



AbGradCon 2018

1  
00:00:00,260 --> 00:00:11,350

[Music]

2  
00:00:16,700 --> 00:00:14,570

so I was asked to give the geology and

3  
00:00:18,680 --> 00:00:16,710

chemistry warm up talk and I would like

4  
00:00:20,200 --> 00:00:18,690

to just apologize to all the geologists

5  
00:00:22,370 --> 00:00:20,210

in the room to begin with I'm a chemist

6  
00:00:23,780 --> 00:00:22,380

but we'll get through it and you can

7  
00:00:27,050 --> 00:00:23,790

tell me what I got wrong at the coffee

8  
00:00:28,670 --> 00:00:27,060

break and so I'm fairly simple and so

9  
00:00:33,709 --> 00:00:28,680

when I think geology and chemistry

10  
00:00:36,100 --> 00:00:33,719

I think rocks and goo and so will will

11  
00:00:39,890 --> 00:00:36,110

sort of see if that's that's the right

12  
00:00:42,170 --> 00:00:39,900

depiction or not and of course it's not

13  
00:00:44,569 --> 00:00:42,180

so when I actually think about geology

14

00:00:46,670 --> 00:00:44,579

and chemistry I think of them as setting

15

00:00:48,380 --> 00:00:46,680

the boundary conditions for life so

16

00:00:50,990 --> 00:00:48,390

they're providing the environments and

17

00:00:53,690 --> 00:00:51,000

the possibilities of how things could be

18

00:00:56,479 --> 00:00:53,700

habitable and what is possible in sort

19

00:00:59,450 --> 00:00:56,489

of the parameter space of life and

20

00:01:01,190 --> 00:00:59,460

habitability and I think there are sort

21

00:01:04,189 --> 00:01:01,200

of multiple boundary conditions we can

22

00:01:05,209 --> 00:01:04,199

think about in terms of how to go with

23

00:01:07,370 --> 00:01:05,219

this and I think there's there's

24

00:01:09,770 --> 00:01:07,380

historical there's what was present on

25

00:01:12,080 --> 00:01:09,780

an early Earth there's environmental

26

00:01:15,649 --> 00:01:12,090

what is present now on a different

27

00:01:17,990 --> 00:01:15,659

planet or what is present now in the

28

00:01:19,969 --> 00:01:18,000

earth and then there's also sort of more

29

00:01:22,039 --> 00:01:19,979

fundamental physical boundary conditions

30

00:01:25,130 --> 00:01:22,049

in terms of thermodynamics and kinetics

31

00:01:28,039 --> 00:01:25,140

what chemistry can occur and how can it

32

00:01:29,420 --> 00:01:28,049

occur and so from that I think I mean

33

00:01:30,710 --> 00:01:29,430

it's sort of your classic bottom-up

34

00:01:33,859 --> 00:01:30,720

approach in terms of thinking about

35

00:01:35,690 --> 00:01:33,869

habitability in life but I think it's a

36

00:01:39,649 --> 00:01:35,700

really powerful tool for getting us

37

00:01:43,600 --> 00:01:39,659

towards understanding the actual sort of

38

00:01:47,960 --> 00:01:43,610

physical constraints on on life as well

39

00:01:50,090 --> 00:01:47,970

and so just to orient everyone to this

40

00:01:51,649 --> 00:01:50,100

timeline I really like this depiction of

41

00:01:53,570 --> 00:01:51,659

sort of the earth timeline I'm borrowing

42

00:01:56,179 --> 00:01:53,580

these slides adapted from Steven

43

00:02:00,819 --> 00:01:56,189

Freeland you think if you haven't met

44

00:02:03,170 --> 00:02:00,829

him but there's sort of four major

45

00:02:07,280 --> 00:02:03,180

geologic eras

46

00:02:09,859 --> 00:02:07,290

there's the phanerozoic the Proterozoic

47

00:02:11,750 --> 00:02:09,869

the Archaean and the Hadean and we're

48

00:02:15,020 --> 00:02:11,760

just gonna walk our way backwards from

49

00:02:18,080 --> 00:02:15,030

there so I think of the phanerozoic is

50

00:02:19,759 --> 00:02:18,090

sort of the normal geology part of the

51

