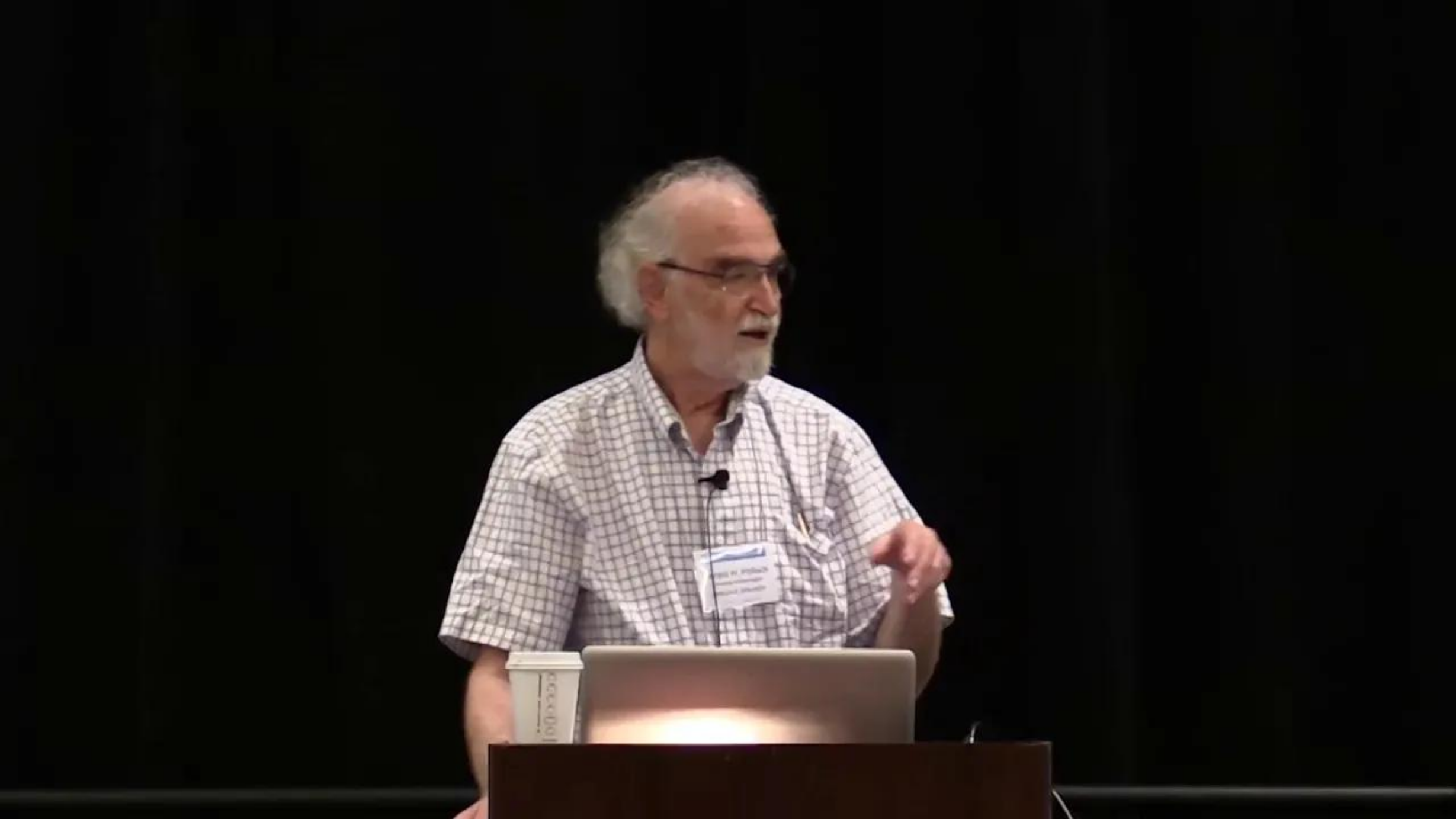

1
00:00:25,030 --> 00:00:16,080
[Music]

