1
00:00:00,419 --> 00:00:03,002
(gentle music)

2
00:00:08,900 --> 00:00:11,850
- Welcome back to
Conversations at the Perimeter.

3
00:00:11,850 --> 00:00:14,330
Today Colin and I are excited to bring you

4
00:00:14,330 --> 00:00:17,070
a conversation with Hilding Neilson.

5
00:00:17,070 --> 00:00:19,590
Hilding's research is at
the intersection of science,

6
00:00:19,590 --> 00:00:22,040
astronomy and indigenous knowledge.

7
00:00:22,040 --> 00:00:24,930
He studies the physics of stars
and he works to incorporate

8
00:00:24,930 --> 00:00:27,960
indigenous knowledge into
all of the work that he does.

9
00:00:27,960 --> 00:00:30,130
- Yeah, Hilding grew up in Newfoundland,

10
00:00:30,130 --> 00:00:33,100
where he would stare up
at the starry night sky

11
00:00:33,100 --> 00:00:35,000
and dream about what
the stars were made of.

12
00:00:35,000 --> 00:00:36,340
And now as a grown up,

13
00:00:36,340 --> 00:00:38,990
he studies their inner
workings for a living.

14
00:00:38,990 --> 00:00:42,270
And that professional pursuit
of astronomy has also led him

15
00:00:42,270 --> 00:00:44,900
to reconnect with his own indigenous roots

16
00:00:44,900 --> 00:00:46,450
as a Mi'kmaq person.

17
00:00:46,450 --> 00:00:48,140
And that has inspired him

18
00:00:48,140 --> 00:00:50,060
to look into indigenous astronomies

19
00:00:50,060 --> 00:00:51,600
and how they compare and contrast

20
00:00:51,600 --> 00:00:53,810
to sort of our Western astronomies.

21
00:00:53,810 --> 00:00:55,630
- You know, I was looking
at Hilding's website

22
00:00:55,630 --> 00:00:57,030
and I think that the subtitle

23
00:00:57,030 --> 00:00:59,170
he has on there really says it all.

24
00:00:59,170 --> 00:01:01,960
He writes, every star tells a story.

25
00:01:01,960 --> 00:01:04,433
So let's hear some of
those stories from Hilding.

26
00:01:08,550 --> 00:01:12,180
So Hilding thank you so
much for joining us today.

27
00:01:12,180 --> 00:01:15,150
One thing that I'm hoping you
might be able to help us with

28
00:01:15,150 --> 00:01:17,380
is something that's a goal of mine

29
00:01:17,380 --> 00:01:18,560
for this series in general,

30
00:01:18,560 --> 00:01:22,760
which is to just maybe shed
some light on the meaning

31
00:01:22,760 --> 00:01:25,260
of some words or expressions
that we hear a lot

32
00:01:25,260 --> 00:01:30,260
in popular culture or the
media, but maybe not everyone

33
00:01:30,290 --> 00:01:31,580
is so sure exactly what they mean.

34
00:01:31,580 --> 00:01:34,000
So I thought we could start

with a really fundamental one

35
00:01:34,000 --> 00:01:35,170
in I think everything that you do,

36
00:01:35,170 --> 00:01:36,420
which is the word astronomy.

37
00:01:36,420 --> 00:01:40,660
So could you just tell us what
it means to study astronomy?

38
00:01:40,660 --> 00:01:42,930
- Thank you for inviting
me and thanks for starting

39
00:01:42,930 --> 00:01:46,870
with the easy questions like
astronomy, from my perspective,

40
00:01:46,870 --> 00:01:48,343
astronomy is just the study of everything

41
00:01:48,343 --> 00:01:50,450
that we look up and see in the sky.

42
00:01:50,450 --> 00:01:52,140
Scientists have some artificial construct

43
00:01:52,140 --> 00:01:53,640
that where our atmosphere ends

44
00:01:53,640 --> 00:01:55,733
and space begins, astronomy is,

45
00:01:55,733 --> 00:01:58,920
from the moon to the sun, to the planets.

46

00:01:58,920 --> 00:02:01,600
- And how does that
differ from astrophysics?

47
00:02:01,600 --> 00:02:03,480
- The story I usually
tell is if I'm on a plane,

48
00:02:03,480 --> 00:02:06,030
I wanna have a conversation,
I say I'm an astronomer.

49
00:02:06,030 --> 00:02:07,630
If I'm less interested in conversation,

50
00:02:07,630 --> 00:02:09,209
I say astrophysicist.

51
00:02:09,209 --> 00:02:10,230
(laughing)

52
00:02:10,230 --> 00:02:11,847
I think in reality today,
there's no real difference.

53
00:02:11,847 --> 00:02:16,070
There's some historical
context where people,

54
00:02:16,070 --> 00:02:18,220
there were astronomy
groups with telescopes

55
00:02:18,220 --> 00:02:19,750
doing observations.

56
00:02:19,750 --> 00:02:21,630
In the physics department,
there were scientists

57
00:02:21,630 --> 00:02:25,479
doing the maths and the experiments
related to astrophysics.

58
00:02:25,479 --> 00:02:28,830
Those were the distinguishing
features of the two fields.

59
00:02:28,830 --> 00:02:31,490
But today, it's all the
same as far as I can tell.

60
00:02:31,490 --> 00:02:33,500
- And I really like the
definition you give too,

61
00:02:33,500 --> 00:02:35,880
because I think it seems to me

62
00:02:35,880 --> 00:02:37,680
like a pretty all encompassing definition.

63
00:02:37,680 --> 00:02:40,550
But since you're saying
that astronomy is defined

64
00:02:40,550 --> 00:02:41,670
by what you look up and see,

65
00:02:41,670 --> 00:02:43,393
it depends so much on where you are,

66
00:02:43,393 --> 00:02:48,071
I guess both physically, but
also in time, is that true?

67
00:02:48,071 --> 00:02:48,904
- I think if we talk about astronomy

68
00:02:48,904 --> 00:02:50,080
as what we can see then, yeah,

69
00:02:50,080 --> 00:02:52,780
it depends on who's doing it
depends on our relationship

70
00:02:52,780 --> 00:02:54,210
to the night sky.

71
00:02:54,210 --> 00:02:57,130
Whether we can see the north
star or the Southern cross,

72
00:02:57,130 --> 00:03:00,191
whether we see the imagine
line clouds or Andromeda

73
00:03:00,191 --> 00:03:01,710
and all these different things.

74
00:03:01,710 --> 00:03:03,100
And it does depend on time.

75
00:03:03,100 --> 00:03:05,790
We somehow could observe the universe

76
00:03:05,790 --> 00:03:06,920
a second after it was born,

77
00:03:06,920 --> 00:03:09,870
it would look very
different, but you know,

78
00:03:09,870 --> 00:03:11,360
it depends on when and where we are.

79
00:03:11,360 --> 00:03:13,950

- And I know you
specifically are interested

80
00:03:13,950 --> 00:03:16,830
in studying stellar astronomy.

81
00:03:16,830 --> 00:03:19,543
What really draws you
to focusing on stars?

82
00:03:20,761 --> 00:03:22,300
- 'Cause stars carry so
much of the information

83
00:03:22,300 --> 00:03:24,360
that we use in astronomy and astrophysics.

84
00:03:24,360 --> 00:03:27,910
Almost the entirety of our
field is defined by using light

85
00:03:27,910 --> 00:03:29,600
to understand the universe.

86
00:03:29,600 --> 00:03:30,530
Today's a little different

87
00:03:30,530 --> 00:03:33,930
thanks to Neutrino experiments
and gravitational waves

88
00:03:33,930 --> 00:03:35,330
and the hunt for dark matter,

89
00:03:36,595 --> 00:03:37,760
but almost everything else is light.

90
00:03:37,760 --> 00:03:39,890
And almost all that light come from stars.

91
00:03:39,890 --> 00:03:42,770
We wanna understand things like
the shape of our Milky Way.

92
00:03:42,770 --> 00:03:45,720
We look at stars, shape
of a halo over galaxy,

93
00:03:45,720 --> 00:03:48,340
we look at stars, we look for exoplanets,

94
00:03:48,340 --> 00:03:49,710
we're looking at stars.

95
00:03:49,710 --> 00:03:51,410
I think when we look at stars,

96
00:03:51,410 --> 00:03:53,305
it shares all these
stories, 'cause no star,

97
00:03:53,305 --> 00:03:56,040
no two stars are the same really.

98
00:03:56,040 --> 00:03:58,230
So many science is looking
for stars like our sun,

99
00:03:58,230 --> 00:04:00,340
but it's hard to find one exactly alike.

100
00:04:00,340 --> 00:04:02,090
It's like trying to understand people.

101
00:04:02,090 --> 00:04:03,780
- You mentioned the only star

102

00:04:03,780 --> 00:04:05,740
that a lot of people are
really familiar with.

103
00:04:05,740 --> 00:04:09,580
The one that keeps us alive
and heats us, keeps us warm.

104
00:04:09,580 --> 00:04:12,240
What kind of star is our sun

105
00:04:12,240 --> 00:04:14,640
compared to some of the other
stars that you're studying?

106
00:04:14,640 --> 00:04:16,140
Is it a run of the mill star?

107
00:04:16,140 --> 00:04:18,425
Is it an extraordinary star?

108
00:04:18,425 --> 00:04:20,020
- I think all stars are
extraordinary in some way,

109
00:04:20,020 --> 00:04:22,970
but I think for many situations,

110
00:04:22,970 --> 00:04:25,150
our sun is sort of the average.

111
00:04:25,150 --> 00:04:27,480
It has a perfect mass.

112
00:04:27,480 --> 00:04:28,690
If it we're much more massive,

113
00:04:28,690 --> 00:04:29,550
it wouldn't live very long.

114
00:04:29,550 --> 00:04:32,430
So we wouldn't be able to
be here or much smaller,

115
00:04:32,430 --> 00:04:34,300
it would live a very long time,

116
00:04:34,300 --> 00:04:35,800
but it wouldn't generate that much heat.

117
00:04:35,800 --> 00:04:38,010
It would be very red and cool,

118
00:04:38,010 --> 00:04:40,950
like cool as saying 3000 degrees Celsius.

119
00:04:40,950 --> 00:04:43,550
So in many respects, our
sun is sort of the average.

120
00:04:43,550 --> 00:04:44,950
Doesn't really stand out.

121
00:04:44,950 --> 00:04:48,010
Doesn't have like a whole bunch
of other stars orbiting it,

122
00:04:48,010 --> 00:04:50,440
'cause we're the only
planets we know of with life.

123
00:04:50,440 --> 00:04:52,810
I guess in that respect,
our sun is very special.

124
00:04:52,810 --> 00:04:55,240
- What are the other
types of stars out there

125
00:04:55,240 --> 00:04:56,430
that you're studying?

126
00:04:56,430 --> 00:04:58,370
How do they sort of compare to our sun?

127
00:04:58,370 --> 00:05:00,780
- I tend to jump around different stars,

128
00:05:00,780 --> 00:05:03,560
but I like also trying to
understand the most massive stars,

129
00:05:03,560 --> 00:05:06,530
stars that are 10 times
more massive than our sun

130
00:05:06,530 --> 00:05:08,290
and stars that are even a hundred times

131
00:05:08,290 --> 00:05:09,150
more massive than the sun.

132
00:05:09,150 --> 00:05:11,440
'Cause these are these really hot.

133
00:05:11,440 --> 00:05:12,580
We call them O type stars.

134
00:05:12,580 --> 00:05:13,890
They look very blue.

135
00:05:13,890 --> 00:05:18,530
They live fast, die young,
go out with an explosion.

136
00:05:18,530 --> 00:05:19,760

They're kind of rock stars.

137
00:05:19,760 --> 00:05:21,230
We get to learn so much about these stars

138
00:05:21,230 --> 00:05:22,830
because they're doing all
these different things.

139
00:05:22,830 --> 00:05:25,450
'Cause they're so massive
that when they spin,

140
00:05:25,450 --> 00:05:28,390
they can deform their shape
when they spin fast enough,

141
00:05:28,390 --> 00:05:30,180
we get to learn about how they rotate.

142
00:05:30,180 --> 00:05:32,910
We learn about the fluid
dynamics, magnetic fields.

143
00:05:32,910 --> 00:05:34,153
On the other hand,

144
00:05:34,153 --> 00:05:36,995
I also like studying super
giant stars like Betelgeuse.

145
00:05:36,995 --> 00:05:38,650
Betelgeuse is this great
red super giant star

146
00:05:38,650 --> 00:05:40,890
that sits in Orion and so beautifully

147
00:05:40,890 --> 00:05:42,730

when you see it on the night sky.

148
00:05:42,730 --> 00:05:43,790
But for most astronomers,

149
00:05:43,790 --> 00:05:47,170
all we're waiting for is
for the thing to explode.

150
00:05:47,170 --> 00:05:48,519
'Cause we know it's going to explode soon.

151
00:05:48,519 --> 00:05:52,010
- Relatively soon, I assume,
not tomorrow necessarily.

152
00:05:52,010 --> 00:05:53,762
- Although not tomorrow,

153
00:05:53,762 --> 00:05:54,929
but within 100,000 years ish.

154
00:05:54,929 --> 00:05:55,762
- Ish relatively soon.

155
00:05:55,762 --> 00:05:56,850
- Yeah.

156
00:05:56,850 --> 00:05:58,300
- Do you have any idea of when

157
00:05:58,300 --> 00:06:00,863
in those 100,000 years
or it's just any time.

158
00:06:01,810 --> 00:06:02,960
- I have lots of ideas.

159

00:06:03,840 --> 00:06:05,570
None of them are really that good

160
00:06:05,570 --> 00:06:07,520
or any better than any others.

161
00:06:07,520 --> 00:06:09,460
The unfortunate reality is
we just don't know enough

162
00:06:09,460 --> 00:06:10,740
about the start to be able to predict

163
00:06:10,740 --> 00:06:12,827
the exact time is going to explode,

164
00:06:12,827 --> 00:06:15,100
but we know it's getting close.

165
00:06:15,100 --> 00:06:16,640
- Can you tell us why
it's going to explode

166
00:06:16,640 --> 00:06:17,870
and how you know that?

167
00:06:17,870 --> 00:06:20,310
- We know that pretty much
every star that's more massive

168
00:06:20,310 --> 00:06:21,840
than eight times the mass of our sun

169
00:06:21,840 --> 00:06:23,990
will end up exploding as a supernova.

170
00:06:23,990 --> 00:06:26,920
And this has to do with
how stars form elements

171
00:06:26,920 --> 00:06:27,753
in their core.

172
00:06:27,753 --> 00:06:29,730
Stars like our sun generates energy,

173
00:06:29,730 --> 00:06:31,860
give us our light from
taking two hydrogen atoms,

174
00:06:31,860 --> 00:06:35,020
banging together to
eventually create helium.

175
00:06:35,020 --> 00:06:36,500
And that get off a little bit of energy

176
00:06:36,500 --> 00:06:39,230
that turns on the photons
that eventually reach us,

177
00:06:39,230 --> 00:06:40,531
but more massive stars.

178
00:06:40,531 --> 00:06:42,600
When the core runs out of hydrogen,

179
00:06:42,600 --> 00:06:43,850
they're able to defuse helium,

180
00:06:43,850 --> 00:06:45,207
they're able to defuse carbon and oxygen.