00:02:22,309 --> 00:02:19,769

timeline of Earth

52

00:02:23,929 --> 00:02:22,319

and so up here really early we have the

53

00:02:26,089 --> 00:02:23,939

extinction of the dinosaurs and the

54

00:02:27,830 --> 00:02:26,099

Cambrian explosion and we're gonna be

55

00:02:31,699 --> 00:02:27,840

hearing from Amanda about sort of

56

00:02:35,360 --> 00:02:31,709

neoproterozoic geology earth yeah

57

00:02:38,500 --> 00:02:35,370

geology today and then around here we

58

00:02:41,869 --> 00:02:38,510

had our earliest multicellular fossil

59

00:02:43,670 --> 00:02:41,879

and then working our way backwards we

60

00:02:48,490 --> 00:02:43,680

have the great oxidation event at about

61

00:02:51,979 --> 00:02:48,500

two and a half million years ago and

62

00:02:56,300 --> 00:02:51,989

working from there Chloe is going to be

63

00:02:59,089 --> 00:02:56,310

telling us about possible chemistry that

64

00:03:01,640 --> 00:02:59,099

occurred from following the great

65

00:03:04,789 --> 00:03:01,650

oxidation event and then working our way

66

00:03:06,710 --> 00:03:04,799

even farther backwards we are sort of

67

00:03:08,420 --> 00:03:06,720

oldest micro fossils and our oldest

68

00:03:10,640 --> 00:03:08,430

evidence for direct evidence for life

69

00:03:13,339 --> 00:03:10,650

art about three and a half billion years

70

00:03:15,920 --> 00:03:13,349

ago and our indirect evidence for life

71

00:03:17,990 --> 00:03:15,930

is you know somewhere between 3.8 and

72

00:03:19,909 --> 00:03:18,000

four billion years ago depending on who

73

00:03:22,879 --> 00:03:19,919

you believe in which which controversies

74

00:03:24,469 --> 00:03:22,889

you like to pick and this is also around

75

00:03:26,509 --> 00:03:24,479

the period of the late heavy bombardment

76

00:03:30,319 --> 00:03:26,519

if you like the idea of a late heavy

77

00:03:33,800 --> 00:03:30,329

bombardment and really the period we're

78

00:03:36,080 --> 00:03:33,810

gonna be talking about most for the

79

00:03:38,960 --> 00:03:36,090

talks in the afternoon suffer in the

80

00:03:40,520 --> 00:03:38,970

post coffee break session are gonna be

81

00:03:42,500 --> 00:03:40,530

our prebiotic chemistry talks and

82

00:03:45,680 --> 00:03:42,510

they're really quite far down on this

83

00:03:48,110 --> 00:03:45,690

timeline towards the formation of the

84

00:03:49,849 --> 00:03:48,120

earth and one of the interesting things

85

00:03:51,199 --> 00:03:49,859

when we're thinking about prebiotic

86

00:03:52,670 --> 00:03:51,209

chemistry in particular and the

87

00:03:55,369 --> 00:03:52,680

conditions and the boundary conditions

88

00:03:58,280 --> 00:03:55,379

for that is that to a large part we no

89

00:04:00,050 --> 00:03:58,290

longer have a rock record back that far

90

00:04:02,119 --> 00:04:00,060

because of plate tectonics and because

91

00:04:03,649 --> 00:04:02,129

of the recycling of material and so

92

00:04:07,219 --> 00:04:03,659

other than a few sort of detrit

93

00:04:08,929 --> 00:04:07,229

detrital zircons here and there there

94

00:04:12,110 --> 00:04:08,939

really are sort of limits on the

95

00:04:14,539 --> 00:04:12,120

constraints we have from geology and so

96

00:04:16,129 --> 00:04:14,549

that's really where the realm of the the

97

00:04:17,180 --> 00:04:16,139

chemist comes in and they get to sort of

98

00:04:19,819 --> 00:04:17,190

play around with it I whatever

99

00:04:24,360 --> 00:04:19,829

conditions they want because we're not

100

00:04:26,350 --> 00:04:24,370

super constrained by actual geology

101  
00:04:29,659 --> 00:04:26,360

[Laughter]