2
00:00:26,470 --> 00:00:25,040
there's a real honor and I can't tell

3
00:00:28,960 --> 00:00:26,480
you how much is appreciated and

4
00:00:30,609 --> 00:00:28,970
Garrett's introduction reminded me I'm

5
00:00:34,630 --> 00:00:30,619
using up my precious time which is

6
00:00:37,180 --> 00:00:34,640
already ten minutes used that the

7
00:00:39,130 --> 00:00:37,190
Institute for venture science is

8
00:00:40,840 --> 00:00:39,140
actually coming into being what he

9
00:00:44,620 --> 00:00:40,850
mentioned earlier and there will be a

10
00:00:46,810 --> 00:00:44,630
website that will be published in about

11
00:00:49,170 --> 00:00:46,820
two or three weeks and this is going to

12
00:00:53,590 --> 00:00:49,180
be a major Institute and it's designed

13
00:00:55,990 --> 00:00:53,600

designed to to fund promising ideas that

14
00:00:57,729 --> 00:00:56,000
challenge conventional thinking so

15
00:01:00,520 --> 00:00:57,739
please look out for it I think you

16
00:01:03,670 --> 00:01:00,530
people will be quite interested okay so

17
00:01:05,740 --> 00:01:03,680
I want to talk about water and since I I

18
00:01:08,440 --> 00:01:05,750
couldn't find water around here I have a

19
00:01:12,370 --> 00:01:08,450
prop please pretend that this is water

20
00:01:14,139 --> 00:01:12,380
okay is my problem so well most of you

21
00:01:18,520 --> 00:01:14,149
probably think or some of you probably

22
00:01:20,709 --> 00:01:18,530
think that that everything that to be

23
00:01:23,830 --> 00:01:20,719
known about water must already be known

24
00:01:26,319 --> 00:01:23,840
because you know water is the most

25
00:01:28,899 --> 00:01:26,329
common substance on the face of the

26
00:01:30,219 --> 00:01:28,909
earth and and it's around and it's

27
00:01:31,779 --> 00:01:30,229
everywhere and I want to start by

28
00:01:33,340 --> 00:01:31,789
demonstrating to you that your

29
00:01:36,550 --> 00:01:33,350
assumption that everything is known

30
00:01:38,859 --> 00:01:36,560
about water is not correct okay so here

31
00:01:41,319 --> 00:01:38,869
are three three challenges for you and

32
00:01:44,169 --> 00:01:41,329
tell me if you can explain these okay we

33
00:01:47,620 --> 00:01:44,179
start with a cloud that you can always

34
00:01:50,709 --> 00:01:47,630
see and the issue is this you know the

35
00:01:52,870 --> 00:01:50,719
water is rising from everywhere and so

36
00:01:54,699 --> 00:01:52,880
how is it possible that there's only one

37
00:01:56,289 --> 00:01:54,709
cloud how come there's no cloud here

38
00:01:58,330 --> 00:01:56,299

this is all the water gets sucked into

39
00:02:01,019 --> 00:01:58,340
this one and how come we don't

40
00:02:05,080 --> 00:02:01,029
understand this we see it every day

41
00:02:08,410 --> 00:02:05,090
here's another case we have droplets of

42
00:02:10,480 --> 00:02:08,420
water heating water and of course

43
00:02:12,550 --> 00:02:10,490
everybody knows they coalesce instantly

44
00:02:14,800 --> 00:02:12,560
but you see that they don't coalesce

45
00:02:18,550 --> 00:02:14,810
instantly it depends on the situation

46
00:02:20,280 --> 00:02:18,560
and how do we explain this another case

47
00:02:22,050 --> 00:02:20,290
which is well known to one or

48
00:02:26,250 --> 00:02:22,060
two of the people in the audience's

49
00:02:28,289 --> 00:02:26,260
Elmar Fuchs is water water bridge and so

50
00:02:30,449 --> 00:02:28,299
it's very simple you put kill the

51
00:02:33,860 --> 00:02:30,459
beakers with water put two electrodes

52
00:02:36,179 --> 00:02:33,870
and put a high voltage between them and

53
00:02:38,550 --> 00:02:36,189
when you turn on the high voltage you

54
00:02:40,649 --> 00:02:38,560
get a bridge this is water and if you

55
00:02:43,890 --> 00:02:40,659
separate one of the beakers from the

56
00:02:45,960 --> 00:02:43,900
other beaker the bridge sustains itself

57
00:02:48,660 --> 00:02:45,970
and it's the same as itself for

58
00:02:51,119 --> 00:02:48,670
effectively indefinitely for distances

59
00:02:54,420 --> 00:02:51,129
up to about four centimeters this is

60
00:02:56,490 --> 00:02:54,430
water how come how come we don't

61
00:02:59,339 --> 00:02:56,500
understand what's going on here

62
00:03:01,770 --> 00:02:59,349
so I mean that that's the point is is

63
00:03:04,589 --> 00:03:01,780

that there are a lot of observations

64
00:03:06,030 --> 00:03:04,599
which which escape our understanding so

65
00:03:08,759 --> 00:03:06,040
we really don't know all there is to

66
00:03:11,429 --> 00:03:08,769
know about water we started with water

67
00:03:14,909 --> 00:03:11,439
or this book which was published in 2001

68
00:03:17,729 --> 00:03:14,919
and the book described the role of water

69
00:03:19,830 --> 00:03:17,739
in biology when people learn biology

70
00:03:22,289 --> 00:03:19,840
they learned that water is practically

71
00:03:24,059 --> 00:03:22,299
meaningless they learned that water is

72
00:03:25,979 --> 00:03:24,069
the background carrier of the most

73
00:03:28,319 --> 00:03:25,989
important molecules of life but as a

74
00:03:30,210 --> 00:03:28,329
reactant or something central to biology

75
00:03:32,280 --> 00:03:30,220
forget it it's not interesting you can

76
00:03:34,649 --> 00:03:32,290
even almost have trouble finding the

77
00:03:38,009 --> 00:03:34,659
word water and the index of some books

78
00:03:40,439 --> 00:03:38,019
well the evidence is not in favor of

79
00:03:45,240 --> 00:03:40,449
that and the book was designed to show

80
00:03:46,920 --> 00:03:45,250
the central the central that water is

81
00:03:50,039 --> 00:03:46,930
absolutely central to all that goes on

82
00:03:52,409 --> 00:03:50,049
in biology and one of the main concepts

83
00:03:54,689 --> 00:03:52,419
in the book which was taken from the

84
00:03:58,229 --> 00:03:54,699
extensive work of one Gilbert Lange

85
00:04:00,119 --> 00:03:58,239
who's now 95 years old and the idea is

86
00:04:02,219 --> 00:04:00,129
that inside the cell the cell is a very

87
00:04:05,219 --> 00:04:02,229
dense matrix of proteins and next to

88
00:04:07,740 --> 00:04:05,229

each protein and other natural macro

89
00:04:10,409 --> 00:04:07,750
molecular surface the water molecules

90
00:04:13,949 --> 00:04:10,419
are not just like water in in the glass

91
00:04:15,990 --> 00:04:13,959
they're they're actually ordered in some

92
00:04:18,060 --> 00:04:16,000
way so the water is represented here by

93
00:04:20,580 --> 00:04:18,070
a dipole and so you can see the dipoles

94
00:04:22,230 --> 00:04:20,590
are are kind of ordered then eventually

95
00:04:25,050 --> 00:04:22,240
they get disordered with some distance

96
00:04:27,689 --> 00:04:25,060
and we were curious despite the fact

97
00:04:29,640 --> 00:04:27,699
that this the evidence points to the

98
00:04:33,410 --> 00:04:29,650
fact that this is the way the water is

99
00:04:35,930 --> 00:04:33,420
inside cells your cells the water is

100
00:04:38,990 --> 00:04:35,940
ordered we wanted to find out more about

101
00:04:41,120 --> 00:04:39,000
this this kind of water and one of the

102
00:04:42,560 --> 00:04:41,130
chief characteristics of this is that

103
00:04:44,960 --> 00:04:42,570
because this water is just like the

104
00:04:47,480 --> 00:04:44,970
crystal the molecules are lined up

105
00:04:48,950 --> 00:04:47,490
crystals tend to exclude solutes and so

106
00:04:51,680 --> 00:04:48,960
one of the very well-established

107
00:04:54,710 --> 00:04:51,690
features of this is that solutes are

108
00:04:56,330 --> 00:04:54,720
excluded so so we came with that that

109
00:04:58,850 --> 00:04:56,340
presumption and we came upon an

110
00:05:03,290 --> 00:04:58,860
experimental way of studying this water

111
00:05:09,290 --> 00:05:03,300
and the results amazed us so that that's

112
00:05:11,330 --> 00:05:09,300
a in a chamber whoops my pointer is seem

113
00:05:13,280 --> 00:05:11,340

to have lost it anyway

114
00:05:15,230 --> 00:05:13,290
oh here we go you have a jail that you

115
00:05:17,960 --> 00:05:15,240
put in the water and we noticed that and

116
00:05:20,780 --> 00:05:17,970
here's water actually this is water plus

117
00:05:23,870 --> 00:05:20,790
some particles and we use microspheres

118
00:05:25,490 --> 00:05:23,880
little 1 micrometer spheres that we put

119
00:05:28,310 --> 00:05:25,500
in the water we notice that there could

120
00:05:30,500 --> 00:05:28,320
be a zone where these are excluded so we

121
00:05:32,480 --> 00:05:30,510
thought well perhaps this might have

122
00:05:34,640 --> 00:05:32,490
something to do with the region of

123
00:05:37,130 --> 00:05:34,650
ordered water but there was more to it

124
00:05:38,570 --> 00:05:37,140
we found that as soon as we put the

125
00:05:40,340 --> 00:05:38,580
microspheres in water in the

126
00:05:43,700 --> 00:05:40,350
microspheres were excluded they were

127
00:05:47,120 --> 00:05:43,710
pushed out of this growing zone and and

128
00:05:50,480 --> 00:05:47,130
we had this seemingly gigantic zone 50

129
00:05:53,240 --> 00:05:50,490
60 micrometers which which would be huge

130
00:05:55,540 --> 00:05:53,250
numbers of water molecules that were

131
00:05:57,800 --> 00:05:55,550
pushing this out and and and these

132
00:06:00,200 --> 00:05:57,810
microspheres remained here they would

133
00:06:01,970 --> 00:06:00,210
never go back in into this region they

134
00:06:05,120 --> 00:06:01,980
would show Brownian motion of all sorts

135
00:06:07,880 --> 00:06:05,130
but would not return to this so because

136
00:06:11,570 --> 00:06:07,890
the particles were excluded we call this

137
00:06:15,950 --> 00:06:11,580
the exclusion zone or easy easy to

138
00:06:18,320 --> 00:06:15,960

remember so we we stuck with this so we

139
00:06:19,730 --> 00:06:18,330
tried another another sample instead of

140
00:06:21,530 --> 00:06:19,740
the gel that you see here which was a

141
00:06:25,070 --> 00:06:21,540
polyvinyl alcohol this was the first

142
00:06:27,170 --> 00:06:25,080
record that we got we used a sheet of

143
00:06:29,420 --> 00:06:27,180
naffy on naffy on you'll see a lot of

144
00:06:31,190 --> 00:06:29,430
Navion because it turns out to be really

145
00:06:33,290 --> 00:06:31,200
convenient it's a polymer that's a bit

146
00:06:35,870 --> 00:06:33,300
like teflon but it has sulfonate groups

147
00:06:38,090 --> 00:06:35,880
it's charged it comes in sheets so you

148
00:06:40,880 --> 00:06:38,100
can cut the sheet out into for example

149
00:06:43,720 --> 00:06:40,890
into something of this shape plunk it

150
00:06:46,370 --> 00:06:43,730
down in the chamber add the water and

151
00:06:47,390 --> 00:06:46,380
microspheres and when you do that as

152
00:06:52,970 --> 00:06:47,400
soon as you

153
00:06:56,300 --> 00:06:52,980
what happens is this and this exclusion

154
00:06:58,700 --> 00:06:56,310
zone can grow up to half a millimetre

155
00:07:01,940 --> 00:06:58,710
you can see it with your naked eye you

156
00:07:04,430 --> 00:07:01,950
don't you don't need a microscope this

157
00:07:07,540 --> 00:07:04,440
is taken through the microscope anyway

158
00:07:09,800 --> 00:07:07,550
this this seemed to be to us to be a

159
00:07:12,080 --> 00:07:09,810
astounding observation because we

160
00:07:13,760 --> 00:07:12,090
thought nobody had seen this before it

161
00:07:15,920 --> 00:07:13,770
turns out there was a paper published in

162
00:07:18,470 --> 00:07:15,930
1970 in the Journal of physiology that

163
00:07:21,440 --> 00:07:18,480

demonstrated exactly this and by now a

164
00:07:23,000 --> 00:07:21,450
lot of people have tried this and have

165
00:07:27,230 --> 00:07:23,010
confirmed that there is an exclusion

166
00:07:28,010 --> 00:07:27,240
zone so the question is what is it all

167
00:07:31,190 --> 00:07:28,020
about

168
00:07:33,160 --> 00:07:31,200
is the exclusion phenomenon general or

169
00:07:36,560 --> 00:07:33,170
just those couple of slides I showed

170
00:07:41,300 --> 00:07:36,570
does it really arise from the ordering

171
00:07:42,950 --> 00:07:41,310
of water can water ordering explain

172
00:07:45,410 --> 00:07:42,960
those first three slides that I showed

173
00:07:47,660 --> 00:07:45,420
you and in order to create order you

174
00:07:51,500 --> 00:07:47,670
need energy so where does the energy

175
00:07:54,110 --> 00:07:51,510
come from it's not obvious and might

176
00:07:55,610 --> 00:07:54,120
these findings apply broadly over nature

177
00:08:01,640 --> 00:07:55,620
so for the first question about

178
00:08:04,250 --> 00:08:01,650
generality we've to summarize we've

179
00:08:06,770 --> 00:08:04,260
looked at many surfaces many jails at

180
00:08:10,460 --> 00:08:06,780
least a dozen different gels various

181
00:08:12,140 --> 00:08:10,470
polymers biological surfaces and

182
00:08:15,230 --> 00:08:12,150
monitors and as long as they're

183
00:08:16,360 --> 00:08:15,240
hydrophilic water-loving we've seen this

184
00:08:20,300 --> 00:08:16,370
exclusion zone

185
00:08:22,880 --> 00:08:20,310
now what's excluded from it well we've

186
00:08:25,340 --> 00:08:22,890
tried maliki particles and then

187
00:08:26,720 --> 00:08:25,350
molecules down to a hundred or so

188
00:08:30,200 --> 00:08:26,730

molecular weight and they're all

189
00:08:32,750 --> 00:08:30,210
excluded so I'll give you one example in

190
00:08:34,280 --> 00:08:32,760
the next slide we actually you know in

191
00:08:36,230 --> 00:08:34,290
order to see what's excluded you have to

192
00:08:38,300 --> 00:08:36,240
see what there is you have to see them

193
00:08:40,280 --> 00:08:38,310
the molecules and so you'd think well

194
00:08:42,740 --> 00:08:40,290
the best thing to use is a dye right

195
00:08:44,840 --> 00:08:42,750
because you can see it so we used the pH

196
00:08:46,520 --> 00:08:44,850
sensitive dyes some of you know remember

197
00:08:49,550 --> 00:08:46,530
litmus paper you stick in and changes

198
00:08:50,990 --> 00:08:49,560
color so the dyes are soluble and you

199
00:08:53,750 --> 00:08:51,000
can get the dyes and they're mixtures of

200
00:08:56,690 --> 00:08:53,760
molecules about molecular weight 100 or

201
00:08:59,910 --> 00:08:56,700
so typically and you put put them in and

202
00:09:02,009 --> 00:08:59,920
and you can see what happens and

203
00:09:04,769 --> 00:09:02,019
I'm not sure if it's dark enough yeah I

204
00:09:06,300 --> 00:09:04,779
think you can see it so so we have a

205
00:09:08,610 --> 00:09:06,310
piece of nappy on at the bottom of the

206
00:09:12,389 --> 00:09:08,620
chamber gives you an exclusion zone and

207
00:09:13,949 --> 00:09:12,399
it's just water dye and nappy on so

208
00:09:16,470 --> 00:09:13,959
here's the dye and you see all these

209
00:09:19,470 --> 00:09:16,480
lovely colors but there's no dye here

210
00:09:21,090 --> 00:09:19,480
there's a clear zone and so the dye is

211
00:09:24,660 --> 00:09:21,100
excluded and these are a molecular

212
00:09:26,370 --> 00:09:24,670
weight approximately 100 or so okay more

213
00:09:28,560 --> 00:09:26,380

interesting is the color distribution

214
00:09:31,259 --> 00:09:28,570
not only because of its attractiveness

215
00:09:34,199 --> 00:09:31,269
but because of what it signifies so for

216
00:09:37,920 --> 00:09:34,209
this particular pH sensitive dye the

217
00:09:40,379 --> 00:09:37,930
orange color means pH 3 or less which

218
00:09:42,870 --> 00:09:40,389
means a huge number of protons so

219
00:09:45,720 --> 00:09:42,880
there's a proton gradient that runs from

220
00:09:50,090 --> 00:09:45,730
here to here we'll come back to that

221
00:09:53,189 --> 00:09:50,100
it's important so in terms of generality

222
00:09:55,470 --> 00:09:53,199
well many hydrophilic surfaces generate

223
00:09:59,160 --> 00:09:55,480
exclusion zones and many solutes are

224
00:10:04,550 --> 00:09:59,170
excluded question 2 is this zone really