181
00:06:45,207 --> 00:06:47,870
And so on you reach
our iron or most people

182

00:06:47,870 --> 00:06:51,790
who study climate, we realize
that when irons tries to fuse,

183
00:06:51,790 --> 00:06:54,520
it's a problem because it
takes energy away from the star

184
00:06:54,520 --> 00:06:55,750
as opposed to creating energy.

185
00:06:55,750 --> 00:06:56,870
So when that happens,

186
00:06:56,870 --> 00:06:59,530
there's no way for the star
to support itself anymore.

187
00:06:59,530 --> 00:07:01,341
It collapses onto itself,

188
00:07:01,341 --> 00:07:03,825
creating perhaps a neutron
star or a block hole.

189
00:07:03,825 --> 00:07:06,640
And then a shock wave
creates the explosion.

190
00:07:06,640 --> 00:07:07,850
And because we know Betelgeuse

191
00:07:07,850 --> 00:07:10,090
is much more massive
than eight solar masses

192
00:07:10,090 --> 00:07:12,120
or eight times mass in the sun,

193

00:07:12,120 --> 00:07:13,010
we can be fairly certain

194
00:07:13,010 --> 00:07:14,920
that it's going to explode eventually.

195
00:07:14,920 --> 00:07:16,700
And because we know it's cool,

196
00:07:16,700 --> 00:07:19,630
it's only about 3000,
3500 degrees Celsius.

197
00:07:19,630 --> 00:07:20,880
And the amount of light it emits,

198
00:07:20,880 --> 00:07:23,890
we can guess that it's very
well beyond fusing hydrogen

199
00:07:23,890 --> 00:07:27,810
and is probably burning helium
or maybe burning carbon,

200
00:07:27,810 --> 00:07:29,320
but it's getting very much closer

201
00:07:29,320 --> 00:07:30,230
and we know the time scales

202
00:07:30,230 --> 00:07:32,710
for burning these heavier elements.

203
00:07:32,710 --> 00:07:33,910
It gets shorter and shorter and shorter.

204
00:07:33,910 --> 00:07:35,689
And by the time it gets to like oxygen,

205
00:07:35,689 --> 00:07:37,988
last a year burning oxygen
or few tens of years.

206
00:07:37,988 --> 00:07:40,120
And so we know it's getting close,

207
00:07:40,120 --> 00:07:42,090
but we don't know enough
precisely about the star

208
00:07:42,090 --> 00:07:43,670
to be able to say exactly when.

209
00:07:43,670 --> 00:07:45,761
- And is that partly
because we don't have enough

210
00:07:45,761 --> 00:07:49,650
other examples that we can compare it to?

211
00:07:49,650 --> 00:07:51,400
- No, I think it's more of the fact

212
00:07:51,400 --> 00:07:54,320
that we can only know
about the stars so well,

213
00:07:54,320 --> 00:07:56,610
to be able to figure out
exactly how old it is

214
00:07:56,610 --> 00:07:57,930
and how much longer we'll have,

215
00:07:57,930 --> 00:07:59,900
we need to know very precisely exactly

216

00:07:59,900 --> 00:08:00,750
how much light it's emitting.

217
00:08:00,750 --> 00:08:01,997
So we need to know how far away it is.

218
00:08:01,997 --> 00:08:03,920
And we can do things
like stellar parallax,

219
00:08:03,920 --> 00:08:05,510
where you survey the stars

220
00:08:05,510 --> 00:08:06,790
and just see how they move
relative to each other.

221
00:08:06,790 --> 00:08:08,240
But even that doesn't work very well.

222
00:08:08,240 --> 00:08:09,520
We don't have a very good certainty

223
00:08:09,520 --> 00:08:11,120
of how far away Betelgeuse is.

224
00:08:11,120 --> 00:08:12,670
Even though it's one of the closest stars,

225
00:08:12,670 --> 00:08:14,860
we don't necessarily
know how massive it is,

226
00:08:14,860 --> 00:08:18,390
'cause it's a single star and
we measure the masses stars

227
00:08:18,390 --> 00:08:19,223
by gravity.

228
00:08:19,223 --> 00:08:20,520
So we need to see them interacting

229
00:08:20,520 --> 00:08:21,940
with other stars to do this.

230
00:08:21,940 --> 00:08:24,450
And so we have to sort of
guess what this mass is,

231
00:08:24,450 --> 00:08:26,910
based off its amount of light
and amount of temperature

232
00:08:26,910 --> 00:08:30,250
we see it sort of fitting our
solar evolution calculations

233
00:08:30,250 --> 00:08:31,220
or doing computer modeling.

234
00:08:31,220 --> 00:08:32,610
So we can't do that very precisely.

235
00:08:32,610 --> 00:08:34,250
So we have very limited knowledge.

236
00:08:34,250 --> 00:08:36,600
We know Betelgeuse is more
than eight solar masses,

237
00:08:36,600 --> 00:08:38,050
but we don't know whether that's means

238
00:08:38,050 --> 00:08:39,900
that's 10 solar masses or 20 solar masses

239

00:08:39,900 --> 00:08:43,410
or 25 solar masses, the
lifetime starters between 10.5.

240
00:08:43,410 --> 00:08:44,890
It could be very different.

241
00:08:44,890 --> 00:08:47,963
- And how far away, you say
it's relatively near, but again,

242
00:08:49,522 --> 00:08:50,521
everything's relative.

243
00:08:50,521 --> 00:08:51,520
How roughly distant is Betelgeuse?

244
00:08:51,520 --> 00:08:52,510
- I always wanna say this in light years,

245
00:08:52,510 --> 00:08:54,000
but I never remember in light years,

246
00:08:54,000 --> 00:08:56,390
but in Parex is about a thousand parsecs.

247
00:08:56,390 --> 00:08:58,330
- I was gonna ask if it
does explode tomorrow,

248
00:08:58,330 --> 00:09:00,110
when will we find out about it?

249
00:09:00,110 --> 00:09:01,180
- And about the time it takes

250
00:09:01,180 --> 00:09:04,210
the light to travel our of parsecs, sorry.

251
00:09:05,625 --> 00:09:06,852
(laughing)

252
00:09:06,852 --> 00:09:07,730
- That's the homework
challenge for the listener,

253
00:09:07,730 --> 00:09:10,110
calculate the light years.

254
00:09:10,110 --> 00:09:13,660
- But it's far enough
away that we probably,

255
00:09:13,660 --> 00:09:15,190
we'll see it at night for sure.

256
00:09:15,190 --> 00:09:17,058
If the explosion's bright enough,

257
00:09:17,058 --> 00:09:17,891
we might even see during the day,

258
00:09:17,891 --> 00:09:19,330
which has happened historically
where you actually,

259
00:09:19,330 --> 00:09:21,790
you could see light from
stream over during the day,

260
00:09:21,790 --> 00:09:23,380
it's that nice place

261
00:09:23,380 --> 00:09:26,410
where it's just gonna be
in very nice light show.

262

00:09:26,410 --> 00:09:28,590
- I'm looking forward to
it if I live long enough.

263
00:09:28,590 --> 00:09:30,990
- And I wanna go back to
a word you said before,

264
00:09:30,990 --> 00:09:32,160
which is exoplanets.

265
00:09:32,160 --> 00:09:34,420
Can you talk about what an exoplanet is?

266
00:09:34,420 --> 00:09:38,230
And some of the processes
we would use to find them.

267
00:09:38,230 --> 00:09:41,040
- Up to about 1990 or so,
the only planets we knew

268
00:09:41,040 --> 00:09:43,230
in our galaxy were the
ones orbiting our sun,

269
00:09:43,230 --> 00:09:45,990
big problem with that is why
should we be the only place

270
00:09:45,990 --> 00:09:46,823
with planets?

271
00:09:46,823 --> 00:09:48,030
So stronger started
coming up with techniques

272
00:09:48,030 --> 00:09:48,890
to look at other stars

273
00:09:48,890 --> 00:09:51,160
and try to find ways
to find other planets.

274
00:09:51,160 --> 00:09:53,520
And one is through radio velocity,

275
00:09:53,520 --> 00:09:54,980
where you take the light from a star,

276
00:09:54,980 --> 00:09:57,170
you break into a spectrum,
like it's rainbow.

277
00:09:57,170 --> 00:09:59,970
And you're what you're
looking for is the lines,

278
00:09:59,970 --> 00:10:01,440
the chemical fingerprints of the star,

279
00:10:01,440 --> 00:10:03,770
because as a planet is
going around a star,

280
00:10:03,770 --> 00:10:06,010
the star is exerting
gravity onto the planet,

281
00:10:06,010 --> 00:10:07,120
planets gravity in the star.

282
00:10:07,120 --> 00:10:09,070
So the star is actually moving wobbling

283
00:10:09,070 --> 00:10:10,450
on its center of access.

284

00:10:10,450 --> 00:10:12,950
And so one of the ways was
to try to find that motion.

285
00:10:12,950 --> 00:10:15,370
A Nobel prize was given
for that a few years ago,

286
00:10:15,370 --> 00:10:17,020
method and that first results.

287
00:10:17,020 --> 00:10:18,720
That's a very hard way to find planets.

288
00:10:18,720 --> 00:10:20,740
An easier way to find planets

289
00:10:20,740 --> 00:10:23,100
is if you take your
telescope and you just stare

290
00:10:23,100 --> 00:10:26,450
at a star long enough, you
just wait for the light.

291
00:10:26,450 --> 00:10:27,950
As you're watching the light with time,

292
00:10:27,950 --> 00:10:29,740
light to drop just a little bit.

293
00:10:29,740 --> 00:10:31,960
And that little drop in light
could be due to a planet

294
00:10:31,960 --> 00:10:34,370
passing in front of the
star, casting a shadow.

295

00:10:34,370 --> 00:10:35,203
When we do it that way,

296
00:10:35,203 --> 00:10:36,350
we can actually find a lot more planets,

297
00:10:36,350 --> 00:10:37,700
a lot easier

298
00:10:37,700 --> 00:10:39,240
because we don't need to
break into the rainbow.

299
00:10:39,240 --> 00:10:40,640
We just need the stare
at stars long enough.

300
00:10:40,640 --> 00:10:43,288
And so we did this with great experiments,

301
00:10:43,288 --> 00:10:44,203
like the Kepler Space Telescope,

302
00:10:45,247 --> 00:10:46,877
which found thousands of exo planets.

303
00:10:46,877 --> 00:10:48,460
Today we have the transit
exoplanet survey satellite,

304
00:10:48,460 --> 00:10:50,290
which is finding thousands more.

305
00:10:50,290 --> 00:10:53,250
There are currently proposed
a handful of other missions

306
00:10:53,250 --> 00:10:55,490
ready to go up and keep

looking for more exoplanets.

307
00:10:55,490 --> 00:10:58,130
And to begin trying to characterize
these in greater detail,

308
00:10:58,130 --> 00:10:58,963
see if we can try to measure

309
00:10:58,963 --> 00:11:01,160
the atmosphere of these exoplanets.

310
00:11:01,160 --> 00:11:02,810
- You wrote, I think on your website,

311
00:11:02,810 --> 00:11:04,160
by better knowing stars,

312
00:11:04,160 --> 00:11:06,420
we can better know the planets they host.

313
00:11:06,420 --> 00:11:08,000
By studying a star, how
can you know anything

314
00:11:08,000 --> 00:11:10,363
about the planet, aside
from that it's there?

315
00:11:10,363 --> 00:11:13,730
- Both these techniques
requires understanding

316
00:11:13,730 --> 00:11:15,170
the light from the star,

317
00:11:15,170 --> 00:11:18,850
but for a transit, when it
passes by at one wavelength,

318
00:11:18,850 --> 00:11:21,190
the light is going go
through the planet as well.

319
00:11:21,190 --> 00:11:23,340
Or the atmosphere of the planet,
heading on the wavelength.

320
00:11:23,340 --> 00:11:25,290
The planet might appear a
little bigger or smaller

321
00:11:25,290 --> 00:11:27,310
and using the thread, the
planet will appear bigger

322
00:11:27,310 --> 00:11:29,640
because the infrared light is
scattering off its atmosphere.

323
00:11:29,640 --> 00:11:30,660
So if we observe these trends

324
00:11:30,660 --> 00:11:31,620
in all these different wavelengths,

325
00:11:31,620 --> 00:11:34,830
we can sort of piece together
the spectrum of the planet.

326
00:11:34,830 --> 00:11:36,740
The problem is that as
soon as we understand

327
00:11:36,740 --> 00:11:38,600
the life from the star enough,

328
00:11:38,600 --> 00:11:41,480

that we can actually remove
that signal from the planet,

329
00:11:41,480 --> 00:11:44,580
given that the light from the
star is about a thousand times

330
00:11:44,580 --> 00:11:46,800
more contrast than what
we see from the planet

331
00:11:46,800 --> 00:11:48,460
or what we're moving from the exoplanet,

332
00:11:48,460 --> 00:11:50,050
that kind of work means
we have to understand

333
00:11:50,050 --> 00:11:53,910
the start to that much
more precision like 0.1%.

334
00:11:53,910 --> 00:11:56,100
In astronomy, this is kind
of a very difficult challenge

335
00:11:56,100 --> 00:11:57,220
'cause we tend to pride ourselves

336
00:11:57,220 --> 00:11:59,160
on if we're right within a factor 10,

337
00:11:59,160 --> 00:12:01,130
we're having a good day.

338
00:12:01,130 --> 00:12:03,240
This level of precision
is somewhat new to us.

339

00:12:03,240 --> 00:12:05,440
- If there were an alien
civilization with the same tools

340
00:12:05,440 --> 00:12:07,690
we had and they were looking at our sun,

341
00:12:07,690 --> 00:12:10,530
could they glean something
about planet earth

342
00:12:10,530 --> 00:12:13,300
and perhaps our residents on it,

343
00:12:13,300 --> 00:12:14,884
from looking at these same signals?

344
00:12:14,884 --> 00:12:16,230
- Probably not about the
same technology we have,

345
00:12:16,230 --> 00:12:19,210
but if we fast forward
maybe 50 or 100 years

346
00:12:19,210 --> 00:12:22,280
to what we think we're going
be able to do in astronomy,

347
00:12:22,280 --> 00:12:24,030
answer's probably yes.

348
00:12:24,030 --> 00:12:25,433
- What do you think
you're gonna be able to do

349
00:12:25,433 --> 00:12:26,680
in 50 to 100 years?

350

00:12:26,680 --> 00:12:28,000
- Have James Webb Space Telescope.

351
00:12:28,000 --> 00:12:30,310
That's gonna be launched very soon

352
00:12:30,310 --> 00:12:32,840
and it's gonna be able to
use infrared observations

353
00:12:32,840 --> 00:12:34,890
to do that kind of
atmospheric characterization.

354
00:12:34,890 --> 00:12:37,483
But if we had a telescope
that's 10 times bigger in space

355
00:12:37,483 --> 00:12:42,110
and we're staring at a star
like our sun for five, 10 years,

356
00:12:42,110 --> 00:12:44,200
so that you get multiple
transits of the earth,

357
00:12:44,200 --> 00:12:45,420
right, passing in front of the sun,

358
00:12:45,420 --> 00:12:47,640
you might be able to look
for things like small signals

359
00:12:47,640 --> 00:12:50,557
of changes in carbon dioxide and methane

360
00:12:50,557 --> 00:12:53,900
and the infrared wave lengths,
changes in the water vapor.

361
00:12:53,900 --> 00:12:56,176
So you might see clouds,
you might even see,

362
00:12:56,176 --> 00:12:59,610
depending on where the moon
is relative to the transit.

