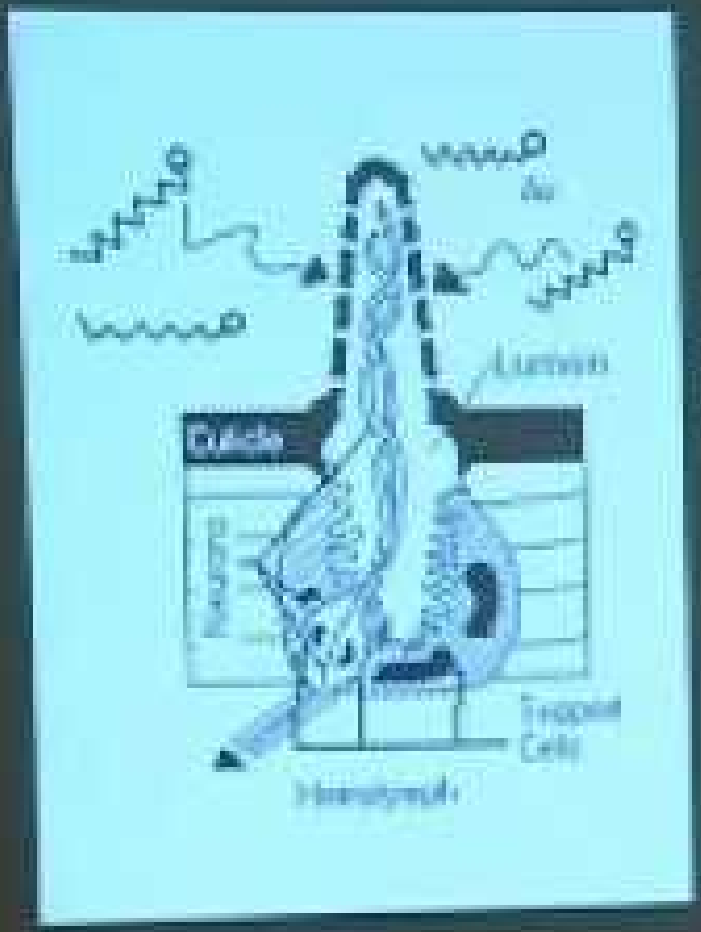

Pheromone is 2 nm long, but the pores are between 10 and 50 nm in diameter.

How does the sensilla prevent clogging of the pores?

Researchers looked for proteins directly on the dendrite, and they found some, but they were not the putative receptors.

Researchers then turned to scanning the genetic code looking for G-proteins.

Immuno-labeling has shown a very low concentration of putative receptors. Where are they?

No receptor-ligand binding has been demonstrated to date.