225
00:10:09,509 --> 00:10:07,800
I'm I'm gonna pretty much list the

226
00:10:11,400 --> 00:10:09,519
evidence without going through it except

227
00:10:13,590 --> 00:10:11,410
for one of them because it's all

228
00:10:16,290 --> 00:10:13,600
published and and I'll take the whole

229
00:10:18,930 --> 00:10:16,300
hour if we if we do that and there's a

230
00:10:21,870 --> 00:10:18,940
lot I want to tell you first of all the

231
00:10:25,170 --> 00:10:21,880
easy molecules are more constrained than

232
00:10:29,490 --> 00:10:25,180
bulk water molecules they're more stable

233
00:10:31,560 --> 00:10:29,500
than than ordinary water and the

234
00:10:34,079 --> 00:10:31,570
surprise for us was that this exclusion

235
00:10:35,460 --> 00:10:34,089
zone has negative charge I'll show you

236
00:10:40,220 --> 00:10:35,470
the experiments because they're

237
00:10:43,740 --> 00:10:40,230
important in a moment it absorbs light

238
00:10:46,050 --> 00:10:43,750

in the UV light 217 nanometers and the

239
00:10:49,050 --> 00:10:46,060
ordinary water doesn't do that it's more

240
00:10:52,230 --> 00:10:49,060
viscous than bulk water the molecules in

241
00:10:54,930 --> 00:10:52,240
the ez are aligned with one another and

242
00:10:57,840 --> 00:10:54,940
the molecular structure appears to be

243
00:10:59,069 --> 00:10:57,850
different from ordinary water and the

244
00:11:02,030 --> 00:10:59,079
optical properties are different

245
00:11:04,500 --> 00:11:02,040
actually this is mostly by two Russian

246
00:11:07,079 --> 00:11:04,510
scientists both from Moscow they don't

247
00:11:08,939 --> 00:11:07,089
know each other they did different

248
00:11:11,430 --> 00:11:08,949
experiments but the result was the same

249
00:11:13,260 --> 00:11:11,440
even quantitatively the same that that

250
00:11:15,420 --> 00:11:13,270
not only is is the

251
00:11:19,080 --> 00:11:15,430
birefringence are ordered but its

252
00:11:20,580 --> 00:11:19,090
refractive index is 11% higher than that

253
00:11:22,950 --> 00:11:20,590
of water which means it's denser

254
00:11:26,670 --> 00:11:22,960
probably then that's the simplest

255
00:11:28,620 --> 00:11:26,680
interpretation then water so so those

256
00:11:30,960 --> 00:11:28,630
are there are actually one or two more I

257
00:11:32,520 --> 00:11:30,970
just didn't bother listening them but I

258
00:11:34,530 --> 00:11:32,530
want to talk about the negative charge

259
00:11:36,360 --> 00:11:34,540
because that will color almost

260
00:11:39,350 --> 00:11:36,370
everything that I'm gonna be talking

261
00:11:41,520 --> 00:11:39,360
about and how do you measure that well

262
00:11:43,230 --> 00:11:41,530
the experiment that sorry it looks a

263
00:11:46,920 --> 00:11:43,240

little complicated but it's really not

264
00:11:48,660 --> 00:11:46,930
inside means the inside of a gel and

265
00:11:51,180 --> 00:11:48,670
outside is the outside of the gel where

266
00:11:54,690 --> 00:11:51,190
we put water so we start with a poly

267
00:11:56,460 --> 00:11:54,700
acrylic acid gel right here and we want

268
00:11:59,040 --> 00:11:56,470
to measure the electrical potential at

269
00:12:01,560 --> 00:11:59,050
the interfacial region here and so how

270
00:12:03,720 --> 00:12:01,570
do we do that we take two electrodes we

271
00:12:06,300 --> 00:12:03,730
stick the reference electrode out here

272
00:12:09,630 --> 00:12:06,310
somewhere and we have a probe electrode

273
00:12:11,970 --> 00:12:09,640
which tapers down to one micrometer or

274
00:12:15,090 --> 00:12:11,980
less used in biology for many years

275
00:12:17,190 --> 00:12:15,100
invented by the same Gilbert thing so if

276
00:12:19,230 --> 00:12:17,200
you're at this point which is several

277
00:12:21,330 --> 00:12:19,240
hundred micrometers from from the

278
00:12:23,940 --> 00:12:21,340
interface the potential difference

279
00:12:25,770 --> 00:12:23,950
between here and here is zero and that's

280
00:12:28,770 --> 00:12:25,780
comforting because you don't expect any

281
00:12:31,370 --> 00:12:28,780
potential difference as you get closer

282
00:12:33,750 --> 00:12:31,380
you begin to pick up a negative

283
00:12:37,290 --> 00:12:33,760
electrical potential and this region

284
00:12:39,990 --> 00:12:37,300
extends for about roughly the size of

285
00:12:42,540 --> 00:12:40,000
the exclusion zone of this poly acrylic

286
00:12:44,430 --> 00:12:42,550
acid gel which is it was shown here so

287
00:12:47,790 --> 00:12:44,440
it looks like the exclusion zone is

288
00:12:49,530 --> 00:12:47,800

negative so next we rip out the gel and

289
00:12:51,000 --> 00:12:49,540
we put a piece of naffy on here and do

290
00:12:54,870 --> 00:12:51,010
the same experiment and you could see

291
00:12:57,510 --> 00:12:54,880
the result and and for Navion remember I

292
00:12:59,850 --> 00:12:57,520
told you that the exclusion zone was on

293
00:13:02,520 --> 00:12:59,860
the order of half a millimeter 400 500

294
00:13:04,710 --> 00:13:02,530
sometimes 600 micrometers again it looks

295
00:13:08,250 --> 00:13:04,720
as though the exclusion zone is

296
00:13:12,780 --> 00:13:08,260
negatively charged that doesn't make

297
00:13:14,970 --> 00:13:12,790
sense why doesn't it make sense it

298
00:13:16,650 --> 00:13:14,980
doesn't make sense because you take a

299
00:13:17,330 --> 00:13:16,660
gel and you put it there and you pour

300
00:13:20,670 --> 00:13:17,340
some water

301
00:13:23,270 --> 00:13:20,680
the water's neutral so how is it

302
00:13:26,730 --> 00:13:23,280
possible that you get these really

303
00:13:27,990 --> 00:13:26,740
extensive negatively charged zones well

304
00:13:30,090 --> 00:13:28,000
if you think about it the only

305
00:13:32,460 --> 00:13:30,100
reasonable possibility is that somehow

306
00:13:34,290 --> 00:13:32,470
the water molecules are splitting into

307
00:13:36,449 --> 00:13:34,300
negative and positive parts and somehow

308
00:13:39,120 --> 00:13:36,459
the negative ones are here and the

309
00:13:43,019 --> 00:13:39,130
positive ones are well probably out here

310
00:13:46,500 --> 00:13:43,029
somewhere but is there any evidence that

311
00:13:49,470 --> 00:13:46,510
they're out here well you've seen the

312
00:13:52,680 --> 00:13:49,480
evidence I turned that 90 degrees here's

313
00:13:54,000 --> 00:13:52,690

a piece of Navion and here's the

314
00:13:55,920 --> 00:13:54,010
exclusion zone I showed you in the

315
00:13:58,530 --> 00:13:55,930
previous slide this region was negative

316
00:14:02,190 --> 00:13:58,540
and remember this one is positive and

317
00:14:04,050 --> 00:14:02,200
and it's got lots of protons so so we

318
00:14:05,880 --> 00:14:04,060
thought let's just check and see if

319
00:14:07,530 --> 00:14:05,890
we're not deluding ourselves into

320
00:14:09,870 --> 00:14:07,540
thinking something is real when it's not

321
00:14:11,579 --> 00:14:09,880
so we put one electrode here one

322
00:14:13,350 --> 00:14:11,589
electrode here and connected them with a

323
00:14:15,810 --> 00:14:13,360
resistor and we expect to see current

324
00:14:17,400 --> 00:14:15,820
flow between between the positive and

325
00:14:20,430 --> 00:14:17,410
the negative and indeed

326
00:14:22,829 --> 00:14:20,440
here's the current flow this is it

327
00:14:25,380 --> 00:14:22,839
starts high at first and then as a

328
00:14:27,240 --> 00:14:25,390
function of time it goes down and it

329
00:14:30,420 --> 00:14:27,250
reaches some kind of plateau which

330
00:14:32,670 --> 00:14:30,430
extends for quite a while it's not patio

331
00:14:35,550 --> 00:14:32,680
value is not zero it's a substantial

332
00:14:38,030 --> 00:14:35,560
amount so you do get current flow which

333
00:14:40,740 --> 00:14:38,040
confirms that really there is charge

334
00:14:42,480 --> 00:14:40,750
separation between the exclusion zone

335
00:14:44,910 --> 00:14:42,490
and the region of water beyond the

336
00:14:49,319 --> 00:14:44,920
exclusion zone so we have a charge

337
00:14:52,110 --> 00:14:49,329
battery in water so I showed you that

338
00:14:54,870 --> 00:14:52,120

the EZ has negative charge and a Russian

339
00:14:57,510 --> 00:14:54,880
group has confirmed that if you look and

340
00:14:59,400 --> 00:14:57,520
try to understand what the structure of

341
00:15:03,569 --> 00:14:59,410
this zone is I showed you a stack of

342
00:15:05,370 --> 00:15:03,579
dipoles it sort of as a generality the

343
00:15:07,740 --> 00:15:05,380
molecules are aligned they're stable

344
00:15:09,630 --> 00:15:07,750
they're constrained this is a the

345
00:15:11,040 --> 00:15:09,640
easiest or a simplest statement of

346
00:15:13,590 --> 00:15:11,050
structure is that it's some kind of

347
00:15:16,980 --> 00:15:13,600
liquid crystal we'll we'll get more to

348
00:15:19,800 --> 00:15:16,990
that so the summary so far is we have

349
00:15:22,170 --> 00:15:19,810
some kind of liquid crystalline region

350
00:15:25,470 --> 00:15:22,180
next to hydrophilic surfaces most of

351
00:15:32,010 --> 00:15:25,480
surfaces are hydrophilic it has negative

352
00:15:33,900 --> 00:15:32,020
charge it excludes solutes profoundly it

353
00:15:35,250 --> 00:15:33,910
may be non dipolar there were hints of

354
00:15:36,990 --> 00:15:35,260
that and I'll get back to that in a

355
00:15:39,750 --> 00:15:37,000
moment we think of the structures the

356
00:15:43,110 --> 00:15:39,760
stack of dipoles but it's not

357
00:15:45,510 --> 00:15:43,120
and it may extend very far from the

358
00:15:49,290 --> 00:15:45,520
nucleating surface so how far is very

359
00:15:50,840 --> 00:15:49,300
far the textbook physical chemistry will

360
00:15:54,150 --> 00:15:50,850
tell you that there may be two or three

361
00:15:57,810 --> 00:15:54,160
ordered molecular layers if we're right

362
00:16:03,840 --> 00:15:57,820
we have a 1 or 2 million molecular

363
00:16:06,540 --> 00:16:03,850

layers or 2 or 3 not not a handful it

364
00:16:09,540 --> 00:16:06,550
was suggested 100 years ago by a famous

365
00:16:12,180 --> 00:16:09,550
physical chemist colloid chemist that

366
00:16:14,130 --> 00:16:12,190
water actually has four phases not three

367
00:16:17,310 --> 00:16:14,140
because it was really impossible to

368
00:16:19,560 --> 00:16:17,320
explain many of the features of water so

369
00:16:21,480 --> 00:16:19,570
I'm not sure if this constitutes a phase

370
00:16:24,600 --> 00:16:21,490
but it satisfies the requirements of

371
00:16:27,420 --> 00:16:24,610
phases it's bounded it's responsive to

372
00:16:29,270 --> 00:16:27,430
temperature and pressure and the

373
00:16:32,460 --> 00:16:29,280
structure is completely different

374
00:16:34,200 --> 00:16:32,470
apparently from from ordinary water the

375
00:16:38,790 --> 00:16:34,210
physical chemical characteristics I

376
00:16:41,850 --> 00:16:38,800
showed you the list show that so it

377
00:16:43,650 --> 00:16:41,860
turns out that that sixty years ago was

378
00:16:45,510 --> 00:16:43,660
70 years ago a lot of people were

379
00:16:47,790 --> 00:16:45,520
interested in this sort of thing this is

380
00:16:52,560 --> 00:16:47,800
a review article from down around here

381
00:16:55,530 --> 00:16:52,570
from Stanford by Henniker it's a review

382
00:16:57,480 --> 00:16:55,540
article and the depth of the surface

383
00:16:59,400 --> 00:16:57,490
zone of a liquid surface zone is the

384
00:17:02,970 --> 00:16:59,410
same as what I've been talking about his

385
00:17:04,710 --> 00:17:02,980
own the interfacial zone and in the

386
00:17:08,210 --> 00:17:04,720
review article they cite more than a

387
00:17:11,340 --> 00:17:08,220
hundred papers that show before 1949

388
00:17:13,860 --> 00:17:11,350

that show that many liquids including

389
00:17:17,550 --> 00:17:13,870
water of course change their structure

390
00:17:20,220 --> 00:17:17,560
radically near interfaces and and that

391
00:17:22,290 --> 00:17:20,230
that change extends out up to hundreds

392
00:17:24,180 --> 00:17:22,300
of micrometers so it's just what we

393
00:17:27,480 --> 00:17:24,190
found so there's nothing new and what we

394
00:17:32,670 --> 00:17:27,490
found it was known 6070 years ago and

395
00:17:34,710 --> 00:17:32,680
even before so where we are as I've

396
00:17:37,230 --> 00:17:34,720
shown you and that now the question is

397
00:17:39,390 --> 00:17:37,240
is it really is this structure which

398
00:17:41,550 --> 00:17:39,400
I've presented as dipoles and my

399
00:17:43,440 --> 00:17:41,560
previous book said dipoles and a lot of

400
00:17:45,930 --> 00:17:43,450
people think dipoles because water is a

401
00:17:48,780 --> 00:17:45,940
dipolar molecule but is it non dipolar

402
00:17:51,060 --> 00:17:48,790
why would we even think that well it's

403
00:17:54,030 --> 00:17:51,070
actually very simple because

404
00:17:56,280 --> 00:17:54,040
the main point is is that this region

405
00:17:58,380 --> 00:17:56,290
has negative charge you can stack

406
00:18:01,190 --> 00:17:58,390
neutral dipoles from here to the moon

407
00:18:06,090 --> 00:18:01,200
and you won't get negative charge so

408
00:18:09,390 --> 00:18:06,100
something is wrong with that and also

409
00:18:12,210 --> 00:18:09,400
this I mentioned the light absorption in

410
00:18:14,790 --> 00:18:12,220
the ultraviolet usually that corresponds

411
00:18:16,410 --> 00:18:14,800
to ring-like structures not dipoles now

412
00:18:20,190 --> 00:18:16,420
if you try to figure out what the

413
00:18:21,720 --> 00:18:20,200

structure of the zone might be one way

414
00:18:23,550 --> 00:18:21,730
of approaching it the way we approach it

415
00:18:25,980 --> 00:18:23,560
is to figure out to start with some

416
00:18:28,680 --> 00:18:25,990
precedent a structure a water structure

417
00:18:30,150 --> 00:18:28,690
that we know exists and think that well

418
00:18:32,400 --> 00:18:30,160
maybe some modification of that

419
00:18:34,410 --> 00:18:32,410
structure could be the structure we're

420
00:18:38,220 --> 00:18:34,420
looking for is better than just pulling

421
00:18:41,520 --> 00:18:38,230
a structure from a hat so the precedent

422
00:18:43,590 --> 00:18:41,530
that we know about is ice we know I

423
00:18:45,840 --> 00:18:43,600
structure its crystalline structure very

424
00:18:46,530 --> 00:18:45,850
well and so you can see the structure on

425
00:18:49,110 --> 00:18:46,540
the left

426
00:18:51,270 --> 00:18:49,120
these are oxygens here and the

427
00:18:53,610 --> 00:18:51,280
hydrogen's would be in between the two

428
00:18:56,850 --> 00:18:53,620
oxygens I'll show you that on the next

429
00:18:58,650 --> 00:18:56,860
slide it's omitted for clarity so you

430
00:19:00,480 --> 00:18:58,660
see that it's a hexagonal sheet

431
00:19:02,220 --> 00:19:00,490
structure and the hexagons are in

432
00:19:05,460 --> 00:19:02,230
register with one another and it's a

433
00:19:06,870 --> 00:19:05,470
very nice crystalline structure if you

434
00:19:10,680 --> 00:19:06,880
look at it from a slightly different

435
00:19:13,650 --> 00:19:10,690
angle that's shown here then you lose

436
00:19:16,410 --> 00:19:13,660
your sense of this hexagonal array but

437
00:19:18,990 --> 00:19:16,420
you do see these blue dots so what are

438
00:19:22,140 --> 00:19:19,000

the blue dots blue dots are protons that

439
00:19:24,480 --> 00:19:22,150
exist between the negative oxygen so

440
00:19:27,770 --> 00:19:24,490
positive in between two negatives and

441
00:19:31,770 --> 00:19:27,780
that's what makes us hard glued together

442
00:19:33,390 --> 00:19:31,780
so we had the idea what happens we want

443
00:19:35,460 --> 00:19:33,400
a negative structure not a neutral

444
00:19:37,260 --> 00:19:35,470
starting structure so you know the first

445
00:19:40,410 --> 00:19:37,270
obvious thing as well as suppose we pull

446
00:19:42,300 --> 00:19:40,420