363
00:12:59,610 --> 00:13:03,100
You might see a variable blip
in the transit light curve

364
00:13:03,100 --> 00:13:04,200
that shows there's a moon.

365
00:13:04,200 --> 00:13:05,250
- Even the moon, wow.

366
00:13:05,250 --> 00:13:07,940
- So it's very much possible
that they can kind of see

367
00:13:07,940 --> 00:13:10,440
what we're doing on earth,
largely in terms of pollution,

368
00:13:10,440 --> 00:13:12,163
unfortunately, as opposed to, you know,

369
00:13:12,163 --> 00:13:13,613
winning the cup or something.

370
00:13:14,490 --> 00:13:15,810
- Well, that's not gonna happen.

371
00:13:15,810 --> 00:13:17,360
- Astronomically speaking.

372

00:13:17,360 --> 00:13:18,273
- Astronomically.

373
00:13:22,530 --> 00:13:24,411
- Hey everyone, you may have heard

374
00:13:24,411 --> 00:13:27,260
that Hilding just mentioned
that James Webb Space Telescope,

375
00:13:27,260 --> 00:13:29,360
and we wanted to share
with you that we recorded

376
00:13:29,360 --> 00:13:32,560
this conversation just before
the James Webb Space Telescope

377
00:13:32,560 --> 00:13:34,220
was scheduled to launch.

378
00:13:34,220 --> 00:13:37,690
It did successfully launch
on Christmas day 2021.

379
00:13:37,690 --> 00:13:39,310
And it has now reached its orbit,

380
00:13:39,310 --> 00:13:41,560
roughly 1.5 million kilometers

381
00:13:41,560 --> 00:13:43,820
from the Earth's orbit of the sun.

382
00:13:43,820 --> 00:13:45,920
So we reached out to Hilding again

383
00:13:45,920 --> 00:13:47,703
after we recorded this conversation,

384
00:13:47,703 --> 00:13:49,630
to get his outlook on astronomy

385
00:13:49,630 --> 00:13:52,900
now that the incredible
new telescope is in place.

386
00:13:52,900 --> 00:13:54,860
And when we did, you'll hear that he spoke

387
00:13:54,860 --> 00:13:56,670
about the amazing things we may learn

388
00:13:56,670 --> 00:13:58,850
about the universe from the telescope,

389
00:13:58,850 --> 00:14:01,420
as well as some things that
we can learn about ourselves

390
00:14:01,420 --> 00:14:02,500
here on earth.

391
00:14:02,500 --> 00:14:04,277
Let's hear what Hilding has to say.

392
00:14:06,780 --> 00:14:11,350
- I wish I got to watch
the launch of the JWST.

393
00:14:11,350 --> 00:14:14,010
I was in Newfoundland for the holidays

394
00:14:14,010 --> 00:14:17,430
to visit my family and
they did not have wifi.

395

00:14:17,430 --> 00:14:20,980
So I was not able to really
keep track the launch directly.

396
00:14:20,980 --> 00:14:24,563
I had to use social media
and keep my eye on Twitter.

397
00:14:25,970 --> 00:14:27,910
And I can't wait to
see what it's gonna do,

398
00:14:27,910 --> 00:14:31,420
now that it's in place at the L2 Point,

399
00:14:31,420 --> 00:14:33,440
we're gonna be able to
see this great opportunity

400
00:14:33,440 --> 00:14:34,860
to learn about exoplanets,

401
00:14:34,860 --> 00:14:37,423
learn about stars, learn about cosmology,

402
00:14:38,637 --> 00:14:42,008
and while that's great,

403
00:14:42,008 --> 00:14:44,277
we still live in a system of astronomy

404
00:14:44,277 --> 00:14:46,863
and physics that is not inclusive.

405
00:14:47,770 --> 00:14:51,025
Its name is still very controversial

406
00:14:51,025 --> 00:14:54,350
and I think leaves many

people out of the field.

407
00:14:54,350 --> 00:14:57,000
It leaves many people
having to do the work

408
00:14:57,000 --> 00:15:00,350
in astronomy and live with that offense

409
00:15:01,460 --> 00:15:02,370
of having to see that name all the time

410
00:15:02,370 --> 00:15:04,270
and the peoples who are harmed

411
00:15:04,270 --> 00:15:07,853
by that person that's being honored.

412
00:15:08,690 --> 00:15:11,190
So I'm glad to see that
the launch was successful,

413
00:15:11,190 --> 00:15:13,380
but in this current form,

414
00:15:13,380 --> 00:15:15,690
I have trouble buying into the hype

415
00:15:15,690 --> 00:15:17,103
and to the excitement.

416
00:15:18,390 --> 00:15:22,650
'Cause we're doing so many great things.

417
00:15:22,650 --> 00:15:24,270
And then we still honor people

418
00:15:24,270 --> 00:15:26,020

who probably should not be honored.

419
00:15:27,450 --> 00:15:29,700
- To give a little bit of extra context,

420
00:15:29,700 --> 00:15:32,640
the namesake of the James
Webb Space Telescope

421
00:15:32,640 --> 00:15:36,370
was the administrator of
NASA for much of the 1960s.

422
00:15:36,370 --> 00:15:39,033
And Webb has become somewhat
of a controversial figure

423
00:15:39,033 --> 00:15:42,060
for his alleged complicity
in the persecution

424
00:15:42,060 --> 00:15:44,160
of federal employees who were members

425
00:15:44,160 --> 00:15:45,980
of the LGBTQ community,

426
00:15:45,980 --> 00:15:48,610
when he was under secretary of state.

427
00:15:48,610 --> 00:15:51,890
So Hilding's enthusiasm
for the scientific mission,

428
00:15:51,890 --> 00:15:55,140
James Webb Space Telescope,
is somewhat counterbalanced

429
00:15:55,140 --> 00:15:58,840

by a deep commitment to making
positive change in science,

430
00:15:58,840 --> 00:16:00,480
overcoming barriers to entry

431
00:16:00,480 --> 00:16:02,380
and really holding everyone accountable

432
00:16:02,380 --> 00:16:06,450
to ensuring that great science
really represents everyone.

433
00:16:06,450 --> 00:16:08,175
I'm really thankful that Hilding shared

434
00:16:08,175 --> 00:16:10,400
this perspective with us today.

435
00:16:10,400 --> 00:16:13,203
And now let's get back to
the rest of the conversation.

436
00:16:13,203 --> 00:16:15,786
(gentle music)

437
00:16:16,970 --> 00:16:18,340
I wanna go back to something

438
00:16:18,340 --> 00:16:21,830
you said just a second ago,
which is about how in astronomy,

439
00:16:21,830 --> 00:16:25,340
if you get something right
to an order of magnitude,

440
00:16:25,340 --> 00:16:26,580
you're doing pretty well.

441
00:16:26,580 --> 00:16:28,440
So this was something
that really struck me

442
00:16:28,440 --> 00:16:32,040
when I first took a course
in astronomy in my undergrad.

443
00:16:32,040 --> 00:16:34,530
And I remember really
specifically that we were looking

444
00:16:34,530 --> 00:16:37,090
at an equation and it had Pi in it

445
00:16:37,090 --> 00:16:38,270
and they just said, oh, well, you know,

446
00:16:38,270 --> 00:16:39,630
Pi is approximately 10.

447
00:16:39,630 --> 00:16:41,610
And I just couldn't believe that,

448
00:16:41,610 --> 00:16:43,410
I had never seen that before,

449
00:16:43,410 --> 00:16:45,120
and it's it stuck with me since then.

450
00:16:45,120 --> 00:16:47,590
And I guess I have a
pretty general question,

451
00:16:47,590 --> 00:16:51,010
but is that something that is
generally okay in astronomy?

452
00:16:51,010 --> 00:16:53,180
Are there any exceptions to that?

453
00:16:53,180 --> 00:16:55,820
- I think in a lot of times like saying Pi

454
00:16:55,820 --> 00:16:57,920
or four Pi is about 10 is okay.

455
00:16:57,920 --> 00:17:00,680
Particularly if you're
just trying to understand

456
00:17:00,680 --> 00:17:01,831
what's happening in principle.

457
00:17:01,831 --> 00:17:03,410
I think we wanna do things
like lab astrophysics,

458
00:17:03,410 --> 00:17:04,960
where we're building instrumentations

459
00:17:04,960 --> 00:17:06,680
and have to worry about cooling

460
00:17:07,550 --> 00:17:09,950
infrared cameras after a Pi

461
00:17:09,950 --> 00:17:11,720
can mean the difference
between burning out the camera

462
00:17:11,720 --> 00:17:12,810
and not.

463
00:17:12,810 --> 00:17:14,693
And as you know, a

chemist friend once said,

464
00:17:14,693 --> 00:17:17,593
being right within an automated
means your lab's blown up.

465
00:17:18,798 --> 00:17:20,280
(laughing)

466
00:17:20,280 --> 00:17:21,113
And there are people who
do astrochemistry as well.

467
00:17:21,113 --> 00:17:22,920
So we have to be very careful about that.

468
00:17:22,920 --> 00:17:24,530
The order of magnitude
is really only valuable

469
00:17:24,530 --> 00:17:26,296
when we wanna sort of
understand the principles

470
00:17:26,296 --> 00:17:29,980
of what we're observing, in our theories,

471
00:17:29,980 --> 00:17:31,210
when we wanna do real predictions,

472
00:17:31,210 --> 00:17:34,100
then we have to keep that
factor of pi in there.

473
00:17:34,100 --> 00:17:36,420
- So, you know, we were
talking about exoplanets

474
00:17:36,420 --> 00:17:38,900

and I know that a more
even specific question

475
00:17:38,900 --> 00:17:41,510
we could look at is how
many planets out there

476
00:17:41,510 --> 00:17:43,180
might host intelligent life.

477
00:17:43,180 --> 00:17:44,550
And I know that Drake equation

478
00:17:44,550 --> 00:17:47,510
is something we might look
at to help us predict that.

479
00:17:47,510 --> 00:17:50,190
So can you talk about this Drake equation

480
00:17:50,190 --> 00:17:52,250
and some of the different
insights you have on that?

481
00:17:52,250 --> 00:17:53,430
- So the Drake equation

482
00:17:53,430 --> 00:17:55,636
is this great historical thought
experiment by Frank Drake.

483
00:17:55,636 --> 00:17:59,428
Not that Drake that
we're all thinking about.

484
00:17:59,428 --> 00:18:01,550
This was in the of radio
astronomy when it was being born.

485

00:18:01,550 --> 00:18:03,770
We're building telescopes,
we're broadcasting

486
00:18:03,770 --> 00:18:05,226
TV signals out in the space.

487
00:18:05,226 --> 00:18:06,920
And he's kind of thinking, well,

488
00:18:06,920 --> 00:18:08,470
if we use radio for communication

489
00:18:08,470 --> 00:18:09,870
and we can broadcast radio into space,

490
00:18:09,870 --> 00:18:12,720
how many civilizations could
we like fire a signal to?

491
00:18:12,720 --> 00:18:13,930
And they can fire a signal back

492
00:18:13,930 --> 00:18:15,859
and we have a conversation with,

493
00:18:15,859 --> 00:18:16,692
and so he broke this down to the parts,

494
00:18:16,692 --> 00:18:18,330
like a nesting doll
where he is like, well,

495
00:18:18,330 --> 00:18:20,140
how many stars are there in our galaxy?

496
00:18:20,140 --> 00:18:22,720
How many stars can host planets?

497
00:18:22,720 --> 00:18:24,550
Not all stars are gonna form planets.

498
00:18:24,550 --> 00:18:26,591
How many of those stars that have planets,

499
00:18:26,591 --> 00:18:29,917
could have planets that could
potentially support life

500
00:18:29,917 --> 00:18:31,230
and if they could
potentially support life,

501
00:18:31,230 --> 00:18:32,930
then how many go on to support life,

502
00:18:32,930 --> 00:18:34,313
then how many have intelligent life,

503
00:18:34,313 --> 00:18:35,550
planets with intelligent life,

504
00:18:35,550 --> 00:18:37,490
how many of those go on
to form civilizations

505
00:18:37,490 --> 00:18:40,490
with technologies
capable of communication?

506
00:18:40,490 --> 00:18:43,220
And the final part of
that discussion was, well,

507
00:18:43,220 --> 00:18:45,970
if they go on to form these civilizations

508

00:18:45,970 --> 00:18:48,360
that can communicate,
how long do they last?

509
00:18:48,360 --> 00:18:50,040
And you know, this was the
height of the cold war.

510
00:18:50,040 --> 00:18:52,750
So when they were thinking
about how long they would last,

511
00:18:52,750 --> 00:18:54,560
it was more along the lines
of how long would it take

512
00:18:54,560 --> 00:18:55,890
before they blow themselves up.

513
00:18:55,890 --> 00:18:57,669
Today, we might talk about it,

514
00:18:57,669 --> 00:18:59,180
how long will it take
before we messed things up

515
00:18:59,180 --> 00:19:00,570
enough with climate change.

516
00:19:00,570 --> 00:19:03,520
When Frank Drake did this,
we had no real information,

517
00:19:03,520 --> 00:19:05,514
'cause we only had ourselves look at

518
00:19:05,514 --> 00:19:07,428
and so asking how many
stars could have planets,

519
00:19:07,428 --> 00:19:11,204
while we only knew at the time
only one star with planets.

520
00:19:11,204 --> 00:19:15,620
We only knew one star that had life.

521
00:19:15,620 --> 00:19:18,490
And so the numbers were very
small and he was thinking five,

522
00:19:18,490 --> 00:19:21,440
10 kind of civilizations
throughout our galaxy.

523
00:19:21,440 --> 00:19:22,453
Today, while we know

524
00:19:22,453 --> 00:19:24,400
that planets are actually fairly common,

525
00:19:24,400 --> 00:19:26,250
but 20% of stars have planets,

526
00:19:26,250 --> 00:19:28,490
but we still only know
of one planet with life.

527
00:19:28,490 --> 00:19:30,530
We still only know one
planet with intelligent life.

528
00:19:30,530 --> 00:19:31,890
I'm sure there are people
who listen to this,

529
00:19:31,890 --> 00:19:33,410
who may question even that assumption.

530
00:19:33,410 --> 00:19:35,230
And we only know of one planet

531
00:19:35,230 --> 00:19:36,720
with possibly having a civilization.

532
00:19:36,720 --> 00:19:39,540
And we don't know how long
that civilization will last.

533
00:19:39,540 --> 00:19:41,750
Frank Drake's whole idea
is built on this premise

534
00:19:41,750 --> 00:19:43,270
that civilization, intelligent life,

535
00:19:43,270 --> 00:19:46,090
being human and being human
in this technological world

536
00:19:46,090 --> 00:19:48,997
that was the 1950s US or 1950s Canada.

537
00:19:48,997 --> 00:19:51,810
And so it was very much based
on this very Eurocentric

538
00:19:51,810 --> 00:19:53,635
Amerocentric kind of perspective

539
00:19:53,635 --> 00:19:56,267
at the height of science in the US.

540
00:19:57,150 --> 00:19:59,110
I think today we can
actually broaden this out.

541

00:19:59,110 --> 00:20:02,110
'Cause we live in Canada,
Canada is indigenous lands.

542
00:20:02,110 --> 00:20:03,920
Indigenous people have been
here since time and Memorial,

543
00:20:03,920 --> 00:20:08,520
whether it's Mississaugas,
Haudenosaunee,Anishinaabe and so on.

544
00:20:08,520 --> 00:20:09,900
And they were civilizations.