1
00:00:04,970 --> 00:00:03,379
hello and welcome to the SSC meeting a

2
00:00:06,860 --> 00:00:04,980
secretary I'd like to welcome you I know

3
00:00:08,450 --> 00:00:06,870
it's the last day right now but this is

4
00:00:10,700 --> 00:00:08,460
I guess one of the first opportunities

5
00:00:12,709 --> 00:00:10,710
I've had to to welcome you I hope you're

6
00:00:13,999 --> 00:00:12,719
enjoying yourself so far what we're

7
00:00:16,250 --> 00:00:14,009
going to do is going to diverge a little

8
00:00:18,290 --> 00:00:16,260
bit why because I'm an entomologist and

9
00:00:20,900 --> 00:00:18,300
I play with bugs so we're going to talk

10
00:00:22,910 --> 00:00:20,910
about protein semiconductors in relation

11
00:00:24,189 --> 00:00:22,920
to insect olfaction now a number of you

12
00:00:26,480 --> 00:00:24,199
probably are more familiar with

13
00:00:28,189 --> 00:00:26,490

semiconductors then you would be insect

14
00:00:30,019 --> 00:00:28,199
olfaction for that reason I'm gonna go

15
00:00:31,820 --> 00:00:30,029
spend a little more time talking about

16
00:00:33,650 --> 00:00:31,830
insect olfaction so that you understand

17
00:00:35,150 --> 00:00:33,660
where I'm coming from and why I'm going

18
00:00:36,650 --> 00:00:35,160
to go in the direction of the

19
00:00:39,350 --> 00:00:36,660
semiconductors at the end of the talk

20
00:00:40,940 --> 00:00:39,360
first how do insects smell I think

21
00:00:42,319 --> 00:00:40,950
everyone knows I hope everyone knows

22
00:00:44,840 --> 00:00:42,329
that they all smell with their antennae

23
00:00:46,729 --> 00:00:44,850
they smell with their antennae and this

24
00:00:48,680 --> 00:00:46,739
is no more obvious in some of the large

25
00:00:52,130 --> 00:00:48,690
moths largest moth of the world right

26
00:00:54,410 --> 00:00:52,140
here 11 inch wingspan atticus Atlas and

27
00:00:55,939 --> 00:00:54,420
they take a look at the antenna here

28
00:00:58,549 --> 00:00:55,949
especially on the Saturn I it's because

29
00:01:00,590 --> 00:00:58,559
they're so big but it's not really the

30
00:01:03,049 --> 00:01:00,600
antenna itself it's usually the sencilla

31
00:01:05,179 --> 00:01:03,059
so if you get a close-up of the sencilla

32
00:01:06,500 --> 00:01:05,189
you can see on this scanning electron

33
00:01:07,789 --> 00:01:06,510
micrograph that they have these long

34
00:01:10,310 --> 00:01:07,799
tricloid sencilla

35
00:01:12,260 --> 00:01:10,320
which we know are the detectors and

36
00:01:14,060 --> 00:01:12,270
these are the actual detectors of the

37
00:01:16,760 --> 00:01:14,070
molecules that they are smelling such as

38
00:01:18,039 --> 00:01:16,770

the pheromone or the plan odorants now

39
00:01:22,070 --> 00:01:18,049
if I go ahead and make a cross-section

40
00:01:24,770 --> 00:01:22,080
now of this you can see that the

41
00:01:26,870 --> 00:01:24,780
sencilla is does have some tiny pores in

42
00:01:28,249 --> 00:01:26,880
the side right there they also have some

43
00:01:30,020 --> 00:01:28,259
dendrites emanating from these cells

44
00:01:31,819 --> 00:01:30,030
down here try could get into our image

45
00:01:34,569 --> 00:01:31,829
and cell the dendrites are sent up

46
00:01:37,730 --> 00:01:34,579
they're bathed in a saline solution and

47
00:01:41,030 --> 00:01:37,740
this is the basic setup for most types

48
00:01:43,130 --> 00:01:41,040
of insect sencilla this is where i'm an

49
00:01:44,899 --> 00:01:43,140
agreement with them and we do not differ

50
00:01:46,310 --> 00:01:44,909
at all things start to get a little

51
00:01:47,690 --> 00:01:46,320
hairy right now let me tell you what the

52
00:01:49,520 --> 00:01:47,700
current theory is right now so that

53
00:01:52,429 --> 00:01:49,530
you're up to date we have the pheromones

54
00:01:54,410 --> 00:01:52,439
out here the pheromone is in blue the

55
00:01:56,569 --> 00:01:54,420
pheromone diffuses through the air it

56
00:01:58,789 --> 00:01:56,579
