:56:15,760
to the thermodynamics

1487
00:56:25,030 --> 00:56:21,349
i think we need to know this answer

1488
00:56:26,390 --> 00:56:25,040

um i i can see arguing either way sorry

1489

00:56:27,589 --> 00:56:26,400

sean you go ahead i see your fingers in

1490

00:56:29,510 --> 00:56:27,599

the button

1491

00:56:31,349 --> 00:56:29,520

no no i i was gonna say i think it's an

1492

00:56:33,270 --> 00:56:31,359

interesting question that that should be

1493

00:56:37,910 --> 00:56:33,280

addressed but i don't have the answer as

1494

00:56:44,630 --> 00:56:39,670

it gets back to one of these very basic

1495

00:56:50,630 --> 00:56:46,789

okay well maybe the right question but

1496

00:56:55,270 --> 00:56:52,230

thanks

1497

00:56:58,150 --> 00:56:55,280

uh unless there are any other questions

1498

00:57:00,390 --> 00:56:58,160

from uh attendees again ask you to raise

1499

00:57:04,150 --> 00:57:00,400

your hand if you'd like to say something

1500

00:57:07,190 --> 00:57:04,160

um i think it sounds like that frost

1501
00:57:09,190 --> 00:57:07,200
worn out and uh it's uh it's probably

1502
00:57:10,390 --> 00:57:09,200
time for us to start to wrap this up

1503
00:57:12,150 --> 00:57:10,400
just while people are thinking about

1504
00:57:14,390 --> 00:57:12,160
whether they want to raise their hand

1505
00:57:16,630 --> 00:57:14,400
just to close up again to remind you the

1506
00:57:18,390 --> 00:57:16,640
conversation will continue on the

1507
00:57:20,470 --> 00:57:18,400
website

1508
00:57:22,470 --> 00:57:20,480
we encourage you to come there and join

1509
00:57:23,990 --> 00:57:22,480
in there'll also be a

1510
00:57:25,750 --> 00:57:24,000
a youtube

1511
00:57:29,430 --> 00:57:25,760
video of this conversation so you can

1512
00:57:32,069 --> 00:57:29,440
see it in its entirety uh and also the

1513
00:57:33,589 --> 00:57:32,079

other uh themes uh and discussions that

1514

00:57:35,589 --> 00:57:33,599

have happened over the last couple of

1515

00:57:37,829 --> 00:57:35,599

weeks they are awesome again we

1516

00:57:39,030 --> 00:57:37,839

encourage you to step into those other

1517

00:57:42,470 --> 00:57:39,040

themes as well because there's quite a

1518

00:57:46,630 --> 00:57:42,480

lot of cross conversation cross cross

1519

00:57:48,789 --> 00:57:46,640

theme uh uh topics and questions so um

1520

00:57:51,750 --> 00:57:48,799

so please join in

1521

00:57:54,470 --> 00:57:51,760

i don't see any more hands writing uh

1522

00:57:57,270 --> 00:57:54,480

stein sean did you need to wind up with

1523

00:57:57,280 --> 00:58:01,990

all done

1524

00:58:06,549 --> 00:58:04,630

in which case i will say thank you very

1525

00:58:07,670 --> 00:58:06,559

much to everybody for attending

1526

00:58:09,829 --> 00:58:07,680

thank you very much to the panel thank

1527

00:58:11,430 --> 00:58:09,839

you to francis for popping you

1528

00:58:13,510 --> 00:58:11,440

towards the end and giving you your your

1529

00:58:15,430 --> 00:58:13,520

points on it uh much appreciated uh

1530

00:58:17,190 --> 00:58:15,440

we'll finish it and