545
00:20:09,900 --> 00:20:11,040
And when we talk about intelligent life,

546
00:20:11,040 --> 00:20:13,100
well humans might not be
the only intelligent life.

547
00:20:13,100 --> 00:20:14,950
There may be other paths to intelligence.

548
00:20:14,950 --> 00:20:16,560
We talk about intelligent
life being used tools

549
00:20:16,560 --> 00:20:18,160
while we know crows and whales

550
00:20:18,160 --> 00:20:20,180
and monkeys all use tools.

551
00:20:20,180 --> 00:20:22,570
We talk about intelligent
life through emotions

552

00:20:22,570 --> 00:20:25,670
and self-awareness, well,
we know of killer whales

553
00:20:25,670 --> 00:20:27,360
who carry their dead children

554
00:20:27,360 --> 00:20:29,240
along with them, you know, who mourn.

555
00:20:29,240 --> 00:20:31,500
We know that dolphins can laugh.

556
00:20:31,500 --> 00:20:33,330
And so self-awareness seems pretty common.

557
00:20:33,330 --> 00:20:36,340
So our definitions kind of have to broaden

558
00:20:36,340 --> 00:20:38,170
and even the definition of what is life,

559
00:20:38,170 --> 00:20:39,610
from many indigenous perspectives

560
00:20:39,610 --> 00:20:41,480
can be very important and
very crucial to think about

561
00:20:41,480 --> 00:20:42,560
because we tend to think of,

562
00:20:42,560 --> 00:20:43,640
NASA tends to define life

563
00:20:43,640 --> 00:20:45,730
by something that consumes material

564

00:20:45,730 --> 00:20:48,180
and reproduces and various other things.

565
00:20:48,180 --> 00:20:51,310
But no matter how well NASA defines life,

566
00:20:51,310 --> 00:20:52,650
there's always an exception

567
00:20:52,650 --> 00:20:55,030
like a virus doesn't
reproduce without a host.

568
00:20:55,030 --> 00:20:58,120
Self replicating robots
aren't necessarily self-aware,

569
00:20:58,120 --> 00:20:59,130
but they replicate.

570
00:20:59,130 --> 00:21:00,440
But for many indigenous peoples

571
00:21:00,440 --> 00:21:03,050
life sort of comes from relationships,

572
00:21:03,050 --> 00:21:06,520
being in relationships with
the salmon, the bear, the elk.

573
00:21:06,520 --> 00:21:08,760
So on, that's part of being alive.

574
00:21:08,760 --> 00:21:10,354
Where I'm from in Mi'kmaq,

575
00:21:10,354 --> 00:21:12,400
we're connected to the bear very much

576
00:21:12,400 --> 00:21:15,720
as part of our cosmology or
we're connected to the cod

577
00:21:15,720 --> 00:21:17,680
and lobster and the other fish

578
00:21:17,680 --> 00:21:19,440
as part of our ways of living,

579
00:21:19,440 --> 00:21:21,800
being a life form is part of
being in that relationship.

580
00:21:21,800 --> 00:21:25,300
In that respect, maybe life
goes beyond carbon base

581
00:21:25,300 --> 00:21:28,140
and becomes something
more broadly defined.

582
00:21:28,140 --> 00:21:30,060
- It seems like as every year passes,

583
00:21:30,060 --> 00:21:32,100
as we discover more
exoplanets, more stars,

584
00:21:32,100 --> 00:21:34,040
we've realized how huge the universe is

585
00:21:34,040 --> 00:21:35,480
and we have new perspectives

586
00:21:35,480 --> 00:21:37,210
on what life is and what life isn't,

587

00:21:37,210 --> 00:21:38,950
does it seem like the Drake equation

588
00:21:38,950 --> 00:21:40,750
just becomes more and more applicable

589
00:21:40,750 --> 00:21:44,510
to the conclusion that there
must be life out there.

590
00:21:44,510 --> 00:21:47,210
- Yeah, I think definitely
we have to conclude

591
00:21:47,210 --> 00:21:48,496
there's life out there.

592
00:21:48,496 --> 00:21:49,329
I mean, I think just a philosophy

593
00:21:49,329 --> 00:21:51,245
that there's billions
of stars in our galaxy

594
00:21:51,245 --> 00:21:54,670
and we're the only life
forms that's well, boring.

595
00:21:54,670 --> 00:21:56,520
- Boring doesn't make it false though.

596
00:21:56,520 --> 00:21:58,690
- Doesn't make it false,
not much of playing poker,

597
00:21:58,690 --> 00:22:00,750
but those are really bad odds.

598
00:22:00,750 --> 00:22:02,650

I think assuming that
we're the only life forms

599
00:22:02,650 --> 00:22:05,490
in the galaxy is a very difficult pill

600
00:22:05,490 --> 00:22:07,900
to swallow 'cause just
it's just so unlikely.

601
00:22:07,900 --> 00:22:09,983
- And you say the galaxy,

602
00:22:10,860 --> 00:22:14,027
- Yes, there are billions of galaxies.

603
00:22:15,093 --> 00:22:18,300
plans Andromada and in the
mag line clouds potentially.

604
00:22:18,300 --> 00:22:19,290
And so on.

605
00:22:19,290 --> 00:22:21,003
I mean there are questions of whether,

606
00:22:22,735 --> 00:22:23,738
how easy it is to form planets

607
00:22:23,738 --> 00:22:24,850
when you have less iron
and carbon and oxygen.

608
00:22:24,850 --> 00:22:26,030
So you sort of have to have

609
00:22:26,030 --> 00:22:27,800
some level of cosmic evolution perhaps,

610
00:22:27,800 --> 00:22:30,690
but almost certainly other
galaxies will have life as well.

611
00:22:30,690 --> 00:22:33,030
- In your research, in the
signals that you're looking at,

612
00:22:33,030 --> 00:22:33,940
the data you're looking at,

613
00:22:33,940 --> 00:22:36,360
are there signals that could identify

614
00:22:36,360 --> 00:22:39,040
that there's life on this exo planet?

615
00:22:39,040 --> 00:22:40,040
Or are we not there yet?

616
00:22:40,040 --> 00:22:41,260
- I don't think we're there yet.

617
00:22:41,260 --> 00:22:43,230
Right now, we're just sort of at the point

618
00:22:43,230 --> 00:22:45,380
of finding out whether there's water

619
00:22:45,380 --> 00:22:48,410
or no water or lot of
carbon or not much carbon,

620
00:22:48,410 --> 00:22:51,090
I think we're very much
in the qualification

621
00:22:51,090 --> 00:22:52,890

of whether there's actually these elements

622
00:22:52,890 --> 00:22:54,420
in these atmospheres around these planets.

623
00:22:54,420 --> 00:22:55,836
To be honest,

624
00:22:55,836 --> 00:22:56,669
we still haven't actually found a planet

625
00:22:56,669 --> 00:22:57,580
where we can actually safely assume

626
00:22:57,580 --> 00:22:59,249
that it's very much like earth.

627
00:22:59,249 --> 00:23:00,883
When we say we find an Earth-like planet,

628
00:23:00,883 --> 00:23:02,660
what we're saying was
we're finding a planet

629
00:23:02,660 --> 00:23:04,972
that's roughly the same size and radius

630
00:23:04,972 --> 00:23:06,760
as a sphere as the earth.

631
00:23:06,760 --> 00:23:08,520
That doesn't mean it's
not made of a diamond

632
00:23:08,520 --> 00:23:11,630
or is a ball of gas or something else.

633
00:23:11,630 --> 00:23:14,080

We are just at the point
of getting bulk properties.

634
00:23:14,080 --> 00:23:16,114
I think in the next generation,

635
00:23:16,114 --> 00:23:19,320
we'll be getting to the point
where we can start asking,

636
00:23:19,320 --> 00:23:20,990
are we seeing oxygen?

637
00:23:20,990 --> 00:23:22,757
If we see oxygen, that's
a good sign of life.

638
00:23:22,757 --> 00:23:24,400
'Cause we know on earth,

639
00:23:24,400 --> 00:23:25,930
the oxygen in our atmosphere was created

640
00:23:25,930 --> 00:23:28,150
by life forms being here,
anaerobic life forms.

641
00:23:28,150 --> 00:23:30,780
If we see lots of methane or something,

642
00:23:30,780 --> 00:23:32,870
maybe that says something about life

643
00:23:32,870 --> 00:23:34,740
or maybe it's a natural process.

644
00:23:34,740 --> 00:23:36,460
And we saw this controversy
with things like

645
00:23:36,460 --> 00:23:39,510
the idea of the anomal signal on Venus,

646
00:23:39,510 --> 00:23:42,220
where they saw the signal
of this one kind of molecule

647
00:23:42,220 --> 00:23:43,537
that they couldn't explain away.

648
00:23:43,537 --> 00:23:44,470
And to the other script,

649
00:23:44,470 --> 00:23:46,040
didn't really say it was necessarily life,

650
00:23:46,040 --> 00:23:47,620
but that it could be.

651
00:23:47,620 --> 00:23:50,370
When the data analysis
done by other people,

652
00:23:50,370 --> 00:23:52,710
sometimes that signal came, went away.

653
00:23:52,710 --> 00:23:55,320
And so it's hard, we're not
re even really at the point

654
00:23:55,320 --> 00:23:56,879
of having a signal

655
00:23:56,879 --> 00:23:58,610
where we can be sure that
we're getting it right.

656

00:23:58,610 --> 00:24:01,210
- Like in general too,
thinking what you were saying

657
00:24:01,210 --> 00:24:03,940
about how we just often
need to remind ourselves

658
00:24:03,940 --> 00:24:05,700
to broaden our definition.

659
00:24:05,700 --> 00:24:08,420
So if we're just looking for a planet

660
00:24:08,420 --> 00:24:10,720
that's like ours in as
many ways as possible,

661
00:24:10,720 --> 00:24:12,480
we're gonna miss a lot
of things out there.

662
00:24:12,480 --> 00:24:14,120
But I feel like that advice

663
00:24:14,120 --> 00:24:16,470
can apply many places in science,

664
00:24:16,470 --> 00:24:19,100
but maybe just life in
general that if we're looking,

665
00:24:19,100 --> 00:24:21,314
if we're really restricted
in what we're looking for

666
00:24:21,314 --> 00:24:23,980
and we're gonna miss
some other possibilities.

667
00:24:23,980 --> 00:24:24,970
And I guess I'm just wondering

668
00:24:24,970 --> 00:24:28,360
if maybe there's other
examples where kind of changing

669
00:24:28,360 --> 00:24:31,703
that way of thinking could
help us scientifically.

670
00:24:32,791 --> 00:24:34,260
- I think with the search
of life in our solar system,

671
00:24:34,260 --> 00:24:36,360
we tend to focus on Mars and Venus

672
00:24:36,360 --> 00:24:38,190
because they're in the habitable zone,

673
00:24:38,190 --> 00:24:39,890
where we're just the right
distance from the sun,

674
00:24:39,890 --> 00:24:42,008
where we know that water
can exist as a liquid

675
00:24:42,008 --> 00:24:44,210
and a solid and a gas,

676
00:24:44,210 --> 00:24:45,560
but probably the best place

677
00:24:45,560 --> 00:24:47,310
to find life in our solar system,

678

00:24:47,310 --> 00:24:50,120
outside the earth is around
the moons of Jupiter.

679
00:24:50,120 --> 00:24:52,403
We know those moons like Galileo or,

680
00:24:53,280 --> 00:24:56,430
it's solid core, ice shell,

681
00:24:56,430 --> 00:24:58,780
that seems like a very
good spot to find life

682
00:24:58,780 --> 00:25:01,520
because has all the ingredients with ways

683
00:25:01,520 --> 00:25:03,350
of mixing minerals in the water.

684
00:25:03,350 --> 00:25:05,000
So therefore may be forming DNA.

685
00:25:05,000 --> 00:25:06,510
And I think that's
actually the better place

686
00:25:06,510 --> 00:25:07,343
to search for life.

687
00:25:07,343 --> 00:25:10,140
Like Mars might have life, but
it's gonna be hard to find.

688
00:25:10,140 --> 00:25:11,900
But I imagine if we could
go to Europa and ganymede

689
00:25:11,900 --> 00:25:14,740

we could probably go ice
fishing and find life.

690
00:25:14,740 --> 00:25:17,450
So I think that that's
one kind of possibility.

691
00:25:17,450 --> 00:25:19,810
- Is that one of your
motivations behind the research,

692
00:25:19,810 --> 00:25:21,970
is to determine whether there is life

693
00:25:21,970 --> 00:25:24,320
or not life out there or is
it you're more interested

694
00:25:24,320 --> 00:25:26,560
in sort of the stellar astrophysics

695
00:25:26,560 --> 00:25:28,010
and those kind of questions

696
00:25:28,010 --> 00:25:30,500
are a bit more philosophical
for others to ponder?

697
00:25:30,500 --> 00:25:32,170
- I think it depends on
which day of the week it is.

698
00:25:32,170 --> 00:25:34,620
Some days I'm very much about
the stellar astrophysics

699
00:25:34,620 --> 00:25:36,210
side of trying to
understand the properties

700
00:25:36,210 --> 00:25:37,870
with stars and the details there.

701
00:25:37,870 --> 00:25:40,290
And sometimes I really
like the astrobiology

702
00:25:40,290 --> 00:25:42,720
and the idea of trying to understand

703
00:25:42,720 --> 00:25:44,620
the idea of life in our galaxy

704
00:25:44,620 --> 00:25:48,480
and the universe, because
we're part of that.

705
00:25:48,480 --> 00:25:51,302
One of the funny things
about sciences and astronomy

706
00:25:51,302 --> 00:25:52,135
is that we tend to think of ourselves

707
00:25:52,135 --> 00:25:54,300
as being very objective
and we're not really part

708
00:25:54,300 --> 00:25:55,850
of our observations and all that stuff.

709
00:25:55,850 --> 00:25:58,070
But fact that we live in this universe

710
00:25:58,070 --> 00:26:00,495
where we can actually see these things

711
00:26:00,495 --> 00:26:02,040

and have some interaction, so wonderful,

712
00:26:02,040 --> 00:26:04,630
because if we do discover
life on another planet,

713
00:26:04,630 --> 00:26:07,281
then we have to reevaluate our own place,

714
00:26:07,281 --> 00:26:08,860
in the world, in the galaxy.

715
00:26:08,860 --> 00:26:10,910
If we find microbial life on Mars

716
00:26:10,910 --> 00:26:15,133
or some sort of fish life on Europa,

717
00:26:15,133 --> 00:26:17,760
then we have to sort of rethink
all these different things

718
00:26:17,760 --> 00:26:19,070
about our understanding in the universe

719
00:26:19,070 --> 00:26:21,700
and our place into it and
our relationships with it.

720
00:26:21,700 --> 00:26:22,860
'Cause it's very much a problematic,

721
00:26:22,860 --> 00:26:25,350
we're currently in a world
where we're slowly burning it up

722
00:26:25,350 --> 00:26:26,430
with fossil fuels,

723
00:26:26,430 --> 00:26:29,170
where we got rich people sending rockets

724
00:26:29,170 --> 00:26:30,450
into the space all the time

725
00:26:30,450 --> 00:26:33,500
on some sort of weird rich competition.

726
00:26:33,500 --> 00:26:37,350
I think it's the relationships
between our solar system

727
00:26:37,350 --> 00:26:40,830
and us as a society and as a species,

728
00:26:40,830 --> 00:26:42,980
is very valuable and
as part of our makeup.