away these blue dots you know then we've

447
00:19:43,830 --> 00:19:42,310
from neutral we've taken positive

448
00:19:46,770 --> 00:19:43,840
therefore we get negative and we thought

449
00:19:48,180 --> 00:19:46,780
we thought you know this this might be

450
00:19:50,520 --> 00:19:48,190
the answer because it gives us negative

451
00:19:52,650 --> 00:19:50,530
charge since the glue is removed we're

452
00:19:55,110 --> 00:19:52,660
not a solid anymore which is ice it's

453
00:19:56,820 --> 00:19:55,120
something that might be different we

454
00:19:59,490 --> 00:19:56,830
thought we had the answer until someone

455
00:20:02,640 --> 00:19:59,500
tapped us on the shoulder and said you

456
00:20:05,480 --> 00:20:02,650
know it's wrong why is it wrong well

457
00:20:07,820 --> 00:20:05,490
it's wrong because if you remove the

458
00:20:10,370 --> 00:20:07,830
we have two- sitting right next to each

459
00:20:12,820 --> 00:20:10,380
other they repel the structure will fly

460
00:20:18,260 --> 00:20:12,830
apart so minor problem it's not stable

461
00:20:24,680 --> 00:20:18,270
can't exist so after after some period

462
00:20:27,530 --> 00:20:24,690
of depression an idea arose that that

463
00:20:30,470 --> 00:20:27,540

scene seemed to be okay so you take here

464
00:20:33,380 --> 00:20:30,480
we've put back the hydrogen so you have

465
00:20:35,960 --> 00:20:33,390
oxygen hydrogen and so on and here's the

466
00:20:38,270 --> 00:20:35,970
one plane from behind and the plane

467
00:20:40,790 --> 00:20:38,280
closest to us and the idea was simply to

468
00:20:42,770 --> 00:20:40,800
shift this one by half of the oxygen

469
00:20:44,540 --> 00:20:42,780
oxygen distance to a new position and

470
00:20:46,760 --> 00:20:44,550
then as something nice happens because

471
00:20:49,900 --> 00:20:46,770
you still have the negativity but now

472
00:20:53,090 --> 00:20:49,910
the negative negative oxygen lies

473
00:20:55,160 --> 00:20:53,100
juxtaposed next to the positive hydrogen

474
00:20:57,140 --> 00:20:55,170
so there's a glue a weak glue an

475
00:20:59,450 --> 00:20:57,150
electrostatic attraction between the two

476
00:21:01,340 --> 00:20:59,460
and you see that in many places in the

477
00:21:02,870 --> 00:21:01,350
lattice so you have a weak weak

478
00:21:04,880 --> 00:21:02,880
attraction of these planes so they're

479
00:21:06,530 --> 00:21:04,890
not permanently glued you can shear one

480
00:21:09,280 --> 00:21:06,540
past the other if you put enough shear

481
00:21:12,230 --> 00:21:09,290
force and it satisfies the negativity

482
00:21:14,020 --> 00:21:12,240
requirement so it's stable so the idea

483
00:21:17,210 --> 00:21:14,030
is something like this you have a

484
00:21:18,919 --> 00:21:17,220
hydrophilic material sitting next to

485
00:21:22,669 --> 00:21:18,929
water I don't know if you can see the

486
00:21:26,210 --> 00:21:22,679
warps I can't even see the slide okay

487
00:21:29,030 --> 00:21:26,220
I don't can you see it huh oh okay

488
00:21:31,310 --> 00:21:29,040

anyway and and these layers build one by

489
00:21:33,950 --> 00:21:31,320
one and and remember they're offset from

490
00:21:36,440 --> 00:21:33,960
one another shifted slightly and then

491
00:21:39,140 --> 00:21:36,450
next one grows and then the next one

492
00:21:41,690 --> 00:21:39,150
grows and they keep growing layer by

493
00:21:43,970 --> 00:21:41,700
layer if you look at the structure of a

494
00:21:47,570 --> 00:21:43,980
single plane remember it has this

495
00:21:51,350 --> 00:21:47,580
hexagonal structure and if you think

496
00:21:54,710 --> 00:21:51,360
it's h2o it's not because if you count

497
00:21:56,330 --> 00:21:54,720
the number remember h2o is neutral and

498
00:21:59,180 --> 00:21:56,340
this is negatively charged so it

499
00:22:01,820 --> 00:21:59,190
shouldn't be h2o if you count the number

500
00:22:04,820 --> 00:22:01,830
of oxygens and hydrogen's per unit cell

501
00:22:07,490 --> 00:22:04,830
it's h3o - so it's different

502
00:22:13,030 --> 00:22:07,500
not exactly water it's sort of like

503
00:22:15,260 --> 00:22:13,040
water we've in order to do this we've we

504
00:22:17,120 --> 00:22:15,270
implemented a right shift but we could

505
00:22:19,070 --> 00:22:17,130
have done a left shift and get the same

506
00:22:19,520 --> 00:22:19,080
result because it's symmetrical or 60

507
00:22:22,910 --> 00:22:19,530
degrees

508
00:22:24,830 --> 00:22:22,920
120-degree it doesn't matter the and why

509
00:22:26,870 --> 00:22:24,840
is that important it's important because

510
00:22:30,080 --> 00:22:26,880
you can actually get a helical structure

511
00:22:32,000 --> 00:22:30,090
so so here's layer zero the next one

512
00:22:34,670 --> 00:22:32,010
we've shifted zero degrees 60 degrees

513
00:22:37,130 --> 00:22:34,680

120 degrees and so on we'll get a nice

514
00:22:40,460 --> 00:22:37,140
helix oh so why is that cool

515
00:22:44,030 --> 00:22:40,470
well helix is important because in

516
00:22:47,180 --> 00:22:44,040
biology many proteins nucleic acids and

517
00:22:49,640 --> 00:22:47,190
such have helical structures and fibrous

518
00:22:51,050 --> 00:22:49,650
proteins and it's well known that next

519
00:22:53,810 --> 00:22:51,060
to these structures is some kind of

520
00:22:57,260 --> 00:22:53,820
ordered water so this ordered water

521
00:22:59,990 --> 00:22:57,270
suffices for explaining next to some

522
00:23:03,380 --> 00:23:00,000
other molecule here how you can get

523
00:23:07,460 --> 00:23:03,390
ordered water so the advantages of this

524
00:23:09,590 --> 00:23:07,470
non dipolar easy is number one precedent

525
00:23:11,900 --> 00:23:09,600
it's not so different from ice although

526
00:23:15,800 --> 00:23:11,910
it's different it has negative charge

527
00:23:19,130 --> 00:23:15,810
which the evidence demands the ring like

528
00:23:21,260 --> 00:23:19,140
structures absorb at 270 could absorb

529
00:23:23,570 --> 00:23:21,270
could explain the 270 nanometer

530
00:23:25,250 --> 00:23:23,580
absorption and it's able to accommodate

531
00:23:27,680 --> 00:23:25,260
helical structure so you ask the

532
00:23:29,570 --> 00:23:27,690
question okay you've presented some

533
00:23:33,350 --> 00:23:29,580
logical arguments but has anybody ever

534
00:23:34,910 --> 00:23:33,360
seen this kind of helical structure the

535
00:23:36,290 --> 00:23:34,920
answer is yes many people have seen it

536
00:23:38,780 --> 00:23:36,300
but the techniques have mostly been

537
00:23:40,850 --> 00:23:38,790
techniques that can actually look only

538
00:23:43,730 --> 00:23:40,860

at two or three molecular layers with

539
00:23:46,460 --> 00:23:43,740
one exception and this is this is the

540
00:23:50,320 --> 00:23:46,470
exception now this is from a group from

541
00:23:58,670 --> 00:23:55,310
and and I've heard that in Stanford has

542
00:24:04,160 --> 00:23:58,680
now overtaken Harvard as the place okay

543
00:24:08,030 --> 00:24:04,170
so local loyalty okay and so this is an

544
00:24:09,820 --> 00:24:08,040
ancient protein ATP synthase subunit of

545
00:24:13,580 --> 00:24:09,830
that and the role of this subunit

546
00:24:15,560 --> 00:24:13,590
appears to be that in when it's not when

547
00:24:17,840 --> 00:24:15,570
the humidity is very low and the water

548
00:24:21,350 --> 00:24:17,850
would tend to evaporate this subunit

549
00:24:23,960 --> 00:24:21,360
forms these volumetric structures with

550
00:24:27,080 --> 00:24:23,970
water inside it protects the water from

551
00:24:29,530 --> 00:24:27,090
the evaporation you see and sometimes it

552
00:24:33,139 --> 00:24:29,540
forms these spheres sometimes it forms

553
00:24:35,119 --> 00:24:33,149
hexagonal or other geometric structures

554
00:24:37,459 --> 00:24:35,129
anyway having the ability to see these

555
00:24:40,549 --> 00:24:37,469
in electron microscope and do electron

556
00:24:43,129 --> 00:24:40,559
diffraction the result is shown here and

557
00:24:46,759 --> 00:24:43,139
so this is the structure of the volume

558
00:24:50,419 --> 00:24:46,769
of water that's inside and you'll notice

559
00:24:53,479 --> 00:24:50,429
first that the dots are very sharp which

560
00:24:56,209 --> 00:24:53,489
means there's ordered and the second is

561
00:24:58,070 --> 00:24:56,219
that there's a hexagonal arrangement of

562
00:25:00,859 --> 00:24:58,080
these so the conclusion of these authors

563
00:25:04,070 --> 00:25:00,869

was that this consists of ordered

564
00:25:06,979 --> 00:25:04,080
hexagonal sheets of water inside so

565
00:25:08,599 --> 00:25:06,989
there is at least some evidence that we

566
00:25:10,729 --> 00:25:08,609
might be on the right track so the

567
00:25:13,669 --> 00:25:10,739
answer to the second question is the

568
00:25:15,169 --> 00:25:13,679
easy physically distinct lots of

569
00:25:17,509 --> 00:25:15,179
evidence shows that it's different from

570
00:25:19,849 --> 00:25:17,519
water and I think the best evidence so

571
00:25:24,019 --> 00:25:19,859
far which could be wrong is that it's a

572
00:25:26,180 --> 00:25:24,029
layered honeycomb structure can

573
00:25:28,700 --> 00:25:26,190
crystalline water explain those first

574
00:25:30,859 --> 00:25:28,710
three slides in a few more well so what

575
00:25:33,680 --> 00:25:30,869
kind of behavior do we expect from a

576
00:25:36,320 --> 00:25:33,690
crystal well you know crystals stick

577
00:25:41,450 --> 00:25:36,330
together like a salt crystal or sugar

578
00:25:45,589 --> 00:25:41,460
crystal it can be hard and and if you if

579
00:25:47,539 --> 00:25:45,599
you think if you think about various

580
00:25:50,779 --> 00:25:47,549
substances the first one I always like

581
00:25:53,509 --> 00:25:50,789
to is gelatin dessert as a jello now so

582
00:25:56,209 --> 00:25:53,519
jello is mostly water and when you when

583
00:25:58,700 --> 00:25:56,219
you make the jello and so question is

584
00:26:00,649 --> 00:25:58,710
well gee if it's 95% water how come the

585
00:26:01,099 --> 00:26:00,659
water doesn't dribble out like in the

586
00:26:03,889 --> 00:26:01,109
shower

587
00:26:06,379 --> 00:26:03,899
you hold it you know so some people

588
00:26:09,379 --> 00:26:06,389

would say it's osmotic forces and but

589
00:26:12,469 --> 00:26:09,389
I've held gels from in Japan that field

590
00:26:16,099 --> 00:26:12,479
just like jello but they're not 95%

591
00:26:17,959 --> 00:26:16,109
water they're 99.95 percent water it's

592
00:26:19,759 --> 00:26:17,969
essentially water with a few strands of

593
00:26:22,219 --> 00:26:19,769
polymer holding it all together so the

594
00:26:26,089 --> 00:26:22,229
idea that osmotic forces could hold all

595
00:26:29,239 --> 00:26:26,099
that water it's hard to to imagine so

596
00:26:31,700 --> 00:26:29,249
this is what a gel computer model of a

597
00:26:34,369 --> 00:26:31,710
gel looks like and the yellow stuff is

598
00:26:35,810 --> 00:26:34,379
is the protein or polymer the matrix of

599
00:26:40,339 --> 00:26:35,820
the gel and you see these great big

600
00:26:43,069 --> 00:26:40,349
holes and spaces pores in inside and and

601
00:26:44,659 --> 00:26:43,079
so again the question is well gee with

602
00:26:46,150 --> 00:26:44,669
all this liquid it should it should leak

603
00:26:49,060 --> 00:26:46,160
out however

604
00:26:51,040 --> 00:26:49,070
these surfaces are hydrophilic and we

605
00:26:54,490 --> 00:26:51,050
know that next to hydrophilic surfaces

606
00:26:57,490 --> 00:26:54,500
the water lines up in sheets and forms

607
00:27:00,490 --> 00:26:57,500
this easy and so they're filled with

608
00:27:02,590 --> 00:27:00,500
easy water and the easy layers stick to

609
00:27:04,630 --> 00:27:02,600
one another and stick to the surface and

610
00:27:05,800 --> 00:27:04,640
so that's the reason that the water

611
00:27:07,660 --> 00:27:05,810
doesn't dribble out

612
00:27:10,810 --> 00:27:07,670
it's stuck inside because of these

613
00:27:12,400 --> 00:27:10,820

forces and another another point is you

614
00:27:14,680 --> 00:27:12,410
know you you you feel the jail that

615
00:27:17,440 --> 00:27:14,690
feels gel like it has this really weird

616
00:27:19,930 --> 00:27:17,450
consistency and probably the first time

617
00:27:20,590 --> 00:27:19,940
you saw it as a kid you remember this is

618
00:27:23,350 --> 00:27:20,600
kind of weird

619
00:27:24,880 --> 00:27:23,360
you know and and if you read the

620
00:27:26,530 --> 00:27:24,890
chemistry books they'll tell you that

621
00:27:28,540 --> 00:27:26,540
this has to do with the viscoelastic

622
00:27:31,390 --> 00:27:28,550
properties of the polymers that are

623
00:27:32,860 --> 00:27:31,400
inside however I'd like to suggest to

624
00:27:35,590 --> 00:27:32,870
you it might have to do with the water

625
00:27:39,010 --> 00:27:35,600
that's inside especially especially when

626
00:27:41,740 --> 00:27:39,020
the gel is 99.95% water it's kind of

627
00:27:43,870 --> 00:27:41,750
hard to attribute those properties to

628
00:27:46,840 --> 00:27:43,880
the few strands of polymer that happen

629
00:27:48,790 --> 00:27:46,850
to be inside and you expect gel-like

630
00:27:53,530 --> 00:27:48,800
properties of this kind of structure

631
00:27:57,850 --> 00:27:53,540
another point if you put either this old

632
00:28:00,220 --> 00:27:57,860
Hungarian coin or or a pin on the server

633
00:28:02,080 --> 00:28:00,230
paperclip on the surface despite its

634
00:28:03,670 --> 00:28:02,090
high density it doesn't sink if you do

635
00:28:06,430 --> 00:28:03,680
with carefully if you put it beneath the

636
00:28:08,440 --> 00:28:06,440
surface it sinks but not some of you

637
00:28:10,660 --> 00:28:08,450
have done this and so we were curious

638
00:28:12,490 --> 00:28:10,670

about this and that we found we studied

639
00:28:14,890 --> 00:28:12,500
the water on the surface and we found

640
00:28:16,840 --> 00:28:14,900
that the kind of water I was I've been

641
00:28:20,170 --> 00:28:16,850
talking about grows at the air water

642
00:28:23,020 --> 00:28:20,180
interface an experiment is very simple

643
00:28:24,670 --> 00:28:23,030
it's two pieces of glass like this and

644
00:28:27,370 --> 00:28:24,680
sealed around the edges to make a

645
00:28:30,730 --> 00:28:27,380
chamber you feel the chamber with water

646
00:28:33,690 --> 00:28:30,740
and microspheres so so here you have the

647
00:28:36,280 --> 00:28:33,700
air and then the meniscus is next and

648
00:28:39,490 --> 00:28:36,290
the water and microspheres scatter a lot

649
00:28:42,010 --> 00:28:39,500
of light and the clear zone we found it

650
00:28:44,980 --> 00:28:42,020
didn't start that way but 15 20 minutes

651
00:28:47,830 --> 00:28:44,990
or so this zone opens up and becomes

652
00:28:51,250 --> 00:28:47,840
clear so it basically and it stays that

653
00:28:53,350 --> 00:28:51,260
way and then roughly a day or so later

654
00:28:55,120 --> 00:28:53,360
all the microspheres sediment to the

655
00:28:57,430 --> 00:28:55,130
bottom and nobody knows exactly why that

656
00:28:59,350 --> 00:28:57,440
happens but at any rate it looks like

657
00:29:00,010 --> 00:28:59,360
there's an exclusion zone right here

658
00:29:02,770 --> 00:29:00,020
there's

659
00:29:04,570 --> 00:29:02,780
eurozone we measure the electrical

660
00:29:06,340 --> 00:29:04,580
potential especially near the top we

661
00:29:08,650 --> 00:29:06,350
found the negative big negative

662
00:29:10,990 --> 00:29:08,660
electrical potential and the next slide

663
00:29:14,260 --> 00:29:11,000

will show you that it is not water here

664
00:29:16,090 --> 00:29:14,270
this acts like a gel a cohesive gel or a

665
00:29:18,160 --> 00:29:16,100
thick rubber band that runs right across

666
00:29:20,260 --> 00:29:18,170
the surface and the experiment is shown

667