lands on the sense illa this is the

57
00:02:00,530 --> 00:01:58,799
sencilla right here the outside there is

58
00:02:02,569 --> 00:02:00,540
a very very thin layer of wax they

59
00:02:04,459 --> 00:02:02,579
usually imbed in the wax and when they

60
00:02:06,770 --> 00:02:04,469
embed in the wax they diffuse through

61
00:02:09,589 --> 00:02:06,780
the wax make their way to some tiny

62
00:02:11,180 --> 00:02:09,599
pores through it and then they have to

63
00:02:13,760 --> 00:02:11,190

wait they have to wait because it's a

64
00:02:16,460 --> 00:02:13,770
lipid water and oil don't mix

65
00:02:18,470 --> 00:02:16,470
this is water the pheromones are a

66
00:02:19,700 --> 00:02:18,480
long-chain 14 carbon acetate and

67
00:02:21,680 --> 00:02:19,710
therefore they're not going to diffuse

68
00:02:23,210 --> 00:02:21,690
through it they have to wait for a

69
00:02:25,580 --> 00:02:23,220
pheromone binding protein which is

70
00:02:27,560 --> 00:02:25,590
pretty large in order to come along grab

71
00:02:30,200 --> 00:02:27,570
it from the poor pull it in

72
00:02:32,990 --> 00:02:30,210
it will then ferry it across this until

73
00:02:37,970 --> 00:02:33,000
early it will then make its way to a

74
00:02:39,440 --> 00:02:37,980
receptor and somehow binding is meant to

75
00:02:41,000 --> 00:02:39,450
occur whether it's with the pheromone

76
00:02:43,310 --> 00:02:41,010
directly or whether it's with the

77
00:02:45,620 --> 00:02:43,320
pheromone binding protein complex with

78
00:02:47,660 --> 00:02:45,630
the pheromone and this is how detection

79
00:02:50,330 --> 00:02:47,670
occurs you are now up to date and you

80
00:02:52,340 --> 00:02:50,340
can now publish any information on

81
00:02:53,330 --> 00:02:52,350
insect olfaction because this is about

82
00:02:55,760 --> 00:02:53,340
as far as we go

83
00:02:59,390 --> 00:02:55,770
you can apply for an NIH grant NSF grant

84
00:03:01,090 --> 00:02:59,400
and you will get funded for this now

85
00:03:04,100 --> 00:03:01,100
what is the overlying theme right here

86
00:03:05,770 --> 00:03:04,110
diffusion diffusion diffusion

87
00:03:08,150 --> 00:03:05,780
we've got diffusion through the air

88
00:03:10,430 --> 00:03:08,160

we've got diffusion through a wax layer

89
00:03:11,930 --> 00:03:10,440
and I've got now diffusion through this

90
00:03:13,790 --> 00:03:11,940
ancillary limb even though it has to

91
00:03:15,470 --> 00:03:13,800
piggyback on a pheromone binding protein

92
00:03:16,850 --> 00:03:15,480
well this makes my job a little bit

93
00:03:19,510 --> 00:03:16,860
easier right now because when you've got

94
00:03:21,890 --> 00:03:19,520
a mechanism as singular as diffusion

95
00:03:23,360 --> 00:03:21,900
there are some laws that you can follow

96
00:03:25,100 --> 00:03:23,370
and you think to yourself wow this is

97
00:03:26,900 --> 00:03:25,110
diffusion I mean we can predict this

98
00:03:28,760 --> 00:03:26,910
sure it's going to be faster through air

99
00:03:29,960 --> 00:03:28,770
slower through the wax and a little bit

100
00:03:31,880 --> 00:03:29,970
faster through the water though but

101
00:03:34,340 --> 00:03:31,890
there are some some generalizations that

102
00:03:36,410 --> 00:03:34,350
can be made and Informer talks I've let

103
00:03:38,870 --> 00:03:36,420
you know that diffusion does not account

104
00:03:41,300 --> 00:03:38,880
for the ability for the pheromone to

105
00:03:43,220 --> 00:03:41,310
reach the receptor in time if parent if

106
00:03:45,320 --> 00:03:43,230
the diffusion is all I have to work with

107
00:03:47,480 --> 00:03:45,330
and I assure you that this is all I have

108
00:03:48,860 --> 00:03:47,490
to work with then according to the

109
00:03:51,650 --> 00:03:48,870
current theory I can't get to that

110
00:03:53,510 --> 00:03:51,660
pheromone to the dendrite in time in

111
00:03:55,010 --> 00:03:53,520
order to say that the insect is now

112
00:03:58,070 --> 00:03:55,020