102  
00:04:32,120 --> 00:04:29,669  
maybe not but you know and of course we

103  
00:04:32,750 --> 00:04:32,130  
can we can also look at this with Mars

104  
00:04:35,530 --> 00:04:32,760  
as

105  
00:04:39,920 --> 00:04:35,540  
well and so they're also four main

106  
00:04:42,530 --> 00:04:39,930  
timeline sort of urates all right I

107  
00:04:46,040 --> 00:04:42,540  
don't know anyway four main distinctions

108  
00:04:47,690 --> 00:04:46,050  
here where we have the pre na Qian the

109  
00:04:51,440 --> 00:04:47,700  
no hockey and the Hesperian and the

110  
00:04:53,270 --> 00:04:51,450  
Amazonian my understanding is the sort

111  
00:04:54,710 --> 00:04:53,280  
of border between these two is somewhat

112  
00:04:57,290 --> 00:04:54,720  
controversial as well and where that

113  
00:04:59,540 --> 00:04:57,300

time should go I'm not entirely sure but

114

00:05:02,180 --> 00:04:59,550

this is sort of the area where we think

115

00:05:03,830 --> 00:05:02,190

that Mars would have had some water and

116

00:05:07,490 --> 00:05:03,840

maybe been more habitable and then this

117

00:05:09,920 --> 00:05:07,500

is the dry cold Mars of today and so

118

00:05:14,630 --> 00:05:09,930

we'll be hearing from Jonathan about

119

00:05:17,600 --> 00:05:14,640

some sort of potential stability of bio

120

00:05:21,850 --> 00:05:17,610

signatures in the border between the

121

00:05:24,260 --> 00:05:21,860

Lockean and the Hesperian time line and

122

00:05:26,750 --> 00:05:24,270

so when we're thinking about

123

00:05:27,950 --> 00:05:26,760

constraining the conditions we're

124

00:05:30,950 --> 00:05:27,960

thinking about what might have been

125

00:05:32,630 --> 00:05:30,960

present in oceans the salinity the ions

126

00:05:34,010 --> 00:05:32,640

we're also thinking about what was in

127

00:05:36,410 --> 00:05:34,020

the atmosphere what gases were available

128

00:05:38,300 --> 00:05:36,420

also where their aerosols or Hayes's or

129

00:05:41,510 --> 00:05:38,310

things like that what chemistry can that

130

00:05:43,310 --> 00:05:41,520

provide and also lambs like how much

131

00:05:45,440 --> 00:05:43,320

land was around and what were the

132

00:05:49,550 --> 00:05:45,450

minerals and rocks there as well and

133

00:05:51,170 --> 00:05:49,560

actually we have most of our geology

134

00:05:54,140 --> 00:05:51,180

talks today are actually more focused on

135

00:05:58,610 --> 00:05:54,150

sort of atmospheric tracers and looking

136

00:06:00,650 --> 00:05:58,620

at atmospheric tracers in the yeah and

137

00:06:04,610 --> 00:06:00,660

of course we have interactions between

138

00:06:06,380 --> 00:06:04,620

all of these as well and so we're gonna

139

00:06:08,450 --> 00:06:06,390

be hearing from a different from a few

140

00:06:10,130 --> 00:06:08,460

different sort of techniques as to how

141

00:06:12,230 --> 00:06:10,140

we we can think about it so there are

142

00:06:14,480 --> 00:06:12,240

geologic proxies using elements to sort

143

00:06:15,350 --> 00:06:14,490

of tell us about oxygen I'm in in this

144

00:06:18,020 --> 00:06:15,360

case we're gonna be looking at

145

00:06:20,120 --> 00:06:18,030

fluorescence with Amanda we're gonna be

146

00:06:21,920 --> 00:06:20,130

looking at some some analog sites and

147

00:06:23,480 --> 00:06:21,930

isotope fractionation again and so