00:29:22,300 --> 00:29:20,270
here so this you've seen this in the

668
00:29:24,640 --> 00:29:22,310
past slide here's the clear zone and

669
00:29:27,640 --> 00:29:24,650
here's a probe that's going to touch the

670
00:29:29,770 --> 00:29:27,650
surface perturb it then I would move it

671
00:29:30,880 --> 00:29:29,780
around back and forth and mechanically

672
00:29:32,560 --> 00:29:30,890
perturbed and you'll see that the

673
00:29:36,070 --> 00:29:32,570
thickness of this the height doesn't

674
00:29:38,580 --> 00:29:36,080
change at all or noticeably at any rate

675
00:29:41,170 --> 00:29:38,590
and so here it's touching the surface

676
00:29:44,200 --> 00:29:41,180
mechanical force pulling up and then

677
00:29:47,140 --> 00:29:44,210
going side to side and height thickness

678
00:29:51,760 --> 00:29:47,150
of that dark region doesn't so sticks

679
00:29:55,390 --> 00:29:51,770
together in in some way so so in in

680
00:29:58,660 --> 00:29:55,400
terms of of what holds this up you know

681
00:30:00,580 --> 00:29:58,670
the textbook says water has high surface

682
00:30:02,560 --> 00:30:00,590
tension but if you think of the reason

683
00:30:05,050 --> 00:30:02,570
why water has high surface tension

684
00:30:06,670 --> 00:30:05,060
according to the textbooks it's that the

685
00:30:09,310 --> 00:30:06,680
water molecules like to stick to one

686
00:30:11,440 --> 00:30:09,320
another transiently but at the top they

687
00:30:13,540 --> 00:30:11,450
can't stick to the air you see so these

688
00:30:16,570 --> 00:30:13,550

hydrogen bonds will flip down so you get

689
00:30:18,790 --> 00:30:16,580
a few extra hydrogen bonds in only the

690
00:30:19,150 --> 00:30:18,800
top molecular layer and the question as

691
00:30:21,460 --> 00:30:19,160
well

692
00:30:23,620 --> 00:30:21,470
is that enough to explain this and I you

693
00:30:25,540 --> 00:30:23,630
know it might be but I don't think so

694
00:30:28,090 --> 00:30:25,550
anyway we found that there are many

695
00:30:29,950 --> 00:30:28,100
layers we're talking about millions of

696
00:30:32,320 --> 00:30:29,960
molecular layers that are different from

697
00:30:35,820 --> 00:30:32,330
ordinary water the stiff easy lying on

698
00:30:38,140 --> 00:30:35,830
the top and that's what creates the

699
00:30:41,440 --> 00:30:38,150
so-called anomalously high surface

700
00:30:44,650 --> 00:30:41,450
tension of water and that explains this

701
00:30:48,760 --> 00:30:44,660
guy who's a this is a might explain it

702
00:30:50,860 --> 00:30:48,770
this is a lizard and it's from Central

703
00:30:53,920 --> 00:30:50,870
America and spends part of its time on

704
00:30:57,280 --> 00:30:53,930
branches like this but it spends the

705
00:31:00,160 --> 00:30:57,290
rest of its time walking on water so

706
00:31:03,970 --> 00:31:00,170
it's called the Jesus Christ lizard

707
00:31:06,040 --> 00:31:03,980
because it walks walks on water and so

708
00:31:08,470 --> 00:31:06,050
the question is can one molecular layer

709
00:31:10,870 --> 00:31:08,480
explain this or do you need something

710
00:31:12,360 --> 00:31:10,880
thick that I've shown and I think it's

711
00:31:13,710 --> 00:31:12,370
something thick

712
00:31:16,020 --> 00:31:13,720
and the same thing applies to the

713
00:31:18,120 --> 00:31:16,030

pendant droplet which I showed in one of

714
00:31:19,049 --> 00:31:18,130
the early slides so the droplets going

715
00:31:21,870 --> 00:31:19,059
to fall on the water

716
00:31:23,790 --> 00:31:21,880
but remember this water interfaces with

717
00:31:26,190 --> 00:31:23,800
the air and there's a thick easy layer

718
00:31:29,730 --> 00:31:26,200
on the top this too is interfacing with

719
00:31:32,520 --> 00:31:29,740
the air so it's also got an easy layer

720
00:31:36,000 --> 00:31:32,530
around it so when this meets this it's

721
00:31:39,120 --> 00:31:36,010
not that you have water meeting water

722
00:31:41,580 --> 00:31:39,130
you've got easy meeting easy and so if

723
00:31:43,560 --> 00:31:41,590
that's the case it's no surprise that it

724
00:31:45,900 --> 00:31:43,570
doesn't coalesce instantly you have to

725
00:31:48,660 --> 00:31:45,910
break through the EZ and you can see

726
00:31:52,320 --> 00:31:48,670
this is a it's a kind of like a salsa

727
00:31:54,480 --> 00:31:52,330
that this is by the way we publish this

728
00:31:56,580 --> 00:31:54,490
but is it was published a hundred years

729
00:32:02,220 --> 00:31:56,590
ago there's nothing new we just had a

730
00:32:04,620 --> 00:32:02,230
better camera crystals another point is

731
00:32:06,120 --> 00:32:04,630
crystals can be very stiff as you know

732
00:32:09,480 --> 00:32:06,130
if you have diamonds and rubies and

733
00:32:12,180 --> 00:32:09,490
whatever and it could be so if you if

734
00:32:18,150 --> 00:32:12,190
you think of this structure as as being

735
00:32:21,540 --> 00:32:18,160
you know h2o impossible to understand

736
00:32:23,580 --> 00:32:21,550
how h2o can can do this but if you have

737
00:32:24,900 --> 00:32:23,590
a crystalline version of such then you

738
00:32:28,110 --> 00:32:24,910

can understand that under certain

739
00:32:31,110 --> 00:32:28,120
circumstances it could do that and

740
00:32:34,590 --> 00:32:31,120
finally in this series the crystalline

741
00:32:36,299 --> 00:32:34,600
zone here's a an anomaly you know you

742
00:32:38,520 --> 00:32:36,309
have minus and plus usually when you

743
00:32:41,820 --> 00:32:38,530
have minus and plus the two want to

744
00:32:44,490 --> 00:32:41,830
recombine with with one another now

745
00:32:48,419 --> 00:32:44,500
these don't recombine because you have

746
00:32:50,250 --> 00:32:48,429
negative here and a positive here and we

747
00:32:51,330 --> 00:32:50,260
stick an electrode between here and here

748
00:32:53,640 --> 00:32:51,340
and the potential difference is

749
00:32:55,500 --> 00:32:53,650
maintained essentially indefinitely so

750
00:32:57,750 --> 00:32:55,510
they don't recombine so what is it that

751
00:33:00,150 --> 00:32:57,760
keeps these actually they're not protons

752
00:33:03,000 --> 00:33:00,160
they're if you add proton next to water

753
00:33:05,940 --> 00:33:03,010
gives you h3o plus gives you hydronium

754
00:33:07,650 --> 00:33:05,950
ions so how come these hydronium ions

755
00:33:10,320 --> 00:33:07,660
don't rush in and annihilate all the

756
00:33:14,040 --> 00:33:10,330
negative charges well they don't do that

757
00:33:17,460 --> 00:33:14,050
because we think because the this matrix

758
00:33:19,380 --> 00:33:17,470
here the hexagons are so small to let

759
00:33:21,600 --> 00:33:19,390
only very few things through and they're

760
00:33:24,480 --> 00:33:21,610
all shifted relative to one another so

761
00:33:25,480 --> 00:33:24,490
the effective hole is so small that even

762
00:33:28,100 --> 00:33:25,490
though these

763
00:33:30,770 --> 00:33:28,110

charges one desperately to get in here

764
00:33:33,680 --> 00:33:30,780
they're kept out and so the battery

765
00:33:35,180 --> 00:33:33,690
charges remain separated so the answer

766
00:33:36,799 --> 00:33:35,190
the questio three is yes liquid

767
00:33:39,560 --> 00:33:36,809
crystalline water explains many

768
00:33:43,310 --> 00:33:39,570
anomalies it explains why the water

769
00:33:47,419 --> 00:33:43,320
battery charges remain separated okay so

770
00:33:49,190 --> 00:33:47,429
now here's the $64 question what charges

771
00:33:51,830 --> 00:33:49,200
this battery you know your cell phone

772
00:33:54,860 --> 00:33:51,840
battery you need to plug it in and

773
00:33:57,110 --> 00:33:54,870
there's no receptacle here for this and

774
00:33:59,330 --> 00:33:57,120
so you know where does the energy come

775
00:34:02,090 --> 00:33:59,340
from to build order and separate all

776
00:34:05,299 --> 00:34:02,100
these charges is not so obvious it took

777
00:34:07,270 --> 00:34:05,309
us a while I must admit to figure out

778
00:34:10,310 --> 00:34:07,280
the answer which is very simple light

779
00:34:13,040 --> 00:34:10,320
light photons are doing this and we

780
00:34:16,010 --> 00:34:13,050
found this in a really simple way that

781
00:34:17,960 --> 00:34:16,020
is we found we took a piece of naphtha

782
00:34:20,869 --> 00:34:17,970
and also we had a job but in the first

783
00:34:22,520 --> 00:34:20,879
one a piece of Navion and here's the

784
00:34:24,230 --> 00:34:22,530
exclusion zone and the microspheres and

785
00:34:26,780 --> 00:34:24,240
one of the students came by with a

786
00:34:28,250 --> 00:34:26,790
portable lamp from the laboratory and so

787
00:34:31,550 --> 00:34:28,260
we're doing the experiment they shines

788
00:34:33,589 --> 00:34:31,560

the lamp on and so this is an actual

789
00:34:37,430 --> 00:34:33,599
record of what we saw this is not actual

790
00:34:40,490 --> 00:34:37,440
but and and then when he withdrew the

791
00:34:43,280 --> 00:34:40,500
lamp this went back down to a over a

792
00:34:47,270 --> 00:34:43,290
time constant of tens of minutes went

793
00:34:48,859 --> 00:34:47,280
back to this so you know we didn't take

794
00:34:51,770 --> 00:34:48,869
a rocket scientist to figure out that

795
00:34:55,099 --> 00:34:51,780
you know the energy photon energy might

796
00:34:58,880 --> 00:34:55,109
be responsible for building this we did

797
00:35:00,890 --> 00:34:58,890
spectroscopic measurements and I I don't

798
00:35:03,859 --> 00:35:00,900
want too much time to talk about it but

799
00:35:07,160 --> 00:35:03,869
we found the most powerful of wavelength

800
00:35:09,020 --> 00:35:07,170
surprisingly was infrared so especially

801
00:35:11,359 --> 00:35:09,030
around three micrometers three

802
00:35:13,940 --> 00:35:11,369
micrometers infrared is what water likes

803
00:35:15,740 --> 00:35:13,950
to absorb the most apparently this

804
00:35:19,099 --> 00:35:15,750
energy that the water absorbs is

805
00:35:22,160 --> 00:35:19,109
directly converted into the buildup of

806
00:35:25,339 --> 00:35:22,170
the EZ and the separation of the charge

807
00:35:27,050 --> 00:35:25,349
so some of you know all about infrared

808
00:35:29,870 --> 00:35:27,060
and others might want wonder well where

809
00:35:31,430 --> 00:35:29,880
does infrared come from so you know that

810
00:35:33,800 --> 00:35:31,440
if you turn on the electric range it

811
00:35:36,200 --> 00:35:33,810
gets red and infrared is coming from

812
00:35:37,880 --> 00:35:36,210
from that but actually infrared is all

813
00:35:39,430 --> 00:35:37,890

over the place you can't get rid of it

814
00:35:41,800 --> 00:35:39,440
if I were to turn off

815
00:35:44,349 --> 00:35:41,810
lights in this room and whip out my

816
00:35:46,210 --> 00:35:44,359
infrared camera and turned it on you'd

817
00:35:48,790 --> 00:35:46,220
see a beat I see we'd all see a

818
00:35:50,339 --> 00:35:48,800
beautiful image of the tables and you

819
00:35:54,130 --> 00:35:50,349
and the pencils and the chairs

820
00:35:56,410 --> 00:35:54,140
everything is radiating infrared so it's

821
00:35:59,170 --> 00:35:56,420
free energy in chemistry you learned

822
00:36:01,150 --> 00:35:59,180
about free energy and concepts that were

823
00:36:04,359 --> 00:36:01,160
maybe a little bit complicated this is

824
00:36:06,370 --> 00:36:04,369
literally free energy it comes free and

825
00:36:08,410 --> 00:36:06,380
this is what's building the easy other

826
00:36:11,109 --> 00:36:08,420
wavelengths also but this is the most

827
00:36:14,020 --> 00:36:11,119
powerful for building so we thought ok

828
00:36:16,540 --> 00:36:14,030
can we reduce the amount of radiant

829
00:36:20,140 --> 00:36:16,550
energy and see if that diminishes the

830
00:36:23,620 --> 00:36:20,150
exclusion zone living in Seattle we knew

831
00:36:26,770 --> 00:36:23,630
that Starbucks was the answer you put

832
00:36:29,500 --> 00:36:26,780
ice coffee in here and it stays cold

833
00:36:32,230 --> 00:36:29,510
because it's blocking the infrared from

834
00:36:34,990 --> 00:36:32,240
coming in so instead of iced coffee we

835
00:36:36,670 --> 00:36:35,000
put the chamber inside and of course it

836
00:36:39,280 --> 00:36:36,680
was not this it was a Dewar from the

837
00:36:41,380 --> 00:36:39,290
physics department too and and we found

838
00:36:43,839 --> 00:36:41,390

that so here's the control you can see

839
00:36:44,290 --> 00:36:43,849
the exclusion zone and 15 minutes in the

840
00:36:46,930 --> 00:36:44,300
Dewar

841
00:36:49,120 --> 00:36:46,940
it's diminished and then 15 minutes

842
00:36:51,250 --> 00:36:49,130
outside it builds back up again although

843
00:36:53,680 --> 00:36:51,260
not yet completely so so it's very

844
00:36:55,900 --> 00:36:53,690
simple the idea is that you have a

845
00:36:57,910 --> 00:36:55,910
material and you have easy water and

846
00:37:00,040 --> 00:36:57,920
this has been built by by the

847
00:37:03,400 --> 00:37:00,050
environmental energy that is being

848
00:37:05,890 --> 00:37:03,410
absorbed by the water and if you had

849
00:37:07,210 --> 00:37:05,900
more infrared or whatever it builds up

850
00:37:09,370 --> 00:37:07,220
some more and if you take it away it

851
00:37:12,250 --> 00:37:09,380
comes back to its control so the answer

852
00:37:15,660 --> 00:37:12,260
to Question 4 about energy is that easy

853
00:37:19,150 --> 00:37:15,670
build up is powered by photonic energy

854
00:37:22,000 --> 00:37:19,160
which orders the water charges the water

855
00:37:24,670 --> 00:37:22,010
battery so the situation is kind of like

856
00:37:26,530 --> 00:37:24,680
like this now if you think about what

857
00:37:29,980 --> 00:37:26,540
this might mean for the universe or at

858
00:37:31,839 --> 00:37:29,990
least the earth and so the Sun we know

859
00:37:35,020 --> 00:37:31,849
that the Sun hits the water and

860
00:37:36,069 --> 00:37:35,030
generates Heat ok you can go swimming so

861
00:37:38,140 --> 00:37:36,079
what I've shown you is that there's

862
00:37:41,020 --> 00:37:38,150
another pathway the Sun hit a little

863
00:37:44,290 --> 00:37:41,030

light I should say hits the water and

864
00:37:47,440 --> 00:37:44,300
the energy from the photon energy

865
00:37:50,410 --> 00:37:47,450
imparts energy in the water for building

866
00:37:53,290 --> 00:37:50,420
order and separating charge so whether

867
00:37:54,850 --> 00:37:53,300
this is most important or this is most

868
00:37:57,340 --> 00:37:54,860
it is not clear or indeed whether

869
00:37:59,260 --> 00:37:57,350
there's no real arrow here it goes only

870
00:38:01,720 --> 00:37:59,270
this way and this is degraded as heat

871
00:38:06,340 --> 00:38:01,730
that's another possibility now if this

872
00:38:10,030 --> 00:38:06,350
water so to speak is is absorbing energy

873
00:38:13,060 --> 00:38:10,040
from the environment right you might ask

874
00:38:15,250 --> 00:38:13,070
the question can can we harvest some of

875
00:38:17,950 --> 00:38:15,260
this energy that's in the water now I

876
00:38:21,660 --> 00:38:17,960
bet that not one of you has ever seen

877
00:38:24,610 --> 00:38:21,670
water doing work glass of water right I

878
00:38:25,960 --> 00:38:24,620
presume that you haven't because I but

879
00:38:29,920 --> 00:38:25,970
actually I'm gonna show you that the

880
00:38:33,520 --> 00:38:29,930
water does work again this is another

881
00:38:36,130 --> 00:38:33,530
undergraduate student who who came

882
00:38:38,260 --> 00:38:36,140
running into my it's unforgettable came

883
00:38:40,300 --> 00:38:38,270
running into my office to tell me he

884
00:38:43,150 --> 00:38:40,310
said he took a tube that's made of

885
00:38:44,980 --> 00:38:43,160
Navion and you know it gives exclusion

886
00:38:47,590 --> 00:38:44,990
zone so there would be one inside just

887
00:38:49,840 --> 00:38:47,600
inside and one just outside he put it in

888