729
00:26:42,980 --> 00:26:45,520
So I think is also about understanding us.

730
00:26:45,520 --> 00:26:47,070
- I'm really curious to follow up

731
00:26:47,070 --> 00:26:49,010
on what you were saying
about space exploration,

732
00:26:49,010 --> 00:26:51,260
'cause it seems like this is an area

733
00:26:51,260 --> 00:26:52,880
that's just gonna continue growing.

734
00:26:52,880 --> 00:26:56,120
And so do you have ideas

on maybe some things

735
00:26:56,120 --> 00:26:58,560
that we just as a society

736
00:26:58,560 --> 00:27:02,013
should be keeping in mind
as this field is growing?

737
00:27:03,165 --> 00:27:03,998
- One of the big issues right now

738
00:27:03,998 --> 00:27:04,831
with space exploration

739
00:27:04,831 --> 00:27:08,660
is that it's very much
dominated by a few people.

740
00:27:08,660 --> 00:27:12,650
And to be honest, those
people are more privileged.

741
00:27:12,650 --> 00:27:16,580
They're white, they're
almost entirely men.

742
00:27:16,580 --> 00:27:20,170
There's a very certain
power dynamic in play here.

743
00:27:20,170 --> 00:27:22,470
And there's a lot of voices
in the discussion space,

744
00:27:22,470 --> 00:27:25,060
exploration and settlements
that aren't there.

745

00:27:25,060 --> 00:27:28,390
And this is a problem because
we all see the night sky.

746
00:27:28,390 --> 00:27:29,720
It's part of everyone's being.

747
00:27:29,720 --> 00:27:32,010
Indigenous peoples, peoples
from other countries

748
00:27:32,010 --> 00:27:32,960
share the night sky

749
00:27:32,960 --> 00:27:34,250
and we all have our relationship with it,

750
00:27:34,250 --> 00:27:38,090
whether it's our stories, stories
of the moon and the stars,

751
00:27:38,090 --> 00:27:40,602
whether it's our use for navigation,

752
00:27:40,602 --> 00:27:42,050
having all these satellites,

753
00:27:42,050 --> 00:27:43,430
particularly lower earth orbit satellites

754
00:27:43,430 --> 00:27:45,910
that you can see with the
unaided eye and dark spots

755
00:27:45,910 --> 00:27:47,338
or the idea of mining on the moon.

756
00:27:47,338 --> 00:27:49,870
These are all being dictated by people

757
00:27:49,870 --> 00:27:51,400
with certain levels of power.

758
00:27:51,400 --> 00:27:53,541
So right now, my biggest
concern with space exploration

759
00:27:53,541 --> 00:27:56,780
is being dictated by
people with bigger wallets,

760
00:27:56,780 --> 00:27:58,520
as opposed to people with more wisdom.

761
00:27:58,520 --> 00:28:00,510
- Another place where
I know I've heard you

762
00:28:00,510 --> 00:28:02,810
refer to these power dynamics,

763
00:28:02,810 --> 00:28:04,780
is within a term that I think you refer to

764
00:28:04,780 --> 00:28:06,770
as Astro colonialism?

765
00:28:06,770 --> 00:28:08,010
I know this is a slightly different thing,

766
00:28:08,010 --> 00:28:10,370
but can you also talk about what that is?

767
00:28:10,370 --> 00:28:11,577
- When we talk about astronomy

768
00:28:11,577 --> 00:28:13,050

and space science and space.

769
00:28:13,050 --> 00:28:16,480
We have all these kind of
knowledges and understanding

770
00:28:16,480 --> 00:28:18,740
and we talk about them in
terms of a certain perspective

771
00:28:18,740 --> 00:28:20,877
and that perspective
tends to be Eurocentric.

772
00:28:20,877 --> 00:28:23,540
So for instance, let's talk
about the constellations.

773
00:28:23,540 --> 00:28:24,373
In the Northern hemisphere,

774
00:28:24,373 --> 00:28:27,400
we have the big dipper or
Ursa major if you prefer.

775
00:28:27,400 --> 00:28:32,400
We have Cassiopeia,
Cepheus, we have Draco.

776
00:28:32,790 --> 00:28:35,690
They all come from this
one historical context,

777
00:28:35,690 --> 00:28:37,890
largely Greek and Roman astronomy,

778
00:28:37,890 --> 00:28:40,250
and the Greek Romans told great
stories about these things.

779
00:28:40,250 --> 00:28:42,570
And as you travel through
time, those constellations

780
00:28:42,570 --> 00:28:46,460
sort of get maintained through
star maps in European courts,

781
00:28:46,460 --> 00:28:48,987
they became part of
navigation and the oceans.

782
00:28:48,987 --> 00:28:51,760
When we had first
colonization in the Americas

783
00:28:51,760 --> 00:28:52,937
and then the slave trade,

784
00:28:52,937 --> 00:28:55,260
and they kept existing
until the 20th century

785
00:28:55,260 --> 00:28:56,093
when the International
Astronomical Union formed,

786
00:28:56,093 --> 00:28:58,160
which was great.

787
00:28:58,160 --> 00:29:00,090
That was a way of supporting
astronomy worldwide.

788
00:29:00,090 --> 00:29:02,290
But at the time, was essentially
a bunch of white dudes

789
00:29:02,290 --> 00:29:03,840

from Europe and they formed a committee

790
00:29:03,840 --> 00:29:06,240
to let's simplify the night sky

791
00:29:06,240 --> 00:29:08,727
and we'll have 80 constellations,

792
00:29:08,727 --> 00:29:10,020
'cause all these
overlapping constellations.

793
00:29:10,020 --> 00:29:11,900
So they get together in a
room and it's a British guy.

794
00:29:11,900 --> 00:29:13,480
It's a French guy and it's a German guy

795
00:29:13,480 --> 00:29:16,590
and they dictate constellations,
and it's a bad joke.

796
00:29:16,590 --> 00:29:17,730
There are people around the world,

797
00:29:17,730 --> 00:29:20,600
whether it's in Asian
countries and Asian regions,

798
00:29:20,600 --> 00:29:23,280
in the Northern Europe,
indigenous peoples,

799
00:29:23,280 --> 00:29:24,640
and then America's indigenous peoples,

800
00:29:24,640 --> 00:29:27,537
who have our own stories,

own constellations,

801
00:29:27,537 --> 00:29:29,470
but we don't see them anymore.

802
00:29:29,470 --> 00:29:31,700
I open a textbook, I see ursa major,

803
00:29:31,700 --> 00:29:33,940
I do not see my constellations
from Mi'kmaq or Haudenosaunee

804
00:29:33,940 --> 00:29:38,840
constellations or constellations,

805
00:29:38,840 --> 00:29:39,840
that's erasing our stories.

806
00:29:39,840 --> 00:29:41,230
And that's colonialism.

807
00:29:41,230 --> 00:29:44,190
We have colonialism today with
how we deal with telescopes.

808
00:29:44,190 --> 00:29:46,640
All of our telescopes
that particularly Canada

809
00:29:46,640 --> 00:29:48,840
are part of are on indigenous lands.

810
00:29:48,840 --> 00:29:49,970
Across this country, Canada,

811
00:29:49,970 --> 00:29:51,900
whether it's in Hawaii,
whether it's in Chile.

812
00:29:51,900 --> 00:29:53,630
And then we have the
future of colonialism,

813
00:29:53,630 --> 00:29:55,040
which is going to space.

814
00:29:55,040 --> 00:29:57,160
The way we do space exploration
and space settlement

815
00:29:57,160 --> 00:29:59,700
is the exact same narrative that we did

816
00:29:59,700 --> 00:30:02,410
when Canada, the US was being settled,

817
00:30:02,410 --> 00:30:04,750
the pioneer, the frontiersman ship,

818
00:30:04,750 --> 00:30:07,202
the man versus nature element.

819
00:30:07,202 --> 00:30:08,800
- Can you tell us just a little bit

820
00:30:08,800 --> 00:30:11,320
about your own personal
relationship with the night sky?

821
00:30:11,320 --> 00:30:13,260
You know, surely everybody has looked up

822
00:30:13,260 --> 00:30:15,930
and gotten fascinated and
then your own interest,

823
00:30:15,930 --> 00:30:18,960

your growing interest in
indigenous astronomies

824
00:30:18,960 --> 00:30:20,130
and the history of those.

825
00:30:20,130 --> 00:30:22,763
- Yeah, so from my own
perspective, I'm Mi'kmaq,

826
00:30:22,763 --> 00:30:24,405
from Taqamkuk. Taqamkuk

827
00:30:24,405 --> 00:30:26,920
is the island of Newfoundland.

828
00:30:26,920 --> 00:30:28,160
We didn't grow up in community,

829
00:30:28,160 --> 00:30:30,300
it was a lot of settlements.

830
00:30:30,300 --> 00:30:32,940
The Mi'kmaq were spread
out across the island.

831
00:30:32,940 --> 00:30:34,450
So I grew up basically
in suburbia, you know,

832
00:30:34,450 --> 00:30:36,130
watching Mr. Dress up and Much music.

833
00:30:36,130 --> 00:30:38,665
And so I didn't really
have a strong connection

834
00:30:38,665 --> 00:30:39,860
with my heritage and where I come from.

835
00:30:39,860 --> 00:30:41,280
One of the best parts
of Western Newfoundland,

836
00:30:41,280 --> 00:30:43,890
other than Gross Morne and skiing

837
00:30:43,890 --> 00:30:46,627
is clear night skies, seeing the Milky Way

838
00:30:46,627 --> 00:30:49,010
and all the stars, meteor showers,

839
00:30:49,010 --> 00:30:53,680
you see this blanket of
stars, it feels like home.

840
00:30:53,680 --> 00:30:55,400
- And you don't get that in Toronto?

841
00:30:55,400 --> 00:30:58,060
- No, in Toronto I might see four stars

842
00:30:58,060 --> 00:31:00,000
and two of them are on the CBC.

843
00:31:00,000 --> 00:31:02,040
That's kind of relates this mystery

844
00:31:02,040 --> 00:31:04,970
of everything we have relates to astronomy

845
00:31:04,970 --> 00:31:07,210
and understanding where
we're from on earth.

846
00:31:07,210 --> 00:31:08,280

And more recently,

847
00:31:08,280 --> 00:31:10,770
I'd never really thought about
what I meant to be indigenous

848
00:31:10,770 --> 00:31:12,380
and astronomy in physics

849
00:31:12,380 --> 00:31:14,756
until I attended a national conference

850
00:31:14,756 --> 00:31:19,230
of Canadian astronomers in
Winnipeg and a Cree astronomer,

851
00:31:19,230 --> 00:31:22,920
who worked in communities across Manitoba.

852
00:31:22,920 --> 00:31:25,520
He stood on as podium and
started telling us stories.

853
00:31:25,520 --> 00:31:26,710
He's telling us the Cree stories

854
00:31:26,710 --> 00:31:29,350
of the bear and the hunters,

855
00:31:29,350 --> 00:31:31,510
the Cree stories of three dogs,

856
00:31:31,510 --> 00:31:33,490
told us Cree stories of the sweat lodge.

857
00:31:33,490 --> 00:31:34,620
And I was just dumbfounded.

858

00:31:34,620 --> 00:31:36,720
I didn't know my own stories,
I knew nothing about it.

859
00:31:36,720 --> 00:31:37,553
And why didn't I?

860
00:31:37,553 --> 00:31:39,580
I was teaching history of astronomy,

861
00:31:39,580 --> 00:31:41,740
teaching about Aristotle and Galileo

862
00:31:41,740 --> 00:31:44,950
and Copernicus and Tolomi and Newton

863
00:31:44,950 --> 00:31:48,540
and every other white dude
in past thousand years,

864
00:31:48,540 --> 00:31:49,877
where was the indigenous knowledges?

865
00:31:49,877 --> 00:31:53,460
And that kind of inspired
me to really dig in

866
00:31:53,460 --> 00:31:54,720
and start learning,

867
00:31:54,720 --> 00:31:56,850
so that not only so I
can learn indigenous,

868
00:31:56,850 --> 00:31:59,930
but also reconnect to where
I'm from, as I'm getting older,

869
00:31:59,930 --> 00:32:01,800

it's becoming more important
to know where I come from.

870
00:32:01,800 --> 00:32:03,130
It's not just the stories anymore.

871
00:32:03,130 --> 00:32:07,280
It's indigenous methodologies,
how do we do science?

872
00:32:07,280 --> 00:32:08,987
That's not necessarily the same way,

873
00:32:08,987 --> 00:32:10,320
many indigenous peoples,

874
00:32:10,320 --> 00:32:12,280
and there's no one pan
indigenous knowledge system,

875
00:32:12,280 --> 00:32:13,130
but many indigenous peoples

876
00:32:13,130 --> 00:32:14,790
don't necessarily use
the scientific method

877
00:32:14,790 --> 00:32:16,750
to understand the universe,

878
00:32:16,750 --> 00:32:20,750
but different other ways
through long observation,

879
00:32:20,750 --> 00:32:23,655
through learning and time
and oral transmission stories

880
00:32:23,655 --> 00:32:24,860

and thinking about relationships

881
00:32:24,860 --> 00:32:26,880
and all these different possibilities.

882
00:32:26,880 --> 00:32:28,790
In my mind, all these
different doors opened.

883
00:32:28,790 --> 00:32:31,410
And it just felt like
I was rewiring my brain

884
00:32:31,410 --> 00:32:32,840
from the traditional Western science

885
00:32:32,840 --> 00:32:34,480
to maybe something else.

886
00:32:34,480 --> 00:32:36,750
I really began to fall into
that kind of behavior there

887
00:32:36,750 --> 00:32:38,420
and learning my own stories.

888
00:32:38,420 --> 00:32:41,190
And as today, I still
don't know many stories

889
00:32:41,190 --> 00:32:42,990
other than one or two.

890
00:32:42,990 --> 00:32:44,140
- And what would you say are some

891
00:32:44,140 --> 00:32:47,740
of the maybe more Western
practices in science

892
00:32:47,740 --> 00:32:49,790
that are quite different

893
00:32:49,790 --> 00:32:52,080
from some of these indigenous ways

894
00:32:52,080 --> 00:32:53,560
of establishing knowledge?

895
00:32:53,560 --> 00:32:55,110
- There are scholars who produce lists

896
00:32:55,110 --> 00:32:57,110
of these kind of differences.

897
00:32:57,110 --> 00:32:58,500
And I'm just trying to
compile into a couple,

898
00:32:58,500 --> 00:32:59,580
the two most obvious,

899
00:32:59,580 --> 00:33:02,170
but one of most obvious is
I think Western science,

900
00:33:02,170 --> 00:33:04,010
we have to be a objective.

901
00:33:04,010 --> 00:33:07,670
How often do we see this thing
that if I have an experiment,

902
00:33:07,670 --> 00:33:09,840
you should be able to reproduce
it from my notes verbatim,

903

00:33:09,840 --> 00:33:11,570
no matter what, and get the same result.

904
00:33:11,570 --> 00:33:13,780
That's not necessarily something
many indigenous peoples do.

905
00:33:13,780 --> 00:33:14,930
Everything's big relationship,

906
00:33:14,930 --> 00:33:17,070
where I am, what I
observe, what I experiment.

907
00:33:17,070 --> 00:33:18,560
It's not gonna be the same
thing that what you do,

908
00:33:18,560 --> 00:33:19,790
what you see, what you observe.

909
00:33:19,790 --> 00:33:20,800
As we're different people.