detecting it how long does this take

113
00:03:59,510 --> 00:03:58,080

this takes one millisecond no it takes a

114
00:04:02,540 --> 00:03:59,520
little bit less than one millisecond

115
00:04:04,220 --> 00:04:02,550
point eight point seven milliseconds now

116
00:04:05,949 --> 00:04:04,230
to biologists some of you impressed

117
00:04:08,420 --> 00:04:05,959
right now I think and Tom that's fast

118
00:04:10,820 --> 00:04:08,430
but to you physicists you're like that's

119
00:04:12,940 --> 00:04:10,830
casual you know one millisecond because

120
00:04:15,979 --> 00:04:12,950
you guys are dealing with nanoseconds

121
00:04:17,420 --> 00:04:15,989
picoseconds maybe femtoseconds we're but

122
00:04:18,860 --> 00:04:17,430
the biology is and we're dealing with

123
00:04:22,240 --> 00:04:18,870
less than one millisecond that is

124
00:04:25,700 --> 00:04:22,250
lightning fast for a biological system

125
00:04:26,960 --> 00:04:25,710
so what to do here is our cross section

126
00:04:27,600 --> 00:04:26,970
I've blown it up a little bit so you can

127
00:04:28,860 --> 00:04:27,610
take a closer

128
00:04:30,089 --> 00:04:28,870
to see what we're talking about the

129
00:04:32,399 --> 00:04:30,099
pheromone the friend when I'm dealing

130
00:04:34,379 --> 00:04:32,409
with is about two nanometers long but

131
00:04:36,390 --> 00:04:34,389
the pores are between 10 and 50

132
00:04:37,890 --> 00:04:36,400
nanometers in diameter what's going to

133
00:04:39,779 --> 00:04:37,900
happen when the pheromone hits a

134
00:04:41,790 --> 00:04:39,789
scintilla it's going to clog the pores

135
00:04:43,559 --> 00:04:41,800
it's going to clog the pores because

136
00:04:44,939 --> 00:04:43,569
there's just not that much room and it's

137
00:04:47,550 --> 00:04:44,949
not just the pheromone that gets in

138
00:04:49,110 --> 00:04:47,560

anything that the insect wants to smell

139
00:04:51,089 --> 00:04:49,120
is going to have to get through those

140
00:04:54,029 --> 00:04:51,099
pores and get to the dendrite anything

141
00:04:55,860 --> 00:04:54,039
plant odorants pheromone you name it and

142
00:04:57,510 --> 00:04:55,870
so everything is going to get clogged

143
00:04:59,339 --> 00:04:57,520
because it's not going to diffuse it has

144
00:05:03,059 --> 00:04:59,349
to wait for a ferryboat in order to

145
00:05:04,740 --> 00:05:03,069
carry it across problem also so the

146
00:05:06,209 --> 00:05:04,750
researchers looked for the proteins

147
00:05:08,760 --> 00:05:06,219
because they got the funding for it

148
00:05:10,409 --> 00:05:08,770
research look for proteins directly on

149
00:05:12,330 --> 00:05:10,419
the dendrite well that makes sense I

150
00:05:13,740 --> 00:05:12,340
mean we do know that there's got to be

151
00:05:16,200 --> 00:05:13,750
something there the dendrites are

152
00:05:17,760 --> 00:05:16,210
detecting it somehow so you take a look

153
00:05:19,890 --> 00:05:17,770
at the proteins and they found some of

154
00:05:22,290 --> 00:05:19,900
course because there's always proteins

155
00:05:24,119 --> 00:05:22,300
on dendrites but they were not the

156
00:05:27,119 --> 00:05:24,129
putative receptors so they had to keep

157
00:05:28,740 --> 00:05:27,129
looking the research then tuned to

158
00:05:30,179 --> 00:05:28,750
scanning the genetic codes again are oh

159
00:05:32,309 --> 00:05:30,189
you can't find them directly through

160
00:05:34,409 --> 00:05:32,319
direct means let's do this indirectly

161
00:05:36,689 --> 00:05:34,419
will scan the genetic code we're going

162
00:05:38,189 --> 00:05:36,699
to look for G proteins why why you're

163
00:05:40,379 --> 00:05:38,199

going to look for G proteins because we

164
00:05:43,170 --> 00:05:40,389
know that G proteins are involved in

165
00:05:45,119 --> 00:05:43,180
human olfaction so for UMD's out there

166
00:05:47,640 --> 00:05:45,129
old news for you for the rest of you

167
00:05:49,709 --> 00:05:47,650
this is new news so the G proteins are