00:38:51,700 --> 00:38:49,850

water and with some microspheres and

889
00:38:53,580 --> 00:38:51,710
he's looking at it for a different

890
00:38:59,710 --> 00:38:53,590
different reason and he told me boo

891
00:39:05,410 --> 00:38:59,720
whoops Oh postpone my upgrade okay

892
00:39:07,600 --> 00:39:05,420
he I keep doing that that's why okay so

893
00:39:08,970 --> 00:39:07,610
so he told me that this was running

894
00:39:11,800 --> 00:39:08,980
through and it's running through

895
00:39:13,900 --> 00:39:11,810
indefinitely it just keeps going and he

896
00:39:17,620 --> 00:39:13,910
didn't know but I knew that in order for

897
00:39:19,690 --> 00:39:17,630
for water to go through a tube you need

898
00:39:22,120 --> 00:39:19,700
a pressure gradient because you know it

899
00:39:23,860 --> 00:39:22,130
takes energy it's doing work requires

900
00:39:25,270 --> 00:39:23,870
energy and he said it keeps going we've

901
00:39:29,620 --> 00:39:25,280
actually had it going for a day and a

902
00:39:31,510 --> 00:39:29,630
half more recently so the experiment is

903
00:39:35,590 --> 00:39:31,520
very simple it looks like this you take

904
00:39:37,420 --> 00:39:35,600
a tube of Nath Eon and you feel that

905
00:39:40,150 --> 00:39:37,430
with water make sure there are no air

906
00:39:41,710 --> 00:39:40,160
air bubbles inside because they will

907
00:39:43,500 --> 00:39:41,720
interfere someone put it in the water

908
00:39:45,940 --> 00:39:43,510
with microspheres look in the microscope

909
00:39:48,250 --> 00:39:45,950
we use green light and many of that so a

910
00:39:50,200 --> 00:39:48,260
lot of the images appear green and what

911
00:39:53,320 --> 00:39:50,210
you see looks like this so here's the

912
00:39:55,030 --> 00:39:53,330
naffy on exclusion zone of course and it

913
00:39:58,150 --> 00:39:55,040

just keeps going and going and going

914
00:40:01,780 --> 00:39:58,160
we thought okay well this is nappy on is

915
00:40:03,790 --> 00:40:01,790
this something exclusively associated

916
00:40:06,820 --> 00:40:03,800
with nappy on know do other hydrophilic

917
00:40:10,930 --> 00:40:06,830
surfaces do the same so we tried various

918
00:40:13,900 --> 00:40:10,940
and here's a polyacrylic acid gel and

919
00:40:15,430 --> 00:40:13,910
what we did is we formed the gel by

920
00:40:17,410 --> 00:40:15,440
having a wire inside and you pull out

921
00:40:20,230 --> 00:40:17,420
the wire and when you pull out the wire

922
00:40:22,030 --> 00:40:20,240
you're left with a tunnel so we take the

923
00:40:25,390 --> 00:40:22,040
gel with the tunnel and we put it in

924
00:40:27,610 --> 00:40:25,400
water plus microspheres and what you get

925
00:40:29,590 --> 00:40:27,620
is an exclusion zone of course exclusion

926
00:40:32,620 --> 00:40:29,600
zone and here are the microspheres and

927
00:40:36,100 --> 00:40:32,630
the microspheres just keep flowing

928
00:40:37,870 --> 00:40:36,110
through we've tried six different gels

929
00:40:39,700 --> 00:40:37,880
we got to see where the result the

930
00:40:42,460 --> 00:40:39,710
speeds are a little different and then

931
00:40:46,210 --> 00:40:42,470
finally we tried because we think all of

932
00:40:47,680 --> 00:40:46,220
this is driven somehow by light so we

933
00:40:49,150 --> 00:40:47,690
added more light to see what would

934
00:40:52,090 --> 00:40:49,160
happen and we just published a paper

935
00:40:54,670 --> 00:40:52,100
showing that if you add more light you

936
00:40:59,920 --> 00:40:54,680
get up to five times increase of slow

937
00:41:02,590 --> 00:40:59,930
speed so basically we have a hollow tube

938
00:41:04,900 --> 00:41:02,600

in water work is done because you can't

939
00:41:07,420 --> 00:41:04,910
drive fluid through a tube without doing

940
00:41:09,430 --> 00:41:07,430
work energy is required so this system

941
00:41:10,600 --> 00:41:09,440
must somehow get its energy and where

942
00:41:12,600 --> 00:41:10,610
does it get its energy well I've

943
00:41:15,220 --> 00:41:12,610
demonstrated to you that this is

944
00:41:17,560 --> 00:41:15,230
absorbing energy all the time it's not

945
00:41:19,300 --> 00:41:17,570
at equilibrium with the environment as

946
00:41:21,040 --> 00:41:19,310
the chemistry and physics book will tell

947
00:41:23,470 --> 00:41:21,050
you it keeps absorbing energy it's

948
00:41:26,410 --> 00:41:23,480
transducing that energy into mechanical

949
00:41:28,690 --> 00:41:26,420
and and other kinds of energy okay so

950
00:41:31,900 --> 00:41:28,700
this seems rather radical even to this

951
00:41:34,180 --> 00:41:31,910
group maybe but think about your plant

952
00:41:37,390 --> 00:41:34,190
that think about the plant that you have

953
00:41:38,770 --> 00:41:37,400
that's sitting on the windowsill so

954
00:41:40,530 --> 00:41:38,780
where does it get its energy well you

955
00:41:43,780 --> 00:41:40,540
know where it gets its energy the

956
00:41:46,180 --> 00:41:43,790
photons are converted in into chemical

957
00:41:48,460 --> 00:41:46,190
energy and the chemical energy is

958
00:41:51,640 --> 00:41:48,470
converted into a metabolic energy

959
00:41:54,130 --> 00:41:51,650
bending growth etc the energies from

960
00:41:55,840 --> 00:41:54,140
here and I'm suggesting the same here

961
00:41:59,140 --> 00:41:55,850
and it's no surprise because this is

962
00:42:01,540 --> 00:41:59,150
built mainly of this so so I like to

963
00:42:04,600 --> 00:42:01,550

have the equation you know I know that

964
00:42:06,700 --> 00:42:04,610
the unit's don't match but yeah I think

965
00:42:09,730 --> 00:42:06,710
you get the idea that this is full of

966
00:42:10,300 --> 00:42:09,740
energy it's not at equilibrium with the

967
00:42:13,870 --> 00:42:10,310
environment

968
00:42:16,630 --> 00:42:13,880
last question okay now why is this

969
00:42:20,140 --> 00:42:16,640
important I think it's foundational for

970
00:42:23,859 --> 00:42:20,150
any or all science involving water and

971
00:42:26,170 --> 00:42:23,869
molecules and light so we start with

972
00:42:29,109 --> 00:42:26,180
this slide which summarizes all I've

973
00:42:32,190 --> 00:42:29,119
said so if you're still sleeping you you

974
00:42:36,160 --> 00:42:32,200
can just get it and so if you have a

975
00:42:38,620 --> 00:42:36,170
charged particle or molecule sitting in

976
00:42:42,430 --> 00:42:38,630
water here's the water it's got this

977
00:42:43,839 --> 00:42:42,440
very large exclusion zone around it

978
00:42:45,490 --> 00:42:43,849
which has negative charge and the

979
00:42:48,579 --> 00:42:45,500
corresponding positive charge is all

980
00:42:51,940 --> 00:42:48,589
around around here you see this and and

981
00:42:55,210 --> 00:42:51,950
and all of this is driven by light okay

982
00:42:58,809 --> 00:42:55,220
if you read the chemistry book you'll

983
00:43:02,049 --> 00:42:58,819
see none of this and and so since this

984
00:43:06,250 --> 00:43:02,059
should apply in all aqueous chemical

985
00:43:09,099 --> 00:43:06,260
reactions if it's correct then it might

986
00:43:11,260 --> 00:43:09,109
be necessary to reanalyze many of the

987
00:43:13,180 --> 00:43:11,270
chemical reactions at a current that are

988
00:43:16,750 --> 00:43:13,190

given in the textbook because they don't

989
00:43:19,599 --> 00:43:16,760
take into account any of this if you

990
00:43:22,180 --> 00:43:19,609
have two of them suppose you have two

991
00:43:24,789 --> 00:43:22,190
negatively charged entities and suppose

992
00:43:27,099 --> 00:43:24,799
you drop them into my glass of water

993
00:43:29,109 --> 00:43:27,109
here right here near each other so they

994
00:43:32,470 --> 00:43:29,119
can feel each other's charge

995
00:43:34,000 --> 00:43:32,480
they're both negatively charged so what

996
00:43:36,220 --> 00:43:34,010
do you expect happens to the distance

997
00:43:44,500 --> 00:43:36,230
between them anybody take a guess

998
00:43:49,630 --> 00:43:48,309
and this is not my crazy invention this

999
00:43:51,970 --> 00:43:49,640
has been known for almost a hundred

1000
00:43:54,160 --> 00:43:51,980
years and it was known by Irving

1001
00:43:56,650 --> 00:43:54,170
Langmuir the guy physical chemist for

1002
00:44:01,140 --> 00:43:56,660
whom a journal is named they come come

1003
00:44:04,150 --> 00:44:01,150
together and find men in his lectures

1004
00:44:07,960 --> 00:44:04,160
talked about this and he called it like

1005
00:44:10,390 --> 00:44:07,970
likes like because these are like

1006
00:44:13,240 --> 00:44:10,400
charges and you know they like each

1007
00:44:14,829 --> 00:44:13,250
other so they come together so he said

1008
00:44:17,650 --> 00:44:14,839
like likes like because of an

1009
00:44:19,539 --> 00:44:17,660
intermediate of unlikes so where do the

1010
00:44:22,299 --> 00:44:19,549
unlikes come from that was not clear and

1011
00:44:24,250 --> 00:44:22,309
fineman's and but now you can understand

1012
00:44:26,260 --> 00:44:24,260
where these positive charges come from

1013
00:44:27,789 --> 00:44:26,270

when these negative ones get built up

1014
00:44:29,470 --> 00:44:27,799
you have all these positives and in

1015
00:44:31,329 --> 00:44:29,480
between these two they're in highest

1016
00:44:33,160 --> 00:44:31,339
concentration because you have

1017
00:44:33,980 --> 00:44:33,170
contributions from this side and this

1018
00:44:39,730 --> 00:44:33,990
side and

1019
00:44:45,140 --> 00:44:42,920
of coming together is actually well

1020
00:44:48,590 --> 00:44:45,150
known it starts a thousand years ago in

1021
00:44:52,220 --> 00:44:48,600
the tale of genji the first novel where

1022
00:44:54,800 --> 00:44:52,230
you you have warring parties they don't

1023
00:44:56,390 --> 00:44:54,810
look like this exactly but they and they

1024
00:45:02,090 --> 00:44:56,400
will never come together no matter what

1025
00:45:03,950 --> 00:45:02,100
unless you put you know in in between so

1026
00:45:06,830 --> 00:45:03,960
like likes like because of an

1027
00:45:09,290 --> 00:45:06,840
intermediate of unlike and so they come

1028
00:45:11,359 --> 00:45:09,300
together and they stop we get stability

1029
00:45:14,810 --> 00:45:11,369
when the attractive force bringing them

1030
00:45:17,180 --> 00:45:14,820
together by the positives is equal to

1031
00:45:19,340 --> 00:45:17,190
the repulsive force here and then if you

1032
00:45:21,890 --> 00:45:19,350
have not only to here's the principle

1033
00:45:23,150 --> 00:45:21,900
but have a lot of them you have a

1034
00:45:25,760 --> 00:45:23,160
structure like this it's called a

1035
00:45:27,500 --> 00:45:25,770
colloid crystal and the particles stick

1036
00:45:30,950 --> 00:45:27,510
together to come together because of

1037
00:45:33,310 --> 00:45:30,960
this like likes like principle so this

1038
00:45:36,250 --> 00:45:33,320

is a very easy principle for

1039
00:45:38,660 --> 00:45:36,260
self-assembly all you need basically is

1040
00:45:41,450 --> 00:45:38,670
particles water and light and and

1041
00:45:43,609 --> 00:45:41,460
therefore you might think about the

1042
00:45:45,859 --> 00:45:43,619
beginning of life where you may have had

1043
00:45:48,109 --> 00:45:45,869
molecules and water around the planet

1044
00:45:51,500 --> 00:45:48,119
and light and it will automatically come

1045
00:45:54,650 --> 00:45:51,510
together into a gel like blob okay

1046
00:45:57,349 --> 00:45:54,660
inevitably so and if you've had yogurt

1047
00:46:00,200 --> 00:45:57,359
this morning probably the consistency of

1048
00:46:02,540 --> 00:46:00,210
your yogurt is something explained by

1049
00:46:04,490 --> 00:46:02,550
this this kind of principle and then we

1050
00:46:07,099 --> 00:46:04,500
go back to the cloud and raise the

1051
00:46:08,990 --> 00:46:07,109
question and so how come how come you

1052
00:46:11,030 --> 00:46:09,000
can get a structure like this well if

1053
00:46:13,099 --> 00:46:11,040
you think about what's inside the cloud

1054
00:46:15,410 --> 00:46:13,109
the cloud consists of these little

1055
00:46:18,290 --> 00:46:15,420
droplets so-called aerosol droplets of

1056
00:46:20,090 --> 00:46:18,300
water their negatively charged that's

1057
00:46:22,400 --> 00:46:20,100
known but there's a lot of positive

1058
00:46:24,380 --> 00:46:22,410
charge in the atmosphere and so these

1059
00:46:26,930 --> 00:46:24,390
come together because the positive

1060
00:46:29,180 --> 00:46:26,940
charge pulls those aerosol droplets

1061
00:46:29,810 --> 00:46:29,190
together into a cloud and if you have

1062
00:46:31,970 --> 00:46:29,820
another one

1063
00:46:33,620 --> 00:46:31,980

out here this positive charge would pull

1064
00:46:35,750 --> 00:46:33,630
it in so you can see that you can get

1065
00:46:39,890 --> 00:46:35,760
discrete structures there is a force

1066
00:46:42,890 --> 00:46:39,900
that pulls all these together and by the

1067
00:46:45,170 --> 00:46:42,900
way it's the net negative force I I

1068
00:46:46,760 --> 00:46:45,180
think of the negative charge of the

1069
00:46:47,660 --> 00:46:46,770
cloud and the earth is negatively

1070
00:46:48,950 --> 00:46:47,670
charged and

1071
00:46:50,809 --> 00:46:48,960
the reason the clouds are up there

1072
00:46:53,329 --> 00:46:50,819
instead of showering us on the head

1073
00:46:57,140 --> 00:46:53,339
because of that repulsive force does

1074
00:46:59,809 --> 00:46:57,150
biology use radiant energy well you know

1075
00:47:01,670 --> 00:46:59,819
we receive radiant energy all the time

1076
00:47:04,760 --> 00:47:01,680
and the question is if you were a mother

1077
00:47:07,760 --> 00:47:04,770
nature would you just discard it and

1078
00:47:09,380 --> 00:47:07,770
re-radiate it or would you use it maybe

1079
00:47:12,140 --> 00:47:09,390
in the same way that plants and some

1080
00:47:14,450 --> 00:47:12,150
bacteria use this energy in the first

1081
00:47:16,730 --> 00:47:14,460
step of photosynthesis so one way this

1082
00:47:19,549 --> 00:47:16,740
might happen if you think about it is is

1083
00:47:22,880 --> 00:47:19,559
the vascular system and the vascular

1084
00:47:25,430 --> 00:47:22,890
system is right right near the periphery

1085
00:47:28,069 --> 00:47:25,440
in fact light penetrates pretty deeply

1086
00:47:30,890 --> 00:47:28,079
some wavelengths if you if the room is

1087
00:47:32,359 --> 00:47:30,900
darkened and I take flashlight and I'm

1088
00:47:35,359 --> 00:47:32,369

dark adapted I could see the light

1089
00:47:37,010 --> 00:47:35,369
coming through the palm of my hand so so

1090
00:47:38,450 --> 00:47:37,020
we've got a lot of light and different

1091
00:47:39,049 --> 00:47:38,460
wavelengths that you're absorbing all

1092
00:47:41,359 --> 00:47:39,059
the time

1093
00:47:43,940 --> 00:47:41,369
I started my career studying the

1094
00:47:46,069 --> 00:47:43,950
cardiovascular system and never did it

1095
00:47:47,480 --> 00:47:46,079
ever occurred to me that light might be

1096
00:47:50,660 --> 00:47:47,490
giving an assist

1097
00:47:53,089 --> 00:47:50,670
until I met some Russians who told me

1098
00:47:54,559 --> 00:47:53,099
that there's a problem here what's the

1099
00:47:58,329 --> 00:47:54,569
problem the problem is that the

1100
00:48:01,670 --> 00:47:58,339
capillaries are in young healthy people

1101
00:48:04,069 --> 00:48:01,680
3 4 5 micrometers and the red cells that

1102
00:48:06,380 --> 00:48:04,079
have to pass through are 6 or 7

1103
00:48:08,480 --> 00:48:06,390
micrometers that's weird

1104
00:48:10,220 --> 00:48:08,490
it looks like nature made a mistake I

1105
00:48:12,079 --> 00:48:10,230
mean they're engineers here and no

1106
00:48:15,740 --> 00:48:12,089
engineer would ever design a pipe that's

1107
00:48:20,000 --> 00:48:15,750
smaller than the sewer pipe smaller than

1108
00:48:22,039 --> 00:48:20,010
well you know what I mean it's weird so