910
00:33:20,800 --> 00:33:23,030
So I think that relationality
is very important

911
00:33:23,030 --> 00:33:24,830
for understanding where we
are and where we're going.

912
00:33:24,830 --> 00:33:26,980
And I think Western science
kind of bumps up this

913
00:33:26,980 --> 00:33:29,320
in astrophyics when we talk about,

914

00:33:29,320 --> 00:33:33,073
the fact that the universe
looks the same in all directions

915
00:33:33,073 --> 00:33:34,930
and that kind of bugs us or
the fact that the universe

916
00:33:34,930 --> 00:33:36,313
is just too perfect,

917
00:33:36,313 --> 00:33:39,630
certain quantum mechanical
properties change slightly,

918
00:33:39,630 --> 00:33:41,170
we can't necessarily exist.

919
00:33:41,170 --> 00:33:44,440
So therefore we have to like
get out of that special realm.

920
00:33:44,440 --> 00:33:45,850
And I think that's very much different

921
00:33:45,850 --> 00:33:47,686
between indigenous and Western,

922
00:33:47,686 --> 00:33:49,020
that we have to have that objective idea

923
00:33:49,020 --> 00:33:50,310
where indigenous peoples don't.

924
00:33:50,310 --> 00:33:54,230
A second one partly its
hierarchical nature.

925
00:33:54,230 --> 00:33:58,200

We tend to think of humans
as the apex of nature

926
00:33:58,200 --> 00:33:59,033
and the world.

927
00:33:59,033 --> 00:34:01,330
So humans are above the animals
that are above the plants,

928
00:34:01,330 --> 00:34:04,450
that are above the bugs,
that are above the dirt.

929
00:34:04,450 --> 00:34:06,500
And many indigenous
peoples don't see that.

930
00:34:06,500 --> 00:34:07,950
There are scholars who talk about the fact

931
00:34:07,950 --> 00:34:10,730
that we have treaties with salmon nation

932
00:34:10,730 --> 00:34:13,560
or bear nation Cedar nation.

933
00:34:13,560 --> 00:34:15,500
Thinking about these other species

934
00:34:15,500 --> 00:34:18,560
as having rights to the
land equal to our own,

935
00:34:18,560 --> 00:34:20,930
which for astronomy might not be obvious

936
00:34:20,930 --> 00:34:22,370
how that affects us, but you know,

937
00:34:22,370 --> 00:34:24,626
if we think about environmental
science and climate change,

938
00:34:24,626 --> 00:34:25,880
maybe we can see

939
00:34:25,880 --> 00:34:28,460
how that could be very
valuable perspective.

940
00:34:28,460 --> 00:34:31,221
So those are two kind of
probably the most obvious

941
00:34:31,221 --> 00:34:32,490
differences that come to mind.

942
00:34:32,490 --> 00:34:34,340
- One thing that I kind of think of

943
00:34:34,340 --> 00:34:36,222
when you're talking about this hierarchy

944
00:34:36,222 --> 00:34:39,070
is maybe a related problem
of labeling things.

945
00:34:39,070 --> 00:34:40,370
I know I've heard you say

946
00:34:40,370 --> 00:34:42,410
that some of these indigenous stories,

947
00:34:42,410 --> 00:34:45,110
you don't label that as
being a story about astronomy

948
00:34:45,110 --> 00:34:47,730
or a story about ethics
or a story about hunting.

949
00:34:47,730 --> 00:34:50,650
It's a story about many
things at the same time.

950
00:34:50,650 --> 00:34:53,190
And I feel like in Western society,

951
00:34:53,190 --> 00:34:56,620
we're so obsessed with
classifying things into categories

952
00:34:56,620 --> 00:34:59,570
and labeling them so that
we get to tell ourselves,

953
00:34:59,570 --> 00:35:01,210
do I have to think about that or not?

954
00:35:01,210 --> 00:35:04,890
And just wonder if
there's maybe some cases

955
00:35:04,890 --> 00:35:09,163
you can speak to where that
way of thinking might limit us.

956
00:35:11,180 --> 00:35:12,680
- When we talk about labeling,

957
00:35:12,680 --> 00:35:14,090
I really think of this as siloing

958
00:35:14,090 --> 00:35:15,729
of putting things in boxes.

959
00:35:15,729 --> 00:35:16,562
Like we love putting astronomy box.

960
00:35:16,562 --> 00:35:18,137
Like we started off by
asking, what is astronomy?

961
00:35:18,137 --> 00:35:20,230
And I just said everything above us,

962
00:35:20,230 --> 00:35:22,960
same physics I used to describe
stars is not any different

963
00:35:22,960 --> 00:35:24,300
than the same physics I might describe

964
00:35:24,300 --> 00:35:26,240
to use oceans, same physics I use

965
00:35:26,240 --> 00:35:29,243
to describe orbits going around stars.

966
00:35:29,243 --> 00:35:30,510
It's the same gravity on earth.

967
00:35:30,510 --> 00:35:32,960
Where I think we kind of break down

968
00:35:32,960 --> 00:35:34,930
these kind of recognitions
is when we talk about things

969
00:35:34,930 --> 00:35:36,570
like ethics or we talk about things

970
00:35:36,570 --> 00:35:38,410
like whether we should go to Mars,

971
00:35:38,410 --> 00:35:40,160
we tend to make that to religion.

972
00:35:40,160 --> 00:35:41,990
Respect for land is not
necessarily religion.

973
00:35:41,990 --> 00:35:43,220
It's also scientific.

974
00:35:43,220 --> 00:35:45,510
It is part of understanding
the cycles of connection

975
00:35:45,510 --> 00:35:49,350
that support us for many
Indigenous peoples knowledge,

976
00:35:49,350 --> 00:35:51,580
isn't cycled or isn't siloed.

977
00:35:51,580 --> 00:35:52,650
It's holistic.

978
00:35:52,650 --> 00:35:53,760
And we talk about knowledge.

979
00:35:53,760 --> 00:35:55,480
It can be used in so many different ways.

980
00:35:55,480 --> 00:35:58,480
When I tell a story of the
stars, not necessarily,

981
00:35:58,480 --> 00:36:03,480
I'm not saying that that star is X saying,

982

00:36:04,010 --> 00:36:06,530
or that star is a bear
or that star is a bird,

983
00:36:06,530 --> 00:36:08,310
just telling you about
how it relates to us,

984
00:36:08,310 --> 00:36:12,220
whether how we observe the
star with respect to seasons,

985
00:36:12,220 --> 00:36:13,310
how we talk about ourselves,

986
00:36:13,310 --> 00:36:15,680
how we learn all part
of our way of learning

987
00:36:15,680 --> 00:36:16,790
and gaining knowledge.

988
00:36:16,790 --> 00:36:18,320
In a way that's kind of more narrative

989
00:36:18,320 --> 00:36:20,490
and less direct fact base.

990
00:36:20,490 --> 00:36:23,480
I think that also helps
us relate to these things

991
00:36:23,480 --> 00:36:24,540
and have a connection.

992
00:36:24,540 --> 00:36:27,189
When I mentioned, our
constellations are colonized,

993

00:36:27,189 --> 00:36:29,690
ursaa major is a bear with the tail.

994
00:36:29,690 --> 00:36:31,410
There's no way for us to relate to that.

995
00:36:31,410 --> 00:36:32,450
There are no bears with tails.

996
00:36:32,450 --> 00:36:34,740
Winnie The Pooh does not have a long tail,

997
00:36:34,740 --> 00:36:36,432
but that's our constellation.

998
00:36:36,432 --> 00:36:38,600
So we have to sort of
state it as a factuality.

999
00:36:38,600 --> 00:36:42,580
Whereas in Mi'kmaq we have a
bear and seven bird hunters,

1000
00:36:42,580 --> 00:36:44,660
almost the same constellation
as the big dipper,

1001
00:36:44,660 --> 00:36:47,850
the four stars of the
bowl is Muan the bear.

1002
00:36:47,850 --> 00:36:50,210
And it's called Muan
'cause that's it's name.

1003
00:36:50,210 --> 00:36:51,560
It's the name it tells us.

1004
00:36:51,560 --> 00:36:54,370

'Cause the sound is Muan, which is why,

1005
00:36:54,370 --> 00:36:56,140
one reason why I love
the Mi'kmaq language.

1006
00:36:56,140 --> 00:36:58,010
Most of the names are very, very similar

1007
00:36:58,010 --> 00:37:01,330
to the sounds that they make,
and when we tell that story,

1008
00:37:01,330 --> 00:37:03,610
we tell it at the same
time, every morning,

1009
00:37:03,610 --> 00:37:06,020
couple hours before dawn,
I'm not a morning person,

1010
00:37:06,020 --> 00:37:08,200
but you know, you have to my word on that.

1011
00:37:08,200 --> 00:37:09,280
And that's because, you know,

1012
00:37:09,280 --> 00:37:12,726
the big dipper goes around
the north pole every night.

1013
00:37:12,726 --> 00:37:14,510
But if we tell at the
same time, every morning,

1014
00:37:14,510 --> 00:37:17,570
it goes around the north
pole once every year.

1015

00:37:17,570 --> 00:37:21,130
And if we start in the spring,
Muon is pointing downwards.

1016
00:37:21,130 --> 00:37:23,317
And so when Muon wakes
up from hibernation,

1017
00:37:23,317 --> 00:37:26,500
after so much sleep, Muon is hungry.

1018
00:37:26,500 --> 00:37:27,553
Like anyone would be,

1019
00:37:27,553 --> 00:37:31,600
emerges from her den,
starts looking for food.

1020
00:37:31,600 --> 00:37:33,803
When Robin spies Muan,

1021
00:37:34,740 --> 00:37:37,490
Robin knows that Muan
would feed the community

1022
00:37:37,490 --> 00:37:39,030
for a long time.

1023
00:37:39,030 --> 00:37:40,200
It's meat, it's fat,

1024
00:37:40,200 --> 00:37:43,070
it's grease would help sustain everyone.

1025
00:37:43,070 --> 00:37:44,890
So Robin calls his friends.

1026
00:37:44,890 --> 00:37:46,250
First comes Chickidy,

1027
00:37:46,250 --> 00:37:48,520
carrying a giant pot for cooking Muan.

1028
00:37:48,520 --> 00:37:51,050
And we know this because
Chickidy and the pot

1029
00:37:51,050 --> 00:37:52,748
are two different stars.

1030
00:37:52,748 --> 00:37:53,670
They're very close to each other.

1031
00:37:53,670 --> 00:37:56,050
Following Chickidy is
blue Jay and gray Jay

1032
00:37:56,050 --> 00:38:00,180
and passenger pigeon and
barn arrow and saw wet owl.

1033
00:38:00,180 --> 00:38:02,840
And you know, the birds
that begin this hunt

1034
00:38:02,840 --> 00:38:04,820
and they start chasing Muan.

1035
00:38:04,820 --> 00:38:05,746
We get into the summer,

1036
00:38:05,746 --> 00:38:07,883
the Constellation's kind of flat.

1037
00:38:08,760 --> 00:38:09,960
And so they're running across,

1038

00:38:09,960 --> 00:38:12,160
Muam is running across the land and Robin

1039
00:38:12,160 --> 00:38:13,340
is trying to keep up with his bow

1040
00:38:13,340 --> 00:38:16,270
and arrow and Chickidy's following behind.

1041
00:38:16,270 --> 00:38:18,473
But they're starting to lose the path,

1042
00:38:18,473 --> 00:38:22,390
Muan is starting to escape
and as we get towards fall,

1043
00:38:22,390 --> 00:38:24,280
some of the birds have
fallen away from the hunt

1044
00:38:24,280 --> 00:38:27,260
'cause their stars are below
the horizon at this time,

1045
00:38:27,260 --> 00:38:28,410
but Muon is getting tired.

1046
00:38:28,410 --> 00:38:30,050
So he stands on his hind legs

1047
00:38:30,050 --> 00:38:32,180
and growls and Robin
fires his bow and arrow,

1048
00:38:32,180 --> 00:38:34,690
striking muon in the heart.

1049
00:38:34,690 --> 00:38:37,503
Blood goes everywhere,

covering all the leaves red

1050
00:38:37,503 --> 00:38:40,470
and covering Robin red as well.

1051
00:38:40,470 --> 00:38:42,680
Robin flies into the trees,
shaking the blood off,

1052
00:38:42,680 --> 00:38:45,060
leaving one stain on his chest.

1053
00:38:45,060 --> 00:38:47,440
Muan dies and passes
into the spirit world.

1054
00:38:47,440 --> 00:38:49,740
All the birds gather
and begins celebrating,

1055
00:38:49,740 --> 00:38:51,140
they've been cooking the meat.

1056
00:38:51,140 --> 00:38:52,090
They tell their stories.

1057
00:38:52,090 --> 00:38:54,180
They dance into the
winter and in the winter,

1058
00:38:54,180 --> 00:38:55,800
Muan's in the sky, on his back,

1059
00:38:55,800 --> 00:38:57,950
waiting for the spring and to reemerge,

1060
00:38:57,950 --> 00:39:00,400
this story tells us, but you
know, the motions of the stars,

1061
00:39:00,400 --> 00:39:02,670
it tells us about properties
of some of these stars.

1062
00:39:02,670 --> 00:39:03,790
It tells us about the seasons

1063
00:39:03,790 --> 00:39:05,139
and how we relate to them

1064
00:39:05,139 --> 00:39:08,310
where we're telling the
story in mi'kmaq in this case

1065
00:39:08,310 --> 00:39:10,000
in will be Nova Scotia.

1066
00:39:10,000 --> 00:39:11,790
And it also tells us about ethics.

1067
00:39:11,790 --> 00:39:13,590
Like you don't hunt the bear
in the spring in the summer

1068
00:39:13,590 --> 00:39:17,820
because you know, that's when
it's mating and having cubs,

1069
00:39:17,820 --> 00:39:22,320
you hunt in the fall and it
tells us about community,

1070
00:39:22,320 --> 00:39:23,650
that we share.

1071
00:39:23,650 --> 00:39:25,997
It also honors our
relationship relationships

1072
00:39:25,997 --> 00:39:29,210
with the birds, passenger
pigeons are now extinct,

1073
00:39:29,210 --> 00:39:31,300
but is still part of our
story and our narrative.

1074
00:39:31,300 --> 00:39:33,737
So we honor the birds in that respect.

1075
00:39:33,737 --> 00:39:36,050
And so there's so many
different elements of science

1076
00:39:36,050 --> 00:39:38,983
in here, it's not just a
computer model of a star.

1077
00:39:39,986 --> 00:39:40,990
It's part of how we relate to it.

1078
00:39:40,990 --> 00:39:44,220
- And do you have a sense of
how long it took for that story

1079
00:39:44,220 --> 00:39:47,480
to evolve into the form that
you just shared with us?

1080
00:39:47,480 --> 00:39:49,790
- This is kind of one of the
issues with colonization,

1081
00:39:49,790 --> 00:39:52,140
this story in many
respects was rediscovered,

1082

00:39:52,140 --> 00:39:53,210
maybe about 10 or 20 years ago.

1083
00:39:53,210 --> 00:39:56,980
Now elders in Nova Scotia and researchers

1084
00:39:56,980 --> 00:39:57,870
from Cape Breton university

1085
00:39:57,870 --> 00:39:59,240
came together and sort of rebuilt

1086
00:39:59,240 --> 00:40:02,340
and reconstructed the story,
versions of the story existed,

1087
00:40:02,340 --> 00:40:03,580
but because of colonization,

1088
00:40:03,580 --> 00:40:06,160
so many elements of stories
and knowledge were lost.