148

00:06:25,160 --> 00:06:23,490

because we've heard a lot about isotope

149

00:06:28,280 --> 00:06:25,170

fractionation I'm not gonna go into that

150

00:06:30,350 --> 00:06:28,290

and then also sort of more more truly

151

00:06:34,670 --> 00:06:30,360

chemical ways of modeling reactivity

152

00:06:36,590 --> 00:06:34,680

what are the sources and sinks of  $m_0$  and

153

00:06:38,570 --> 00:06:36,600

as I said on the early Earth partly

154

00:06:39,680 --> 00:06:38,580

because we don't have a great rock

155

00:06:41,960 --> 00:06:39,690

record there's sort of a lack of

156

00:06:43,460 --> 00:06:41,970

constraints as well for a sort of when

157

00:06:45,540 --> 00:06:43,470

we're thinking about more traditional

158

00:06:48,780 --> 00:06:45,550

prebiotic chemistry and

159

00:06:50,340 --> 00:06:48,790

sort of as Sayid showed yesterday when

160

00:06:52,500 --> 00:06:50,350

we're thinking about simple to complex

161

00:06:53,970 --> 00:06:52,510

that's kind of the the main trajectory

162

00:06:55,770 --> 00:06:53,980

were thinking of with chemical evolution

163

00:06:58,530 --> 00:06:55,780

and there are a couple ways of thinking

164

00:06:59,820 --> 00:06:58,540

about complexity and people use

165

00:07:01,500 --> 00:06:59,830

different terms but when I think about

166

00:07:03,960 --> 00:07:01,510

it I think of molecular complexity is

167

00:07:07,110 --> 00:07:03,970

how we go from sort of simple molecules

168

00:07:08,250 --> 00:07:07,120

to more complex molecules and in

169

00:07:09,780 --> 00:07:08,260

particular how we do that without

170

00:07:12,290 --> 00:07:09,790

biology and so we're gonna be hearing

171

00:07:15,390 --> 00:07:12,300

about that from both David and we're on

172

00:07:17,520 --> 00:07:15,400

and just because this comes up at every

173

00:07:19,170 --> 00:07:17,530

ab grad con chemists really like to use

174

00:07:20,640 --> 00:07:19,180

skeletal structures and not everybody

175

00:07:23,670 --> 00:07:20,650

knows what that is so here are a few of

176

00:07:27,390 --> 00:07:23,680

my favorite molecules but basically each

177

00:07:30,780 --> 00:07:27,400

of these are a carbon so each of the

178

00:07:32,790 --> 00:07:30,790

sort of triangular shape here is a

179

00:07:35,070 --> 00:07:32,800

carbon and then there are hydrogen's

180

00:07:38,790 --> 00:07:35,080

that are sort of redacted hanging off

181

00:07:41,190 --> 00:07:38,800

the edge here and so  $C_3H_4O_3$  is the

182

00:07:43,920 --> 00:07:41,200

same as this molecule and then when it

183

00:07:46,050 --> 00:07:43,930

loses a hydrogen its deprotonated and

184

00:07:48,180 --> 00:07:46,060

that just comes up and you can hydrate

185

00:07:50,370 --> 00:07:48,190

or you can do hydrolysis depending on

186

00:07:53,310 --> 00:07:50,380

whether you have a hydrogen or water or

187

00:07:55,950 --> 00:07:53,320

not on there okay so we've got molecular

188

00:07:57,270 --> 00:07:55,960

complexity we've got chemical complexity

189

00:07:59,310 --> 00:07:57,280

what is sort of the hetero genie

190

00:08:01,410 --> 00:07:59,320

heterogeneity of the mixture that was

191

00:08:03,150 --> 00:08:01,420

available what are we thinking about so

192

00:08:05,010 --> 00:08:03,160

there's the foremost reaction of course

193

00:08:07,680 --> 00:08:05,020