1109
00:48:25,609 --> 00:48:22,049
he said he calculated the resistance of

1110
00:48:28,280 --> 00:48:25,619
this of these of the capillaries and the

1111
00:48:31,220 --> 00:48:28,290
resistance of the capillaries was so

1112
00:48:33,079 --> 00:48:31,230
high that it would require he calculated

1113
00:48:35,539 --> 00:48:33,089

or they calculated this from Moscow

1114
00:48:37,549 --> 00:48:35,549
University they calculated that the

1115
00:48:39,620 --> 00:48:37,559
heart would need to develop a pressure 1

1116
00:48:42,109 --> 00:48:39,630
million times higher than it does in

1117
00:48:44,839 --> 00:48:42,119
order to drive the flow through these

1118
00:48:45,470 --> 00:48:44,849
capillaries so therefore you might need

1119
00:48:47,480 --> 00:48:45,480
an assist

1120
00:48:49,490 --> 00:48:47,490
somehow and they have their own ideas

1121
00:48:51,740 --> 00:48:49,500
but I'm thinking well gee you know we're

1122
00:48:54,770 --> 00:48:51,750
absorbing a lot of light is it possible

1123
00:48:56,599 --> 00:48:54,780
that light since it drives flow through

1124
00:49:01,400 --> 00:48:56,609
tubes maybe it drives flow through

1125
00:49:03,680 --> 00:49:01,410
through capillaries and so I here's a

1126
00:49:06,320 --> 00:49:03,690
and the image this is muscle tissue and

1127
00:49:08,900 --> 00:49:06,330
here here are the capillaries that are

1128
00:49:10,280 --> 00:49:08,910
flowing through and and you know the red

1129
00:49:11,810 --> 00:49:10,290
blood cells are supposed to look like

1130
00:49:13,970 --> 00:49:11,820
this but you can see they have to get

1131
00:49:18,910 --> 00:49:13,980
squinch down in order to get through and

1132
00:49:21,170 --> 00:49:18,920
and so they do it they go through whoops

1133
00:49:22,430 --> 00:49:21,180
they go through you'll notice that

1134
00:49:24,470 --> 00:49:22,440
there's no fluctuation with the

1135
00:49:26,030 --> 00:49:24,480
heartbeat anything like they just flow

1136
00:49:28,010 --> 00:49:26,040
through and this guy is having a lot of

1137
00:49:31,130 --> 00:49:28,020
trouble getting through high resistance

1138
00:49:33,860 --> 00:49:31,140

vessels so so the question is you know

1139
00:49:35,930 --> 00:49:33,870
is it possible that radiant energy that

1140
00:49:37,640 --> 00:49:35,940
we absorb is actually driving the flow

1141
00:49:41,120 --> 00:49:37,650
not through the big vessels but through

1142
00:49:43,460 --> 00:49:41,130
the narrow capillaries light radiant

1143
00:49:46,330 --> 00:49:43,470
energy and a PhD student of mine is

1144
00:49:48,590 --> 00:49:46,340
working on this question right now and

1145
00:49:53,000 --> 00:49:48,600
there's just one piece of evidence I'll

1146
00:49:54,860 --> 00:49:53,010
mention that is weird and this is from

1147
00:49:57,110 --> 00:49:54,870
an Israeli group they are studying mice

1148
00:49:59,690 --> 00:49:57,120
and they're they're using the optical

1149
00:50:04,610 --> 00:49:59,700
coherence tomography method which is you

1150
00:50:07,490 --> 00:50:04,620
can measure blood flow even in in planes

1151
00:50:09,740 --> 00:50:07,500
that are deep beneath this light

1152
00:50:12,110 --> 00:50:09,750
scattering you can get very clear images

1153
00:50:14,450 --> 00:50:12,120
and so they're using this technique to

1154
00:50:16,850 --> 00:50:14,460
measure blood flow and in the presence

1155
00:50:19,460 --> 00:50:16,860
of various agents a drug or whatever and

1156
00:50:21,740 --> 00:50:19,470
and so they're doing this at the end of

1157
00:50:24,560 --> 00:50:21,750
the experiment they sacrifice the mouse

1158
00:50:26,030 --> 00:50:24,570
and they do it by clamping the aorta and

1159
00:50:29,960 --> 00:50:26,040
within a minute or so there's no

1160
00:50:32,330 --> 00:50:29,970
heartbeat the mouse is dead however the

1161
00:50:35,390 --> 00:50:32,340
flow continues they find the flow

1162
00:50:39,290 --> 00:50:35,400
continues for one hour at least

1163
00:50:40,940 --> 00:50:39,300

after the mouse dies and they repeated

1164
00:50:43,850 --> 00:50:40,950
this in ten mice and they got the same

1165
00:50:46,220 --> 00:50:43,860
result so the heart is not beating the

1166
00:50:48,680 --> 00:50:46,230
blood is flowing something is there is

1167
00:50:51,290 --> 00:50:48,690
helping to propel the blood and this

1168
00:50:54,500 --> 00:50:51,300
device uses a lot of light by the way so

1169
00:50:58,040 --> 00:50:54,510
I think it's possible that we capitalize

1170
00:51:00,830 --> 00:50:58,050
on this energy and also in your cells

1171
00:51:02,300 --> 00:51:00,840
you know you have you have proteins and

1172
00:51:04,670 --> 00:51:02,310
then you have this easy water

1173
00:51:06,440 --> 00:51:04,680
surrounding these proteins of course the

1174
00:51:08,570 --> 00:51:06,450
cell is very crowded with this stuff and

1175
00:51:10,430 --> 00:51:08,580
this is just a schematic the cells so

1176
00:51:12,830 --> 00:51:10,440
the cells are full of easy water and

1177
00:51:14,150 --> 00:51:12,840
it's been known for years that structure

1178
00:51:14,950 --> 00:51:14,160
most of the water is so-called

1179
00:51:16,750 --> 00:51:14,960
structured

1180
00:51:20,230 --> 00:51:16,760
ordered water and I think we call it

1181
00:51:23,020 --> 00:51:20,240
easy water and and and so most of the

1182
00:51:25,240 --> 00:51:23,030
cell is like that they're full of easy

1183
00:51:27,609 --> 00:51:25,250
water and remember the easy water is

1184
00:51:30,520 --> 00:51:27,619
negatively charged and so if you think

1185
00:51:32,620 --> 00:51:30,530
about why every cell has negative charge

1186
00:51:34,480 --> 00:51:32,630
there's a theory that has to do with

1187
00:51:37,599 --> 00:51:34,490
pumping and channeling of the membranes

1188
00:51:40,300 --> 00:51:37,609

I think that without going into detail

1189
00:51:41,890 --> 00:51:40,310
that at least some contribution comes

1190
00:51:43,480 --> 00:51:41,900
from the water because easy water is

1191
00:51:46,810 --> 00:51:43,490
negatively charged and the cell is

1192
00:51:49,120 --> 00:51:46,820
mostly easy water and and and so this is

1193
00:51:51,579 --> 00:51:49,130
a different kind of explanation for the

1194
00:51:53,770 --> 00:51:51,589
cells negative potential it's known that

1195
00:51:56,380 --> 00:51:53,780
six cells are less negative for example

1196
00:51:58,630 --> 00:51:56,390
cancer cells instead of minus 80 or 90

1197
00:52:01,000 --> 00:51:58,640
millivolts minus 30 millivolts similar

1198
00:52:02,800 --> 00:52:01,010
with with kidney cells and so the idea

1199
00:52:05,079 --> 00:52:02,810
is that some of these sick cells might

1200
00:52:07,570 --> 00:52:05,089
have less easy water and so what you

1201
00:52:09,280 --> 00:52:07,580
want to do to restore health is to build

1202
00:52:13,329 --> 00:52:09,290
up this easy water to rehydrate

1203
00:52:15,520 --> 00:52:13,339
rehydrate and build up the water and the

1204
00:52:18,460 --> 00:52:15,530
negative potential and so that may be

1205
00:52:21,400 --> 00:52:18,470
the reason why your experience is you

1206
00:52:23,140 --> 00:52:21,410
know you go into a sauna or you go into

1207
00:52:24,760 --> 00:52:23,150
sunlight it's been like Seattle it's

1208
00:52:27,579 --> 00:52:24,770
cloudy and the Sun comes out you feel

1209
00:52:29,320 --> 00:52:27,589
good so why do you feel good there could

1210
00:52:32,320 --> 00:52:29,330
be many reasons why you feel good but I

1211
00:52:34,540 --> 00:52:32,330
think possibility is that perfect is

1212
00:52:37,690 --> 00:52:34,550
that you build

1213
00:52:40,480 --> 00:52:37,700

Easy's and sale charge and that enhances

1214
00:52:43,510 --> 00:52:40,490
function and health and so I'm not

1215
00:52:45,720 --> 00:52:43,520
suggesting that we photosynthesize like

1216
00:52:48,400 --> 00:52:45,730
plants but the first step in

1217
00:52:51,160 --> 00:52:48,410
photosynthesis is the light comes in and

1218
00:52:52,780 --> 00:52:51,170
next to a chromophore it splits water

1219
00:52:54,430 --> 00:52:52,790
well that's exactly what I've been

1220
00:52:57,460 --> 00:52:54,440
talking about next to a hydrophilic

1221
00:53:00,790 --> 00:52:57,470
surface the light photon energy is

1222
00:53:03,790 --> 00:53:00,800
splitting so we may we may do something

1223
00:53:06,040 --> 00:53:03,800
similar to what plants do and what

1224
00:53:08,290 --> 00:53:06,050
bacteria do capitalizing on this very

1225
00:53:11,320 --> 00:53:08,300
effective use of energy that we absorb

1226
00:53:15,450 --> 00:53:11,330
to use that energy I can't end without

1227
00:53:19,060 --> 00:53:15,460
the obvious everybody wants to know and

1228
00:53:21,579 --> 00:53:19,070
so the idea is like photovoltaic cell

1229
00:53:23,770 --> 00:53:21,589
getting getting energy from sunlight and

1230
00:53:26,620 --> 00:53:23,780
water without depleting the earth of its

1231
00:53:27,670 --> 00:53:26,630
resources so here's easy water and bulk

1232
00:53:29,530 --> 00:53:27,680
water and you just

1233
00:53:31,180 --> 00:53:29,540
two electrodes in and you should be able

1234
00:53:33,819 --> 00:53:31,190
to get I showed you that you could get

1235
00:53:36,700 --> 00:53:33,829
current out of this so we've gone ahead

1236
00:53:38,650 --> 00:53:36,710
slowly because of funding issues and

1237
00:53:40,359 --> 00:53:38,660
we've shown that you can actually do

1238
00:53:41,859 --> 00:53:40,369

this in a practical way so here are a

1239
00:53:44,650 --> 00:53:41,869
number of these little cells with

1240
00:53:48,099 --> 00:53:44,660
multiple electrodes and we can light an

1241
00:53:50,200 --> 00:53:48,109
LED so out of this this is just the past

1242
00:53:52,000 --> 00:53:50,210
few weeks we can get more than one milli

1243
00:53:54,520 --> 00:53:52,010
watt of energy which is enough to power

1244
00:53:57,120 --> 00:53:54,530
a sense or something like this and the

1245
00:54:00,849 --> 00:53:57,130
second is what about drinking water from

1246
00:54:02,770 --> 00:54:00,859
contaminated water well we have

1247
00:54:07,809 --> 00:54:02,780
something in fact we have a patent for

1248
00:54:09,940 --> 00:54:07,819
it so here's an Avion tube and flow goes

1249
00:54:12,640 --> 00:54:09,950
this way so the flow the water coming in

1250
00:54:14,980 --> 00:54:12,650
may contain all kinds of garbage our

1251
00:54:16,620 --> 00:54:14,990
garbage is microspheres but you could

1252
00:54:21,849 --> 00:54:16,630
have bacteria we showed that they're

1253
00:54:23,290 --> 00:54:21,859
excluded viruses whatever chemicals so

1254
00:54:25,240 --> 00:54:23,300
it comes in and you have an exclusion

1255
00:54:27,790 --> 00:54:25,250
zone here which doesn't have any of that

1256
00:54:29,920 --> 00:54:27,800
junk and all the junk is here and so we

1257
00:54:33,370 --> 00:54:29,930
collect the junk and get rid of it and

1258
00:54:34,960 --> 00:54:33,380
then we this is the stuff that's clear

1259
00:54:37,930 --> 00:54:34,970
of that junk and you can see and we've

1260
00:54:40,930 --> 00:54:37,940
been able to obtain in a single pass 200

1261
00:54:43,450 --> 00:54:40,940
to one separation and we're now trying

1262
00:54:45,280 --> 00:54:43,460
to scale it up because the throughput of

1263
00:54:48,670 --> 00:54:45,290

this the amount of water that we get

1264
00:54:50,620 --> 00:54:48,680
from one tube is enough is trivial it's

1265
00:54:53,980 --> 00:54:50,630
it's enough to satisfy the thirst of a

1266
00:54:55,990 --> 00:54:53,990
flea we have just recently been able to

1267
00:54:58,180 --> 00:54:56,000
confirm that we can separate salt this

1268
00:55:00,280 --> 00:54:58,190
is the past month or so and so it's

1269
00:55:04,510 --> 00:55:00,290
possible that we can actually take

1270
00:55:07,329 --> 00:55:04,520
saltwater we hope and get drinking water

1271
00:55:10,780 --> 00:55:07,339
out of this no energy is required except

1272
00:55:15,880 --> 00:55:10,790
the energy from the Sun so I conclude

1273
00:55:18,490 --> 00:55:15,890
them with the main the main point so

1274
00:55:21,370 --> 00:55:18,500
we've learned that water has three

1275
00:55:23,740 --> 00:55:21,380
phases ice water and vapor and I've

1276
00:55:26,109 --> 00:55:23,750
shown you the evidence that there's a

1277
00:55:28,750 --> 00:55:26,119
fourth phase or if you want to call it

1278
00:55:31,780 --> 00:55:28,760
that easy phase and I put it in between

1279
00:55:33,430 --> 00:55:31,790
these two because it's structure as I

1280
00:55:35,770 --> 00:55:33,440
said it's very similar to ice

1281
00:55:37,960 --> 00:55:35,780
we have evidence if you want to freeze

1282
00:55:40,150 --> 00:55:37,970
water go from here to here you must pass

1283
00:55:41,220 --> 00:55:40,160
through this phase that is you go from

1284
00:55:44,130 --> 00:55:41,230
water to easy

1285
00:55:46,620 --> 00:55:44,140
- ice and if you melt the ice we just

1286
00:55:48,859 --> 00:55:46,630
have a paper published it goes from ice

1287
00:55:52,320 --> 00:55:48,869
to easy to water this is a necessary

1288
00:55:54,570 --> 00:55:52,330

intermediate between these two and the

1289
00:55:57,859 --> 00:55:54,580
implications of this you know the main

1290
00:56:00,240 --> 00:55:57,869
point is that is that water is always

1291
00:56:01,830 --> 00:56:00,250
absorbing it's a transducer always

1292
00:56:04,500 --> 00:56:01,840
absorbing energy from the environment

1293
00:56:06,560 --> 00:56:04,510
and I've shown you it might have

1294
00:56:11,330 --> 00:56:06,570
something to do with driving flow in

1295
00:56:17,970 --> 00:56:13,890
phenomena that I haven't had a time to

1296
00:56:20,130 --> 00:56:17,980
to talk about chemical reactions you

1297
00:56:22,140 --> 00:56:20,140
know if if we're right then it's

1298
00:56:24,300 --> 00:56:22,150
necessary to look again that all the

1299
00:56:27,180 --> 00:56:24,310
chemical a quiesce chemical reactions

1300
00:56:29,640 --> 00:56:27,190
that occur and possibly reinterpret the

1301
00:56:31,650 --> 00:56:29,650
weather these clouds are anything that

1302
00:56:34,710 --> 00:56:31,660
are charged they're full of charge and

1303
00:56:37,560 --> 00:56:34,720
if you the current people who model the

1304
00:56:39,720 --> 00:56:37,570
whether they consider only temperature

1305
00:56:41,750 --> 00:56:39,730
and pressure and historical trends the

1306
00:56:44,910 --> 00:56:41,760
word charge hardly appears even though

1307
00:56:46,590 --> 00:56:44,920
it's obvious that you know we we see

1308
00:56:49,020 --> 00:56:46,600
lightning and such it's obvious that

1309
00:56:51,930 --> 00:56:49,030
charges are all over the place in terms

1310
00:56:53,849 --> 00:56:51,940
of health start drinking certain kinds

1311
00:56:55,560 --> 00:56:53,859
of water I think water that contains a

1312
00:56:57,990 --> 00:56:55,570
lot of easy water is good for your

1313
00:57:00,720 --> 00:56:58,000

health if you want to process food

1314
00:57:02,730 --> 00:57:00,730
either by dehydration or freezing you

1315
00:57:05,310 --> 00:57:02,740
need to know about the water that's

1316
00:57:07,440 --> 00:57:05,320
involved and I've shown you that it's

1317
00:57:10,830 --> 00:57:07,450
possible to filter using this easy

1318
00:57:13,950 --> 00:57:10,840
principle maybe desalination preliminary

1319
00:57:16,560 --> 00:57:13,960
evidence and getting electricity and as

1320
00:57:21,540 --> 00:57:16,570
Garrett mentioned the book that

1321
00:57:24,870 --> 00:57:21,550
describes this is been out for four Oh

1322
00:57:27,270 --> 00:57:24,880
close to a year now and there's so much

1323
00:57:28,920 --> 00:57:27,280
in it that is just much more than I've

1324
00:57:42,960 --> 00:57:28,930
been able to tell you in this short time

1325
00:57:55,240 --> 00:57:51,039
so we have time for questions York many

1326