1089
00:40:06,160 --> 00:40:10,340
And as the Cree elder, I
mentioned from conference Winnipeg

1090
00:40:10,340 --> 00:40:12,140
once told us, 'cause of colonization,

1091
00:40:12,140 --> 00:40:13,940
you can imagine that if
you had a hundred people

1092
00:40:13,940 --> 00:40:15,190
in the community and every person

1093
00:40:15,190 --> 00:40:16,953
remembered one word of a song,

1094
00:40:18,063 --> 00:40:21,070
80% of the people left the
community for whatever or died

1095
00:40:21,070 --> 00:40:22,030
or whatever, you know,

1096
00:40:22,030 --> 00:40:24,913
you're trying to reconstruct
your song from 20 words.

1097
00:40:25,830 --> 00:40:27,170
It's hard to say how long the story lasts

1098
00:40:27,170 --> 00:40:28,780
because so much was lost.

1099
00:40:28,780 --> 00:40:30,650
And I think we've been
rebuilding our stories

1100
00:40:30,650 --> 00:40:33,060
and reconnecting and rediscovering
them at the same time.

1101
00:40:33,060 --> 00:40:37,980
But also the story can be
as old as time and Memorial,

1102
00:40:37,980 --> 00:40:38,850
as we like to say.

1103
00:40:38,850 --> 00:40:41,170
And so we don't know if
there's what the beginning

1104
00:40:41,170 --> 00:40:42,280
of the story is.

1105
00:40:42,280 --> 00:40:44,400
There's evidence, there are stories

1106
00:40:44,400 --> 00:40:46,700
that are probably tens of
thousands of years old.

1107
00:40:46,700 --> 00:40:49,390
We are all familiar with
the Pleiades constellation,

1108
00:40:49,390 --> 00:40:50,980
wherever you go in the world,

1109
00:40:50,980 --> 00:40:53,750
that constellation is
almost always seven stars.

1110
00:40:53,750 --> 00:40:55,917
Even though most places in the world,

1111
00:40:55,917 --> 00:40:56,780
you can't see the seventh star,

1112
00:40:56,780 --> 00:40:58,550
whether it's in Australia
or north America,

1113
00:40:58,550 --> 00:40:59,720
the stories are so similar.

1114
00:40:59,720 --> 00:41:02,220
There's suggestions that
the stories could be tens

1115
00:41:02,220 --> 00:41:04,120
and hundreds of thousands of years old.

1116
00:41:04,120 --> 00:41:05,780
I don't know how old these stories are,

1117
00:41:05,780 --> 00:41:08,014
but a lot older than me.

1118
00:41:08,014 --> 00:41:09,770
- You teach a course right,

1119
00:41:09,770 --> 00:41:10,890
at the University of Toronto

1120
00:41:10,890 --> 00:41:13,277
about intersections of
indigenous astronomy

1121
00:41:13,277 --> 00:41:14,770
and sort of Western astronomy.

1122
00:41:14,770 --> 00:41:16,680
Can you tell us what you hope students

1123
00:41:16,680 --> 00:41:19,140
take from that course overall.

1124
00:41:19,140 --> 00:41:20,100
- Being in Canada,

1125
00:41:20,100 --> 00:41:23,010
it's so easy to sort of
see indigenous peoples

1126
00:41:24,319 --> 00:41:25,152
and the relationship between

1127
00:41:25,152 --> 00:41:27,600
the nation indigenous peoples
through a certain lens,

1128
00:41:27,600 --> 00:41:31,510
whether it's through reserve
and residential schools,

1129
00:41:31,510 --> 00:41:35,587
whether it's through environmental
actions like the protests

1130
00:41:35,587 --> 00:41:37,170
in British Columbia at the moment,

1131
00:41:37,170 --> 00:41:40,880
we kind of fall into these
almost simplifications

1132
00:41:40,880 --> 00:41:42,430
of stereotypes.

1133
00:41:42,430 --> 00:41:43,780
I think it's so easy in that respect

1134
00:41:43,780 --> 00:41:45,270
for us to forget that
in indigenous peoples

1135
00:41:45,270 --> 00:41:48,520
have been here for tens
of thousands of years,

1136
00:41:48,520 --> 00:41:50,723
have had knowledges and societies

1137
00:41:50,723 --> 00:41:55,070
and sophisticated relationships
with nature and each other

1138
00:41:55,070 --> 00:41:58,690
and other first nations

around north America

1139
00:41:58,690 --> 00:42:00,680
in ways that we tend to forget,

1140
00:42:00,680 --> 00:42:02,120
ideally I'd like to see in the university

1141
00:42:02,120 --> 00:42:03,060
is every department

1142
00:42:03,060 --> 00:42:05,140
had some sort of indigenous
knowledge kind of course,

1143
00:42:05,140 --> 00:42:07,610
so that not necessarily
the indigenous students,

1144
00:42:07,610 --> 00:42:09,414
but also students could come in and see

1145
00:42:09,414 --> 00:42:11,030
the indigenous in their field,

1146
00:42:11,030 --> 00:42:12,300
whether it's indigenous and astronomy,

1147
00:42:12,300 --> 00:42:15,270
indigenous and physics,
indigenous and math and so on.

1148
00:42:15,270 --> 00:42:17,370
And so that when you know,
students leave my class,

1149
00:42:17,370 --> 00:42:19,450
if they're lucky enough to be in a place

1150
00:42:19,450 --> 00:42:21,160
with a dark sky and
they see constellations,

1151
00:42:21,160 --> 00:42:22,810
they're not looking for Ursa major,

1152
00:42:22,810 --> 00:42:24,080
or they're not looking for Draco

1153
00:42:24,080 --> 00:42:26,996
they're looking for
Haudenosaunee constellations or

1154
00:42:26,996 --> 00:42:29,500
anishinaabe constellations.

1155
00:42:29,500 --> 00:42:31,234
And they're remembering those stories

1156
00:42:31,234 --> 00:42:33,950
and doing so remembering
whose land they're on

1157
00:42:33,950 --> 00:42:35,510
and where this land came from.

1158
00:42:35,510 --> 00:42:38,700
And also remembering that
there's not just one way

1159
00:42:38,700 --> 00:42:40,040
to learn about the universe.

1160
00:42:40,040 --> 00:42:43,530
There's many indigenous
ways, different groupings.

1161

00:42:43,530 --> 00:42:45,970
And that thinking about the
universe in different ways

1162
00:42:45,970 --> 00:42:48,190
means we can probably come
up with new discoveries.

1163
00:42:48,190 --> 00:42:50,810
You know, western science
has been a fantastic way

1164
00:42:50,810 --> 00:42:54,880
to understand medicine nature,
the universe and so on.

1165
00:42:54,880 --> 00:42:57,410
Indigenous knowledges are so helpful

1166
00:42:57,410 --> 00:42:59,330
and so much doing it another fantastic way

1167
00:42:59,330 --> 00:43:00,860
and as equal partners.

1168
00:43:00,860 --> 00:43:02,650
And we brought them both together equally.

1169
00:43:02,650 --> 00:43:04,450
We can do so much great science.

1170
00:43:04,450 --> 00:43:06,030
- You wrote that doing this,

1171
00:43:06,030 --> 00:43:09,030
looking into this work in
indigenous astronomies,

1172
00:43:09,030 --> 00:43:11,100

that has made you a better scientist.

1173
00:43:11,100 --> 00:43:11,933
Can you speak to that

1174
00:43:11,933 --> 00:43:14,330
in terms of as a professional scientist,

1175
00:43:14,330 --> 00:43:16,640
how has it enhanced your approach?

1176
00:43:16,640 --> 00:43:18,752
- I think first and foremost,

1177
00:43:18,752 --> 00:43:21,050
our hardest things for scientists

1178
00:43:21,050 --> 00:43:22,640
trained in the Western system to do

1179
00:43:22,640 --> 00:43:24,800
is to understand their biases
and where we come from.

1180
00:43:24,800 --> 00:43:28,370
Undergrad, PhD, 10 years,
where you're doing nothing,

1181
00:43:28,370 --> 00:43:31,470
almost nothing but Western science.

1182
00:43:31,470 --> 00:43:34,610
And so you become sort of embedded in it,

1183
00:43:34,610 --> 00:43:36,260
the fish in the ocean
not knowing there's water

1184

00:43:36,260 --> 00:43:37,130
kind of a problem.

1185
00:43:37,130 --> 00:43:37,963
And I think relearning

1186
00:43:39,070 --> 00:43:40,660
a lot of these indigenous knowledge things

1187
00:43:40,660 --> 00:43:43,320
help has helped me see
a lot of the biases.

1188
00:43:43,320 --> 00:43:46,240
A lot of our assumptions,

1189
00:43:46,240 --> 00:43:48,550
how they're not all that good.

1190
00:43:48,550 --> 00:43:50,240
It also helped me, I think,

1191
00:43:50,240 --> 00:43:53,480
learn a lot more about our
perspective and astronomy.

1192
00:43:53,480 --> 00:43:55,860
We tend to think of astronomy
as this benevolent science

1193
00:43:55,860 --> 00:43:57,240
that we're learning with the universe

1194
00:43:57,240 --> 00:43:59,600
for the betterment of all humanity,

1195
00:43:59,600 --> 00:44:01,270
but we're doing so by building telescopes

1196
00:44:01,270 --> 00:44:03,060
on indigenous lands, we're doing so

1197
00:44:03,060 --> 00:44:05,730
using facilities on indigenous lands.

1198
00:44:05,730 --> 00:44:07,260
We're funding it using money

1199
00:44:07,260 --> 00:44:10,380
raised in various ways
on indigenous lands.

1200
00:44:10,380 --> 00:44:12,076
And I think we need to recognize

1201
00:44:12,076 --> 00:44:14,443
that obligation that comes with that.

1202
00:44:15,330 --> 00:44:17,640
And it's not obvious that we always do.

1203
00:44:17,640 --> 00:44:19,590
So I think it's helping me
become a better scientist,

1204
00:44:19,590 --> 00:44:20,440
'cause it's kind of reminded me

1205
00:44:20,440 --> 00:44:23,073
about the humanity of doing astronomy,

1206
00:44:23,073 --> 00:44:27,146
that it is a human endeavor and as humans,

1207
00:44:27,146 --> 00:44:27,979
whatever biases humanity has

1208
00:44:27,979 --> 00:44:29,541
is gonna come out in our
science in that respect.

1209
00:44:29,541 --> 00:44:31,280
And we need to do better,

1210
00:44:31,280 --> 00:44:34,208
whether it's dealing with
issues around racism and sexism

1211
00:44:34,208 --> 00:44:38,000
or anti indigenism and so
on, we need to do better.

1212
00:44:38,000 --> 00:44:39,150
- The thing you've said too, is that,

1213
00:44:39,150 --> 00:44:41,960
maybe in Western science,
we tend to think one way,

1214
00:44:41,960 --> 00:44:43,890
which leads to a certain set of decisions.

1215
00:44:43,890 --> 00:44:46,070
And with indigenous knowledge,

1216
00:44:46,070 --> 00:44:48,030
we would come to a different decision,

1217
00:44:48,030 --> 00:44:50,180
but maybe really the solution forward

1218
00:44:50,180 --> 00:44:51,890
is having a conversation altogether.

1219
00:44:51,890 --> 00:44:54,730

It doesn't mean we have
to be black and white

1220
00:44:54,730 --> 00:44:56,310
and choose one thing or the other.

1221
00:44:56,310 --> 00:44:59,830
And I think this maybe speaks to a concept

1222
00:44:59,830 --> 00:45:01,970
I've heard you talk about,
which is two eyed seeing.

1223
00:45:01,970 --> 00:45:03,845
Can you talk about what that means?

1224
00:45:03,845 --> 00:45:04,921
- So two eyed seeing is a
concept that was developed

1225
00:45:04,921 --> 00:45:09,921
by elders, Albert and Medina
Marshall, out Eastern Canada.

1226
00:45:11,610 --> 00:45:13,686
They brought it to science with this idea,

1227
00:45:13,686 --> 00:45:16,230
as I'm wearing glasses,
it's very easy to see.

1228
00:45:16,230 --> 00:45:17,760
That if you look through one lens,

1229
00:45:17,760 --> 00:45:20,050
that's Western science and
looking through one lens,

1230
00:45:20,050 --> 00:45:21,540

you do really great science,

1231
00:45:21,540 --> 00:45:22,950
'cause it creates a clear picture

1232
00:45:22,950 --> 00:45:24,050
with various understanding.

1233
00:45:24,050 --> 00:45:26,140
The other lens is indigenous knowledges.

1234
00:45:26,140 --> 00:45:27,880
You can learn about nature in our place

1235
00:45:27,880 --> 00:45:29,350
and do great things that way.

1236
00:45:29,350 --> 00:45:31,450
If you're bring them
together as equal partners,

1237
00:45:31,450 --> 00:45:34,070
listen to each other and work
together and we get a deeper,

1238
00:45:34,070 --> 00:45:36,360
more fuller picture of nature in society.

1239
00:45:36,360 --> 00:45:39,250
And that's the basic
premise of two eyed seeing,

1240
00:45:39,250 --> 00:45:40,320
is just bring them together

1241
00:45:40,320 --> 00:45:41,770
as equal partners to work together.

1242

00:45:41,770 --> 00:45:45,473
And I think we can do great
things that way in science,

1243
00:45:45,473 --> 00:45:49,610
it's very commonly applied to
like environmental sciences,

1244
00:45:49,610 --> 00:45:50,660
more so than astronomy.

1245
00:45:50,660 --> 00:45:52,640
But you know, in terms of learning

1246
00:45:52,640 --> 00:45:53,930
about things like stellar physics

1247
00:45:53,930 --> 00:45:56,080
and exoplanets and life in the universe,

1248
00:45:56,080 --> 00:45:57,817
including indigenous knowledges

1249
00:45:58,919 --> 00:46:00,300
and having that as an equal partner

1250
00:46:00,300 --> 00:46:01,394
means we can think more broadly.

1251
00:46:01,394 --> 00:46:02,935
Whereas if we're doing it from
Western science perspective.

1252
00:46:02,935 --> 00:46:05,890
We're simply gonna look for
various chemical elements

1253
00:46:05,890 --> 00:46:07,160
that we understand like oxygen

1254
00:46:07,160 --> 00:46:08,043
or we're gonna look for things

1255
00:46:08,043 --> 00:46:10,080
that are signs of RNA and DNA.

1256
00:46:10,080 --> 00:46:13,260
And we're gonna go from
this very prescribed Western

1257
00:46:13,260 --> 00:46:15,372
scientific method, but together we can do,

1258
00:46:15,372 --> 00:46:16,320
I think the two of them together

1259
00:46:16,320 --> 00:46:19,280
do much better and much fuller science.

1260
00:46:19,280 --> 00:46:22,200
- And in addition to maybe challenging

1261
00:46:22,200 --> 00:46:24,520
the way we present history
or different topics,

1262
00:46:24,520 --> 00:46:27,667
we also have to challenge our
actual scientific process.

1263
00:46:27,667 --> 00:46:29,450
And that just seems like such a difficult

1264
00:46:29,450 --> 00:46:31,610
and fundamental thing to change.

1265
00:46:31,610 --> 00:46:33,340

'Cause I think so many
of us don't even know

1266
00:46:33,340 --> 00:46:36,170
how to define the process that we follow.