168
00:05:52,980 --> 00:05:49,719
looked at lo and behold they find them

169
00:05:55,980 --> 00:05:52,990
but they don't find them in great

170
00:05:57,510 --> 00:05:55,990
quantity mu new labeling comes in next

171
00:05:58,980 --> 00:05:57,520
yes they find them in the sense illa but

172
00:06:00,839 --> 00:05:58,990
the immuno labeling comes in and they

173
00:06:03,659 --> 00:06:00,849
show a very low concentration of these

174
00:06:08,010 --> 00:06:03,669
putative receptors so the question is

175
00:06:10,469 --> 00:06:08,020
where are they and then the big one no

176
00:06:12,749 --> 00:06:10,479
receptor ligand binding has been

177
00:06:13,670 --> 00:06:12,759
demonstrated to date so as I stand

178
00:06:16,079 --> 00:06:13,680
before you

179
00:06:20,129 --> 00:06:16,089
there is no receptor ligand binding

180
00:06:22,740 --> 00:06:20,139
there is no receptor binding this has

181
00:06:25,769 --> 00:06:22,750
not been shown yet it is assumed this is

182
00:06:27,089 --> 00:06:25,779
also a problem why is this I mean as a

183
00:06:28,740 --> 00:06:27,099
matter of fact this is a huge problem

184
00:06:31,829 --> 00:06:28,750
why can't you show binding in

185
00:06:33,659 --> 00:06:31,839
pharmacology we know that molecules bind

186
00:06:37,170 --> 00:06:33,669
to like siedel choline acetylcholine

187
00:06:39,659 --> 00:06:37,180
receptors this makes sense but this we

188
00:06:41,020 --> 00:06:39,669

haven't been able to show any binding so

189
00:06:42,610 --> 00:06:41,030
this thing kind of brings me to the

190
00:06:44,320 --> 00:06:42,620
which I've talked about before but let

191
00:06:46,330 --> 00:06:44,330
me just review for you right now the

192
00:06:48,460 --> 00:06:46,340
current theory is about lock and key

193
00:06:50,440 --> 00:06:48,470
it's about this binding that I told you

194
00:06:52,750 --> 00:06:50,450
about the receptor and it's got the

195
00:06:54,400 --> 00:06:52,760
pheromone the lock and key hypothesis

196
00:06:56,560 --> 00:06:54,410
olfaction says we've got the receptor

197
00:06:58,630 --> 00:06:56,570
the pheromone comes along and it binds

198
00:07:01,090 --> 00:06:58,640
with it and this is what causes the

199
00:07:02,770 --> 00:07:01,100
message to make it to the dendrite the

200
00:07:04,630 --> 00:07:02,780
vibrational theory of odor which some of

201
00:07:06,970 --> 00:07:04,640
you know I am a proponent of does not

202
00:07:09,040 --> 00:07:06,980
say that it's a lock and key system it

203
00:07:10,930 --> 00:07:09,050
can operate either by touching the

204
00:07:13,960 --> 00:07:10,940
sencilla on the outside if it's acting

205
00:07:16,030 --> 00:07:13,970
as an antenna or it can simply come in

206
00:07:18,070 --> 00:07:16,040
close proximity very close proximity to

207
00:07:19,660 --> 00:07:18,080
the antenna and the antenna or that

208
00:07:21,610 --> 00:07:19,670
since Silla will be able to detect it

209
00:07:23,130 --> 00:07:21,620
that's the vibrational Theory voter I

210
00:07:25,750 --> 00:07:23,140
believe that insects are smelling

211
00:07:28,270 --> 00:07:25,760
electromagnetically so let's take a look

212
00:07:30,010 --> 00:07:28,280
but if I'm putting this forward some of

213
00:07:32,350 --> 00:07:30,020

you might be thinking I I don't follow

214
00:07:34,510 --> 00:07:32,360
this is new stuff Tom I need some help

215
00:07:36,250 --> 00:07:34,520
what's the mechanism I mean you've got a

216
00:07:39,010 --> 00:07:36,260
message on the outside of the sencilla

217
00:07:41,590 --> 00:07:39,020
and you got to get it to the inside

218
00:07:45,090 --> 00:07:41,600
dendrite the electrophysiologist tell us

219
00:07:48,010 --> 00:07:45,100
that the dendrite d polarizes a normal

220
00:07:51,370 --> 00:07:48,020
depolarization just like a normal neuron

221
00:07:53,230 --> 00:07:51,380
and a normal neuronal spike passes down

222
00:07:56,200 --> 00:07:53,240
the neuron to eventually reach the

223