00:57:59,170 --> 00:57:55,250
points come to mind but I think the two

1327
00:58:00,640 --> 00:57:59,180
most important if ambient IR if the

1328
00:58:03,759 --> 00:58:00,650
normal thermal radiation of the

1329
00:58:09,970 --> 00:58:03,769
environment is enough to produce an easy

1330
00:58:13,019 --> 00:58:09,980
zone a water battery even though it's

1331
00:58:15,490 --> 00:58:13,029
intensified when you add more light that

1332
00:58:17,410 --> 00:58:15,500
you've already violated the second law

1333
00:58:19,269 --> 00:58:17,420
of thermodynamics congratulations you're

1334
00:58:22,420 --> 00:58:19,279
attracting energy from a uniform heat

1335
00:58:24,309 --> 00:58:22,430
bath also I'm wondering what produces

1336
00:58:27,069 --> 00:58:24,319
the symmetry breaking wear a uniform

1337
00:58:29,380 --> 00:58:27,079
tube produces flow in one direction and

1338
00:58:32,259 --> 00:58:29,390

not the other let me answer the second

1339
00:58:35,920 --> 00:58:32,269
one first because first one is is more

1340
00:58:38,829 --> 00:58:35,930
complicated the the first we don't know

1341
00:58:40,809 --> 00:58:38,839
one day we move in this direction the

1342
00:58:42,190 --> 00:58:40,819
flow goes in this direction the second

1343
00:58:44,950 --> 00:58:42,200
day it goes in the other direction so

1344
00:58:47,499 --> 00:58:44,960
it's not predictable which at least so

1345
00:58:49,720 --> 00:58:47,509
far we don't know we presume with some

1346
00:58:51,730 --> 00:58:49,730
asymmetry because we take a tube and the

1347
00:58:55,029 --> 00:58:51,740
tube it's impossible to have everything

1348
00:58:57,190 --> 00:58:55,039
be symmetrical in the tube the tube we

1349
00:58:59,829 --> 00:58:57,200
cut it and there there are ends of the

1350
00:59:02,740 --> 00:58:59,839
tube and the ends are kind of irregular

1351
00:59:04,809 --> 00:59:02,750
the light is coming in you may have more

1352
00:59:06,579 --> 00:59:04,819
infrared or more other wavelengths

1353
00:59:09,480 --> 00:59:06,589
coming from one side than the other

1354
00:59:12,849 --> 00:59:09,490
as far as thermodynamics is concerned

1355
00:59:15,460 --> 00:59:12,859
you know we we don't first of all the

1356
00:59:18,220 --> 00:59:15,470
principles of thermodynamics are some of

1357
00:59:20,140 --> 00:59:18,230
them are treated in the book and there

1358
00:59:22,329 --> 00:59:20,150
are some issues with with thermodynamics

1359
00:59:24,759 --> 00:59:22,339
with the basic principles that I will

1360
00:59:29,349 --> 00:59:24,769
take up in the book and too much to

1361
00:59:31,599 --> 00:59:29,359
describe here and but one of them is

1362
00:59:34,299 --> 00:59:31,609
that that thermodynamics started with

1363
00:59:36,039 --> 00:59:34,309

steam engines and steam engines and the

1364
00:59:38,319 --> 00:59:36,049
beginnings of thermodynamics started

1365
00:59:41,079 --> 00:59:38,329
with the principle that if you go from

1366
00:59:44,499 --> 00:59:41,089
liquid water to steam you have more

1367
00:59:46,599 --> 00:59:44,509
entropy more disorder it's not true

1368
00:59:48,730 --> 00:59:46,609
we have experimental evidence published

1369
00:59:50,470 --> 00:59:48,740
and in the book that demonstrates that

1370
00:59:53,620 --> 00:59:50,480
the evaporating water is highly

1371
00:59:56,319 --> 00:59:53,630
structured and ordered so the one of the

1372
00:59:59,230 --> 00:59:56,329
fundamental principles of thermodynamics

1373
01:00:01,690 --> 00:59:59,240
language the whole thing is based is not

1374
01:00:04,480 --> 01:00:01,700
necessarily correct and so I question

1375
01:00:06,759 --> 01:00:04,490
the the current understanding of

1376
01:00:08,829 --> 01:00:06,769
thermodynamics be that as it may

1377
01:00:11,319 --> 01:00:08,839
we're actually this is a transducer that

1378
01:00:12,970 --> 01:00:11,329
where you get work and radiant energy

1379
01:00:15,069 --> 01:00:12,980
coming out you have radiant energy

1380
01:00:17,470 --> 01:00:15,079
coming in so it's not just a body that

1381
01:00:18,999 --> 01:00:17,480
absorbs this kind of energy so the

1382
01:00:23,079 --> 01:00:19,009
treatment is it will be different in

1383
01:00:24,460 --> 01:00:23,089
that case okay please um thank you you

1384
01:00:26,829 --> 01:00:24,470
answered my question about the flow

1385
01:00:30,670 --> 01:00:26,839
direction but what about the three

1386
01:00:31,900 --> 01:00:30,680
micron versus the 270 nanometer one is

1387
01:00:33,910 --> 01:00:31,910
apparently creating the charge

1388
01:00:36,609 --> 01:00:33,920

separation and the other is doing what

1389
01:00:40,269 --> 01:00:36,619
well I so the latest evidence we have

1390
01:00:43,990 --> 01:00:40,279
we're not 100% sure we know we know that

1391
01:00:47,380 --> 01:00:44,000
if you put if you take just what start

1392
01:00:50,049 --> 01:00:47,390
with water and you add light to the

1393
01:00:53,349 --> 01:00:50,059
water if you add 279 a meter light you

1394
01:00:56,549 --> 01:00:53,359
get essentially no expansion extra 279

1395
01:00:59,440 --> 01:00:56,559
with no expansion of the EZ if you put

1396
01:01:01,690 --> 01:00:59,450
three micron light you get big expansion

1397
01:01:05,710 --> 01:01:01,700
it's about ten times expansion is easy

1398
01:01:09,069 --> 01:01:05,720
just a very modest amount of infrared

1399
01:01:11,980 --> 01:01:09,079
and essentially essentially no increase

1400
01:01:13,839 --> 01:01:11,990
of temperature that we can measure so so

1401
01:01:14,259 --> 01:01:13,849
that's one thing so for growth of the

1402
01:01:16,870 --> 01:01:14,269
easy

1403
01:01:18,549 --> 01:01:16,880
it looks like the infrared is very

1404
01:01:20,970 --> 01:01:18,559
important and it's probably the infrared

1405
01:01:24,190 --> 01:01:20,980
heating the bulk water which may be

1406
01:01:26,499 --> 01:01:24,200
somehow dissociates the molecules and

1407
01:01:29,529 --> 01:01:26,509
allows them to go to build easy that

1408
01:01:32,890 --> 01:01:29,539
part we're not sure the 270 nanometers

1409
01:01:35,559 --> 01:01:32,900
used inside it absorbed by the EZ not by

1410
01:01:37,990 --> 01:01:35,569
the bulk water that's beyond easy and it

1411
01:01:41,049 --> 01:01:38,000
looks like once you have an exclusion

1412
01:01:43,329 --> 01:01:41,059
zone established this 270 nanometer

1413
01:01:45,460 --> 01:01:43,339

continues to separate charge within that

1414
01:01:47,829 --> 01:01:45,470
exclusion zone that's the best evidence

1415
01:01:50,259 --> 01:01:47,839
we have so once it's established then

1416
01:01:52,150 --> 01:01:50,269
you actually need this UV light to

1417
01:01:54,849 --> 01:01:52,160
perpetuate the separation of charge

1418
01:01:57,490 --> 01:01:54,859
there's some in the environment and we

1419
01:01:59,140 --> 01:01:57,500
have some evidence now in in the case of

1420
01:02:01,990 --> 01:01:59,150
these tubes for example we found that if

1421
01:02:04,150 --> 01:02:02,000
you add infrared light you don't get any

1422
01:02:07,000 --> 01:02:04,160
faster flow you add UV light I didn't

1423
01:02:10,030 --> 01:02:07,010
say that but you get the five times fast

1424
01:02:12,160 --> 01:02:10,040
floo so and because the flow has

1425
01:02:13,840 --> 01:02:12,170
something to do with chart separation by

1426
01:02:17,710 --> 01:02:13,850
mechanism that I haven't had time to

1427
01:02:19,630 --> 01:02:17,720
discuss but it's published I that plus

1428
01:02:23,160 --> 01:02:19,640
other evidence leads us to think that

1429
01:02:26,170 --> 01:02:23,170
probably the 217 nanometer UV absorption

1430
01:02:30,370 --> 01:02:26,180
separates charge doesn't build exclusion

1431
01:02:33,550 --> 01:02:30,380
zone there are cold lasers on the market

1432
01:02:36,190 --> 01:02:33,560
used by chiropractors to eliminate pain

1433
01:02:39,130 --> 01:02:36,200
and they emit infrared to illuminate or

1434
01:02:41,590 --> 01:02:39,140
eliminate eliminate oh okay but they

1435
01:02:43,330 --> 01:02:41,600
emit infrared light and I'm wondering

1436
01:02:46,050 --> 01:02:43,340
what you think is the is having the

1437
01:02:48,460 --> 01:02:46,060
effect on the body sure I mean light

1438
01:02:51,130 --> 01:02:48,470

infrared light some people for different

1439
01:02:52,930 --> 01:02:51,140
syndromes use UV light and some use

1440
01:02:55,600 --> 01:02:52,940
visible light it's all over the spectrum

1441
01:02:58,690 --> 01:02:55,610
literally so to speak it took to cure

1442
01:03:01,060 --> 01:02:58,700
our ills well if you if you think about

1443
01:03:03,580 --> 01:03:01,070
our ills see I think it's actually very

1444
01:03:05,380 --> 01:03:03,590
simple I think whatever ill we have goes

1445
01:03:05,980 --> 01:03:05,390
down to the cellular level something is

1446
01:03:07,600 --> 01:03:05,990
wrong

1447
01:03:09,610 --> 01:03:07,610
they'd have a muscle problem something

1448
01:03:11,290 --> 01:03:09,620
is wrong with my muscle cells right if I

1449
01:03:13,210 --> 01:03:11,300
have a neurological problem something is

1450
01:03:15,550 --> 01:03:13,220
wrong with my nerve cells now a cardiac

1451
01:03:19,240 --> 01:03:15,560
problem etc etc so you want to build the

1452
01:03:20,830 --> 01:03:19,250
function of the cell well how do you

1453
01:03:23,110 --> 01:03:20,840
build the function of the cell and I

1454
01:03:25,360 --> 01:03:23,120
think that relates to the water that's

1455
01:03:27,880 --> 01:03:25,370
inside the cell every protein is

1456
01:03:29,770 --> 01:03:27,890
surrounded by easy water the the prep

1457
01:03:32,320 --> 01:03:29,780
function of the proteins is to do

1458
01:03:34,120 --> 01:03:32,330
something to Bantu to undergo some

1459
01:03:36,730 --> 01:03:34,130
transformation that's what does the work

1460
01:03:38,800 --> 01:03:36,740
of the cell without that water it can't

1461
01:03:40,240 --> 01:03:38,810
function there's a lot of evidence for

1462
01:03:44,080 --> 01:03:40,250
that so you want to restore the water

1463
01:03:46,510 --> 01:03:44,090

you'll restore the easy water and how do

1464
01:03:48,340 --> 01:03:46,520
you restore the easy water light is the

1465
01:03:50,770 --> 01:03:48,350
simplest way so I think that's the

1466
01:03:53,010 --> 01:03:50,780
reason why light at very many

1467
01:03:55,660 --> 01:03:53,020
wavelengths is so effective in reversing

1468
01:03:59,050 --> 01:03:55,670
whatever problems we have whether it's a

1469
01:04:03,880 --> 01:03:59,060
depression problem or you know light

1470
01:04:06,550 --> 01:04:03,890
really does the trick I think I'm a

1471
01:04:08,560 --> 01:04:06,560
medical doctor and I think this is great

1472
01:04:10,510 --> 01:04:08,570
groundbreaking work that you've done and

1473
01:04:12,460 --> 01:04:10,520
I thank you predict that in 10 or 20

1474
01:04:14,140 --> 01:04:12,470
years time this exclusion zone which

1475
01:04:15,010 --> 01:04:14,150
being British I'm going to call the ease

1476
01:04:17,320 --> 01:04:15,020
ed is

1477
01:04:20,020 --> 01:04:17,330
they become very much more fundamental

1478
01:04:23,830 --> 01:04:20,030
to our understanding of of thank you

1479
01:04:27,760 --> 01:04:23,840
one question I was wondering how you

1480
01:04:31,240 --> 01:04:27,770
control between the effect of infrared

1481
01:04:32,740 --> 01:04:31,250
radiation and the thermal effect

1482
01:04:33,940 --> 01:04:32,750
although perhaps you've answered that in

1483
01:04:37,150 --> 01:04:33,950
as much as you were saying that

1484
01:04:40,090 --> 01:04:37,160
ultraviolet has the same has other

1485
01:04:43,330 --> 01:04:40,100
effects similar but also I suppose one

1486
01:04:46,360 --> 01:04:43,340
could argue that according to quantum

1487
01:04:49,510 --> 01:04:46,370
theory that the exchange of energy would

1488
01:04:55,330 --> 01:04:49,520

always involve photons anyway but is it

1489
01:04:56,950 --> 01:04:55,340
specifically photons or is it as I think

1490
01:05:00,280 --> 01:04:56,960
that you know heat and temperature

1491
01:05:02,440 --> 01:05:00,290
another chapter in my book they're vague

1492
01:05:04,810 --> 01:05:02,450
terms different people in different

1493
01:05:06,940 --> 01:05:04,820
disciplines define them different ways I

1494
01:05:10,480 --> 01:05:06,950
think they're not useful terms when we

1495
01:05:12,340 --> 01:05:10,490
deal with physics infrared or radiant

1496
01:05:14,530 --> 01:05:12,350
energy is useful you can define it by

1497
01:05:17,680 --> 01:05:14,540
the wavelength and the intensity but the

1498
01:05:19,390 --> 01:05:17,690
terms I give three or four examples in

1499
01:05:22,330 --> 01:05:19,400
the book of when you try to use

1500
01:05:26,140 --> 01:05:22,340
temperature and try to use heat you come

1501
01:05:28,000 --> 01:05:26,150
up with weird weird results that don't

1502
01:05:29,020 --> 01:05:28,010
make a lot of sense so I tend to stay

1503
01:05:31,810 --> 01:05:29,030
away from heat and temperature

1504
01:05:35,530 --> 01:05:31,820
nevertheless most of the effects that

1505
01:05:38,260 --> 01:05:35,540
we've we put in light and we measure the

1506
01:05:39,700 --> 01:05:38,270
temperature by standard means and none

1507
01:05:41,770 --> 01:05:39,710
of the experiments that we ever use

1508
01:05:43,600 --> 01:05:41,780
enough to raise the temperature by more

1509
01:05:45,580 --> 01:05:43,610
than say one degree so it's it's very

1510
01:05:50,110 --> 01:05:45,590
secondary even if you accept those terms

1511
01:05:53,680 --> 01:05:50,120
as meaningful one parting philosophical

1512
01:05:58,420 --> 01:05:53,690
question so if water can provide a

1513
01:06:02,650 --> 01:05:58,430

photovoltaic effect why does life and

1514
01:06:06,370 --> 01:06:02,660
why do for example the oceans seem to

1515
01:06:09,730 --> 01:06:06,380
require algae or some sort of a plant

1516
01:06:12,490 --> 01:06:09,740
like form to do the PV why can't the

1517
01:06:16,300 --> 01:06:12,500
water PV to do the photovoltaic oh why

1518
01:06:21,610 --> 01:06:16,310
can't the water itself provide energy

1519
01:06:24,430 --> 01:06:21,620
for animals for example well we we don't

1520
01:06:26,350 --> 01:06:24,440
know that that they don't for example at

1521
01:06:27,780 --> 01:06:26,360
the bottom of the sea there are more

1522
01:06:29,190 --> 01:06:27,790
species I'm that

1523
01:06:31,380 --> 01:06:29,200
understand at the bottom of the sea then

1524
01:06:33,480 --> 01:06:31,390
there are at the top you can't there's

1525
01:06:35,460 --> 01:06:33,490
no oxygen there there's no light there

1526
01:06:39,240 --> 01:06:35,470
so you know where are they getting their

1527
01:06:41,430 --> 01:06:39,250
energy it's possible that that the

1528
01:06:43,860 --> 01:06:41,440
thermal energy that's coming from from

1529
01:06:47,010 --> 01:06:43,870
the core of the earth is building easy

1530
01:06:49,140 --> 01:06:47,020
and I mean nobody knows building easy at

1531
01:06:52,530 --> 01:06:49,150
the bottom so it and it's salt water

1532
01:06:54,750 --> 01:06:52,540
around each salt molecule should be easy

1533
01:06:57,000 --> 01:06:54,760
actually the evidence is that you have a

1534
01:07:00,060 --> 01:06:57,010
lot of clusters of salt models with a

1535
01:07:02,820 --> 01:07:00,070
lot of easy that's negative and positive

1536
01:07:04,860 --> 01:07:02,830
outside and so it might be that your

1537
01:07:08,250 --> 01:07:04,870
conjecture is correct that this is

1538
01:07:10,500 --> 01:07:08,260

actually what what is supporting life at

1539
01:07:12,330 --> 01:07:10,510
the bottom of the sea this is I mean an

1540
01:07:16,050 --> 01:07:12,340
idea that needs to be tested good

1541
01:07:18,980 --> 01:07:16,060
comment Thanks yep that's it for the

1542
01:07:21,710 --> 01:07:18,990
questions thank you very much

1543
01:07:28,010 --> 01:07:21,720
[Applause]