1267
00:46:36,170 --> 00:46:37,430
So how do we do that?

1268
00:46:37,430 --> 00:46:40,370
How do we start challenging
our scientific process

1269
00:46:40,370 --> 00:46:44,040
or even understanding what
assumptions we're making?

1270
00:46:44,040 --> 00:46:48,710
- Another very easy question,
it's hard, you know,

1271
00:46:48,710 --> 00:46:51,470
we're so trained in a
certain way of doing science.

1272
00:46:51,470 --> 00:46:54,420
And we tend to like to talk
about it as a scientific method

1273
00:46:54,420 --> 00:46:58,306
where we see something and
then we hypothesize something

1274
00:46:58,306 --> 00:46:59,139
and then we have an experiment

1275
00:46:59,139 --> 00:47:01,880
and we have to falsify
and always be falsifying.

1276
00:47:01,880 --> 00:47:04,440
It's important to recognize
that that's one way

1277
00:47:04,440 --> 00:47:05,821
of doing science, but even
when we're doing science

1278
00:47:05,821 --> 00:47:06,819
in our classrooms,

1279
00:47:06,819 --> 00:47:10,548
we're writing on chalkboards
or typing on our computers,

1280
00:47:10,548 --> 00:47:12,410
we might not be using
the scientific method

1281
00:47:12,410 --> 00:47:15,150
in the same way and we
might not even notice.

1282
00:47:15,150 --> 00:47:17,490
So, you know, I think
taking the time to reflect

1283
00:47:17,490 --> 00:47:21,040
on what we're doing is one
step, perhaps the most important

1284
00:47:21,040 --> 00:47:22,750
what we need to do

1285
00:47:22,750 --> 00:47:25,823
is to sort of seed some of
our authority as scientists.

1286
00:47:27,000 --> 00:47:29,550

There are elders and knowledge
keepers across Rhode Island

1287
00:47:29,550 --> 00:47:31,702
in north America and the Americas,

1288
00:47:31,702 --> 00:47:33,691
have great understanding
of science and nature,

1289
00:47:33,691 --> 00:47:37,220
from where they are at to
where they're going and so on.

1290
00:47:37,220 --> 00:47:39,580
And we need to spend more time listening

1291
00:47:39,580 --> 00:47:41,110
and supporting them.

1292
00:47:41,110 --> 00:47:42,610
And I think that would go a long way

1293
00:47:42,610 --> 00:47:44,690
into helping us be better scientists

1294
00:47:44,690 --> 00:47:46,763
and see the assumptions we're making.

1295
00:47:47,690 --> 00:47:49,230
As a scientist, that's hard, you know,

1296
00:47:49,230 --> 00:47:52,440
we're not used to being
quiet and listening,

1297
00:47:52,440 --> 00:47:53,636
at least I'm not.

1298
00:47:53,636 --> 00:47:55,940
- I mean, you must have gone through

1299
00:47:55,940 --> 00:47:57,370
some of that process yourself.

1300
00:47:57,370 --> 00:47:59,640
If you said that it was at this conference

1301
00:47:59,640 --> 00:48:02,066
where maybe you first started to realize

1302
00:48:02,066 --> 00:48:04,560
that there was a different
way of thinking about things.

1303
00:48:04,560 --> 00:48:06,620
Were there any things that you realized

1304
00:48:06,620 --> 00:48:09,550
about your own thinking
that have really helped you?

1305
00:48:09,550 --> 00:48:12,430
I guess this must involve some unlearning

1306
00:48:12,430 --> 00:48:14,720
of ways that we're used to thinking.

1307
00:48:14,720 --> 00:48:15,700
- For you personally,

1308
00:48:15,700 --> 00:48:20,530
if you had to unlearn some bad
habits or old habits, maybe.

1309
00:48:20,530 --> 00:48:23,250
- Yeah, I think unlearning is

a very good way putting it.

1310
00:48:23,250 --> 00:48:26,440
I felt like I had unlearn a lot of my PhD,

1311
00:48:26,440 --> 00:48:29,990
which was a little ironic, but.

1312
00:48:29,990 --> 00:48:32,730
- Wait, why did you have
to unlearn your PhD?

1313
00:48:32,730 --> 00:48:35,450
- Because my PhD was
defined on here's data,

1314
00:48:35,450 --> 00:48:37,410
here's a computer, apply data fit,

1315
00:48:37,410 --> 00:48:39,355
draw conclusions, repeat.

1316
00:48:39,355 --> 00:48:40,353
- Get PhD.

1317
00:48:40,353 --> 00:48:41,905
- Get PhD, get out.

1318
00:48:41,905 --> 00:48:45,860
But I think it was also trying
to understand sitting there,

1319
00:48:45,860 --> 00:48:49,180
instead of seeing it as
data, seeing it as a story,

1320
00:48:49,180 --> 00:48:51,903
seeing it as a relationship,

1321
00:48:51,903 --> 00:48:54,670
part of my PhD was studying,
variable stars called,

1322
00:48:54,670 --> 00:48:56,801
in which are pulsating variables

1323
00:48:56,801 --> 00:49:00,040
and their pulsation can be
used to measure distances

1324
00:49:00,040 --> 00:49:01,460
when doing cosmology.

1325
00:49:01,460 --> 00:49:03,030
And so, so much of my time I spent

1326
00:49:03,030 --> 00:49:03,907
understanding some of the physics

1327
00:49:03,907 --> 00:49:05,840
and that doing the mathematical equations

1328
00:49:05,840 --> 00:49:09,080
and trying to apply this
as a theory and a test.

1329
00:49:09,080 --> 00:49:10,560
And I think part the unlearning,

1330
00:49:10,560 --> 00:49:13,700
I was just coming back and
asking, okay, is this reasonable?

1331
00:49:13,700 --> 00:49:15,660
What is this telling me
about the relationship

1332

00:49:15,660 --> 00:49:18,823
between the star and the
distance and all these things.

1333
00:49:19,991 --> 00:49:21,380
It might not sound like there's
a really big difference,

1334
00:49:21,380 --> 00:49:23,421
but I think it's just the slowing down

1335
00:49:23,421 --> 00:49:26,880
and sort of appreciating a
lot more about the time issues

1336
00:49:26,880 --> 00:49:30,180
and the constraints of
what I was trying to do,

1337
00:49:30,180 --> 00:49:32,270
as opposed to just plugging
into computer model

1338
00:49:32,270 --> 00:49:34,910
and being done and being happy.

1339
00:49:34,910 --> 00:49:36,460
- You shut up and calculate model.

1340
00:49:36,460 --> 00:49:37,293
- The shut up.

1341
00:49:37,293 --> 00:49:39,100
- Don't think too much
about it, just do the math.

1342
00:49:39,100 --> 00:49:41,270
- Yeah, so the math and trust the math,

1343

00:49:41,270 --> 00:49:42,103
which we should trust our math

1344
00:49:42,103 --> 00:49:44,480
when we're on the right track.

1345
00:49:44,480 --> 00:49:46,350
But I think we also should
understand what the math

1346
00:49:46,350 --> 00:49:47,839
is saying, what the story is,

1347
00:49:47,839 --> 00:49:50,070
and that doesn't make the results wrong,

1348
00:49:50,070 --> 00:49:51,900
but I think it changes
how I relate to them

1349
00:49:51,900 --> 00:49:54,360
and how kind of important
it is in some respects too.

1350
00:49:54,360 --> 00:49:55,610
'cause I think when we're doing a PhD,

1351
00:49:55,610 --> 00:49:57,400
we all want to think we're gonna change

1352
00:49:57,400 --> 00:49:58,748
our understanding of the universe.

1353
00:49:58,748 --> 00:50:01,830
And I think it was a lot of
it's also bit of unlearning

1354
00:50:01,830 --> 00:50:03,570
about the tools we're using.

1355
00:50:03,570 --> 00:50:05,580
Part of that thesis was using observations

1356
00:50:05,580 --> 00:50:09,130
from optical interferometers in California

1357
00:50:09,130 --> 00:50:12,570
or data from the Hawaii telescope.

1358
00:50:12,570 --> 00:50:13,960
Part of that unlearning
means I have to understand

1359
00:50:13,960 --> 00:50:14,793
the history.

1360
00:50:15,841 --> 00:50:17,162
If our telescopes are on,

1361
00:50:17,162 --> 00:50:18,930
like Mauna Kea what are we doing there?

1362
00:50:18,930 --> 00:50:20,280
And do we have that right?

1363
00:50:20,280 --> 00:50:24,110
And what is the local
perspective on Mauna Kea,

1364
00:50:24,110 --> 00:50:26,220
and which can be very different
than us as astronomers

1365
00:50:26,220 --> 00:50:28,200
and scientists from Canada.

1366
00:50:28,200 --> 00:50:31,210

And so I think unlearning a
lot of that sort of hierarchy

1367
00:50:31,210 --> 00:50:34,810
and some superiority of
science was very important.

1368
00:50:34,810 --> 00:50:37,630
Also learning more to trust less

1369
00:50:38,902 --> 00:50:41,210
the word doctor and trust
more of the word elder.

1370
00:50:41,210 --> 00:50:42,610
- We've asked a lot of questions.

1371
00:50:42,610 --> 00:50:46,470
We also got some great
questions from others.

1372
00:50:46,470 --> 00:50:47,971
- Yeah, we have a couple questions.

1373
00:50:47,971 --> 00:50:49,390
- Can we play those for
you over the air here?

1374
00:50:49,390 --> 00:50:50,712
- For sure.

1375
00:50:50,712 --> 00:50:51,709
- Sure.

1376
00:50:51,709 --> 00:50:53,640
- You say you integrate
indigenous knowledge

1377
00:50:53,640 --> 00:50:55,370

in your physics research.

1378
00:50:55,370 --> 00:50:58,051
Do you also integrate
your scientific insights

1379
00:50:58,051 --> 00:51:00,911
back into your indigenous community

1380
00:51:00,911 --> 00:51:05,911
and thus reshape its worldview
on stars and the universe?

1381
00:51:07,030 --> 00:51:07,890
- That's a very interesting question.

1382
00:51:07,890 --> 00:51:09,760
One of the things I try not to do

1383
00:51:09,760 --> 00:51:12,410
is to bring too much Western science

1384
00:51:12,410 --> 00:51:13,755
into indigenous communities.

1385
00:51:13,755 --> 00:51:17,120
We do that already, it's
called being in Canada,

1386
00:51:17,120 --> 00:51:20,069
but one of the things I
do think is very important

1387
00:51:20,069 --> 00:51:20,902
that we should be working towards

1388
00:51:20,902 --> 00:51:22,480
is thinking about what resources

1389
00:51:22,480 --> 00:51:24,608
and tools can we give
indigenous communities

1390
00:51:24,608 --> 00:51:27,880
to do science as they see
fit in their community.

1391
00:51:27,880 --> 00:51:31,220
So what would it mean if we
had a one meter telescope,

1392
00:51:31,220 --> 00:51:33,430
class telescope with a nice,

1393
00:51:33,430 --> 00:51:36,140
sitting in an indigenous community,

1394
00:51:36,140 --> 00:51:37,820
where they can design
their own experiments,

1395
00:51:37,820 --> 00:51:38,980
their own observations,

1396
00:51:38,980 --> 00:51:41,410
their own calculations and write
their own journal articles.

1397
00:51:41,410 --> 00:51:44,260
However they see fit. I think
that would be kind of cool.

1398
00:51:45,110 --> 00:51:46,620
And I think that's kind of
where we should be going

1399
00:51:46,620 --> 00:51:48,850
as scientists in engaging in communities

1400
00:51:48,850 --> 00:51:53,000
is how we share our resources,
not necessarily our results.

1401
00:51:53,000 --> 00:51:54,980
- I should have said too,
that question was from Anna.

1402
00:51:54,980 --> 00:51:58,560
And she's one of our master
students in our PSI program.

1403
00:51:58,560 --> 00:51:59,870
We have one more question for you

1404
00:51:59,870 --> 00:52:02,830
from another one of our graduate students.

1405
00:52:02,830 --> 00:52:05,767
- Hi, I'm Barbara and
I'm a PhD student at PI.

1406
00:52:05,767 --> 00:52:09,825
I was wondering if there
is a star in the sky

1407
00:52:09,825 --> 00:52:12,403
that first catches your
eye when you look up.

1408
00:52:13,790 --> 00:52:15,233
- Living in Toronto,
there's only so many stars

1409
00:52:15,233 --> 00:52:17,120
that can catch my eye at the moment.

1410
00:52:17,120 --> 00:52:20,803

So probably if I can find it,
it's usually a Betelgeuse.

1411
00:52:21,970 --> 00:52:23,680
When I'm in a darker spot,

1412
00:52:23,680 --> 00:52:26,190
I always look for the north star.

1413
00:52:26,190 --> 00:52:28,740
So much of my research, my PhD and so on,

1414
00:52:28,740 --> 00:52:30,540
ended up working on the north star

1415
00:52:30,540 --> 00:52:32,740
'cause it's a cepheid variable.

1416
00:52:32,740 --> 00:52:34,750
So I'm always sort of enamored by it

1417
00:52:34,750 --> 00:52:36,120
'cause it's also a guiding star.

1418
00:52:36,120 --> 00:52:38,500
So it carries so much meaning to me,

1419
00:52:38,500 --> 00:52:40,270
both science and personally,

1420
00:52:40,270 --> 00:52:42,820
'case it personally as a guide star,

1421
00:52:42,820 --> 00:52:44,486
but also personally part of our language.

1422
00:52:44,486 --> 00:52:46,144
Cause in Mi'kmaq, we call it tatapn,

1423
00:52:46,144 --> 00:52:48,313
and so it kind of connects

1424
00:52:48,313 --> 00:52:51,460
all these different
parts of my personality.

1425
00:52:51,460 --> 00:52:53,110
- Does that mean north star?

1426
00:52:53,110 --> 00:52:53,943
Does it have a different meaning?

1427
00:52:53,943 --> 00:52:55,002
- It's been so long since
I did the definition,

1428
00:52:56,356 --> 00:52:57,630
but I think it star of the stands still,

1429
00:52:57,630 --> 00:52:59,130
so effectively north star.

1430
00:52:59,130 --> 00:53:00,060
- Yeah.

1431
00:53:00,060 --> 00:53:01,540
- Well Hilding thank you so much

1432
00:53:01,540 --> 00:53:03,230
for sharing your time with us.

1433
00:53:03,230 --> 00:53:05,290
I've learned a lot from talking to you

1434
00:53:05,290 --> 00:53:08,880
and it was really a pleasure

to sit down with you today.

1435
00:53:08,880 --> 00:53:09,880
- Thank you so much.

1436
00:53:14,316 --> 00:53:16,811
- Thanks for stepping
inside the Perimeter.

1437
00:53:16,811 --> 00:53:18,312
If you like, what you hear,

1438
00:53:18,312 --> 00:53:20,218
please help us spread the word.

1439
00:53:20,218 --> 00:53:22,890
You can rate, review and subscribe

1440
00:53:22,890 --> 00:53:24,660
to Conversations at the Perimeter,

1441
00:53:24,660 --> 00:53:27,040
wherever you get your podcast.

1442
00:53:27,040 --> 00:53:28,863
Every review really helps us a lot

1443
00:53:28,863 --> 00:53:32,180
and it helps more science
enthusiasts find us.

1444
00:53:32,180 --> 00:53:34,691
Thank you for being part of the equation.

1445
00:53:34,691 --> 00:53:37,274
(gentle music)