00:07:58,090 --> 00:07:56,210
normal brain nothing new about this so

224
00:08:00,940 --> 00:07:58,100
because this is a normal spike we know

225
00:08:03,700 --> 00:08:00,950
that dendrite is somehow involved if the

226
00:08:05,380 --> 00:08:03,710
antenna was the detector the antenna was

227
00:08:07,660 --> 00:08:05,390
the detector this whole sencilla right

228
00:08:10,060 --> 00:08:07,670
here acting as an antenna then the

229
00:08:11,260 --> 00:08:10,070
neurons which we do know are projecting

230
00:08:13,240 --> 00:08:11,270
up would be unnecesarry

231
00:08:14,920 --> 00:08:13,250
we wouldn't need them because the

232
00:08:17,260 --> 00:08:14,930
detection is done at the level of the

233
00:08:19,030 --> 00:08:17,270
antenna but we know that there's a

234
00:08:21,580 --> 00:08:19,040
message going down the neuron so if the

235
00:08:24,880 --> 00:08:21,590
antenna is simply the primary detector

236
00:08:26,980 --> 00:08:24,890
but not the final detector then how does

237
00:08:28,960 --> 00:08:26,990
a normal spike and it's very normal get

238
00:08:31,680 --> 00:08:28,970

initiated in the nerve cell and this is

239
00:08:34,150 --> 00:08:31,690
what brings me to the proteins

240
00:08:35,710 --> 00:08:34,160
ultimately sooner or later one must

241
00:08:37,450 --> 00:08:35,720
consider that certain proteins on the

242
00:08:40,150 --> 00:08:37,460
dendrite are mediating this occurrence

243
00:08:42,970 --> 00:08:40,160
in some fashion but like the grinch but

244
00:08:44,380 --> 00:08:42,980
how and so because this is going on and

245
00:08:45,970 --> 00:08:44,390
I do believe that proteins are involved

246
00:08:47,440 --> 00:08:45,980
but I don't believe it's lock and key we

247
00:08:49,390 --> 00:08:47,450
got to take a look at these proteins but

248
00:08:50,860 --> 00:08:49,400
my problem is that because I'm not

249
00:08:52,480 --> 00:08:50,870
dealing with a lock and key I've got to

250
00:08:54,700 --> 00:08:52,490
figure out how to get an electromagnetic

251
00:08:56,560 --> 00:08:54,710
message in

252
00:08:59,410 --> 00:08:56,570
an electromagnetic message as it passes

253
00:09:02,200 --> 00:08:59,420
down the nerve now there is a little bit

254
00:09:04,000 --> 00:09:02,210
of it's not just electromagnetic

255
00:09:07,840 --> 00:09:04,010
electromagnetic there's going to have to

256
00:09:09,040 --> 00:09:07,850
be some some interplay here and so this

257
00:09:11,260 --> 00:09:09,050
kind of brings me to the point where I

258
00:09:12,880 --> 00:09:11,270
think all right I need a protein and I

259
00:09:14,980 --> 00:09:12,890
need it to react to electromagnetic

260
00:09:17,290 --> 00:09:14,990
energy I'll search the literature see

261
00:09:18,820 --> 00:09:17,300
what I can find what do I find well the

262
00:09:20,860 --> 00:09:18,830
first thing that pops up is probably the

263
00:09:22,230 --> 00:09:20,870

most studies rhodopsin I'm looking at

264
00:09:24,880 --> 00:09:22,240
you right now you're looking at me

265
00:09:27,490 --> 00:09:24,890
rhodopsin is firing it's a great system

266
00:09:30,700 --> 00:09:27,500
what happens in rhodopsin which is a

267
00:09:33,220 --> 00:09:30,710
protein by the way incoming light hits

268
00:09:35,410 --> 00:09:33,230
the rhodopsin molecule there is a shift

269
00:09:37,330 --> 00:09:35,420
in electron density this shift and

270
00:09:39,760 --> 00:09:37,340
electron density causes a conformational

271
00:09:43,480 --> 00:09:39,770
change can't get much easier than that

272
00:09:45,040 --> 00:09:43,490
it bends alright and so this is measured

273
00:09:46,780 --> 00:09:45,050
this is measured because the rhodopsin

274
00:09:48,790 --> 00:09:46,790
is that are in our eye it's attached to

275
00:09:50,590 --> 00:09:48,800
the cell membrane cell membrane has some

276
00:09:52,960 --> 00:09:50,600
great electromagnetic properties to it

277
00:09:58,150 --> 00:09:52,970
and it's detected and it's a beautiful