that makes a whole lot of stuff

194

00:08:09,390 --> 00:08:07,690

including a little bit of ribose and the

195

00:08:12,540 --> 00:08:09,400

rajah will be telling us about the role

196

00:08:13,950 --> 00:08:12,550

of heterogeneity and then we also have

197

00:08:15,450 --> 00:08:13,960

what I would characterize as super

198

00:08:19,050 --> 00:08:15,460

molecular complexity we'll be hearing

199

00:08:21,660 --> 00:08:19,060

from all of our organic chemists this

200

00:08:24,450 --> 00:08:21,670

afternoon about sort of what are the

201

00:08:26,550 --> 00:08:24,460

larger 3d organization and in particular

202

00:08:28,350 --> 00:08:26,560

how do we get towards functionality and

203

00:08:32,550 --> 00:08:28,360

how do we get towards you know maybe

204

00:08:34,980 --> 00:08:32,560

getting to biology and biochemistry and

205

00:08:36,540 --> 00:08:34,990

of course we also have to think about if

206

00:08:38,790 --> 00:08:36,550

you're going from simple to complex what

207

00:08:40,740 --> 00:08:38,800

are the back reactions and how are we

208

00:08:42,840 --> 00:08:40,750

going to be breaking down and how we not

209

00:08:44,880 --> 00:08:42,850

and in particular Jonathan's going to be

210

00:08:46,380 --> 00:08:44,890

talking about bio signature stability of

211

00:08:49,230 --> 00:08:46,390

what are these possible back reactions

212

00:08:51,930 --> 00:08:49,240

and how we might be missing things and

213

00:08:54,390 --> 00:08:51,940

yeah just in terms of if we want simple

214

00:08:57,330 --> 00:08:54,400

to complex we have to have sort of

215

00:08:58,410 --> 00:08:57,340

overall something pushing us towards

216

00:09:00,269 --> 00:08:58,420

more complex structure

217

00:09:02,879 --> 00:09:00,279

that generally requires an input of

218

00:09:05,519 --> 00:09:02,889

energy and in general a sustained sort

219

00:09:07,170 --> 00:09:05,529

of out of equilibrium system so I can't

220

00:09:08,579 --> 00:09:07,180

give a talk and not mention the Sun

221

00:09:11,490 --> 00:09:08,589

because I'm a photo chemist and that's

222

00:09:13,560 --> 00:09:11,500

my favorite input of energy but we also

223

00:09:15,660 --> 00:09:13,570

have wet dry cycles that I suspect we

224

00:09:17,389 --> 00:09:15,670

will be hearing about as well as a nice

225

00:09:20,939 --> 00:09:17,399

way of sustaining out of equilibrium

226

00:09:22,500 --> 00:09:20,949

systems and so and then just to remember

227

00:09:24,090 --> 00:09:22,510

that we have to think about all of this

228

00:09:25,800 --> 00:09:24,100

chemistry in the context of the

229

00:09:27,870 --> 00:09:25,810

environment in the context of all of the

230

00:09:30,810 --> 00:09:27,880

other stuff that's going on and not just

231

00:09:34,319 --> 00:09:30,820

in optimization terms but also in terms

232

00:09:36,060 --> 00:09:34,329

of you know just just what is around and

233

00:09:39,300 --> 00:09:36,070

we can't forget that mixtures are really

234

00:09:40,980 --> 00:09:39,310

important as well and so I would say

235

00:09:44,579 --> 00:09:40,990

that our geology talks are roughly

236

00:09:46,650 --> 00:09:44,589

atmospheres and rocks and that our

237

00:09:49,379 --> 00:09:46,660

chemistry talks are largely how do we

238

00:09:52,290 --> 00:09:49,389

avoid goo and so with that we'll move on