

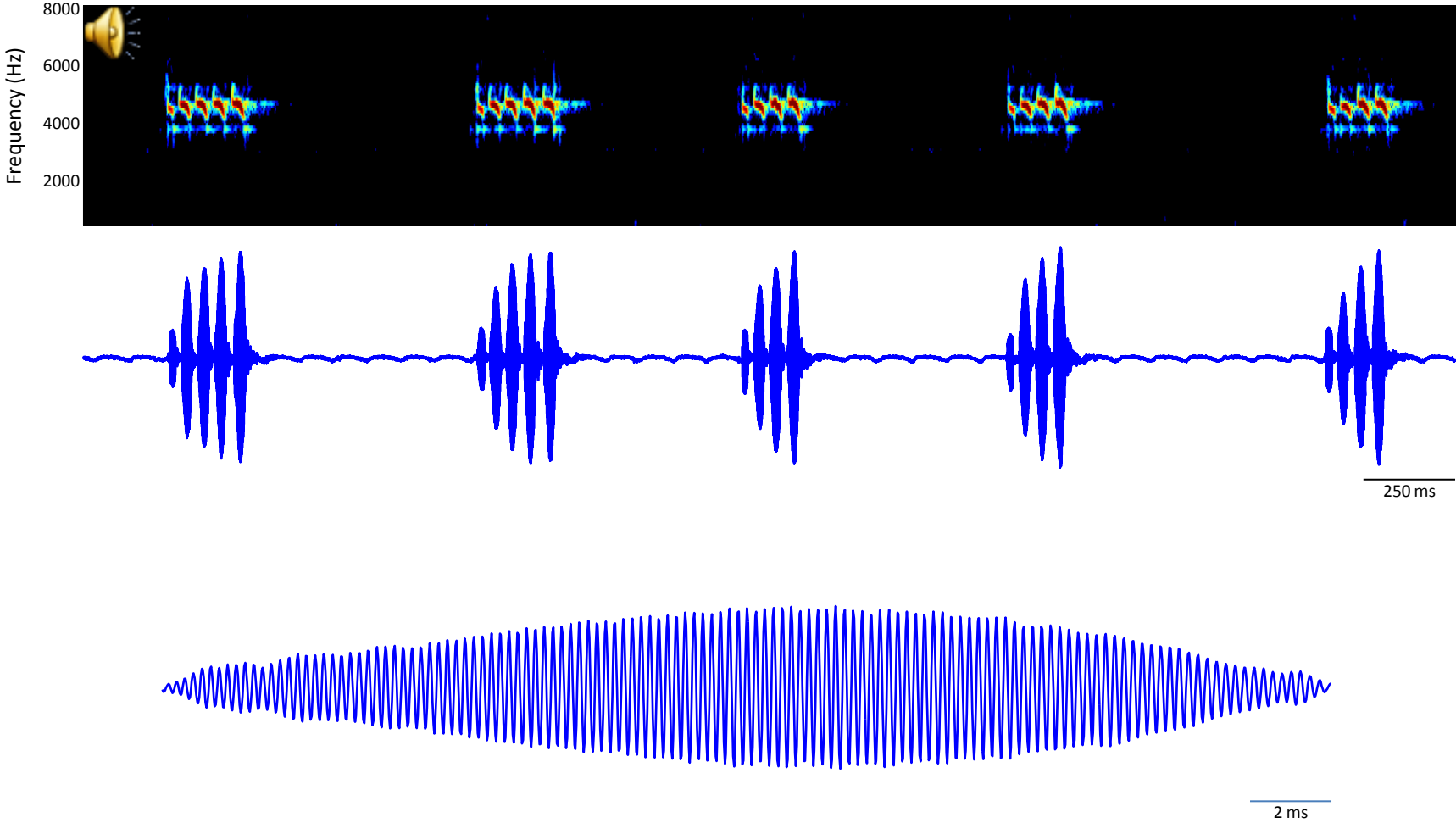
Neural mechanisms of Cricket song

2013/01/17

Tatsuo Okubo

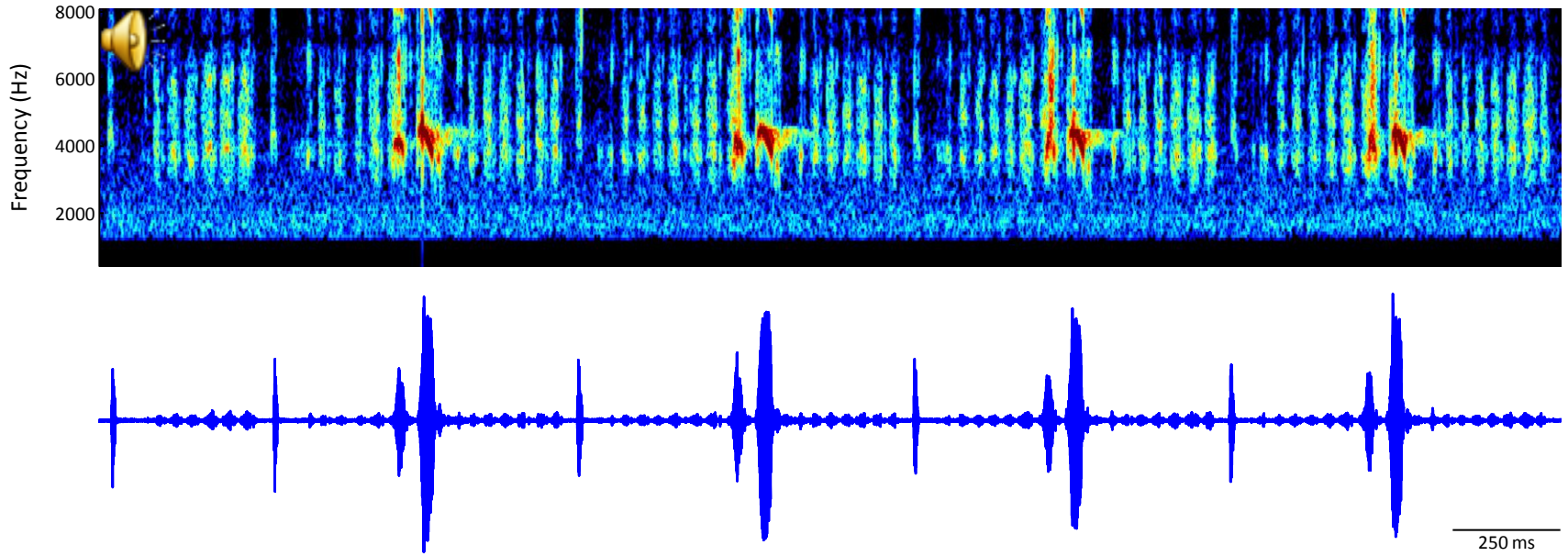


Calling song

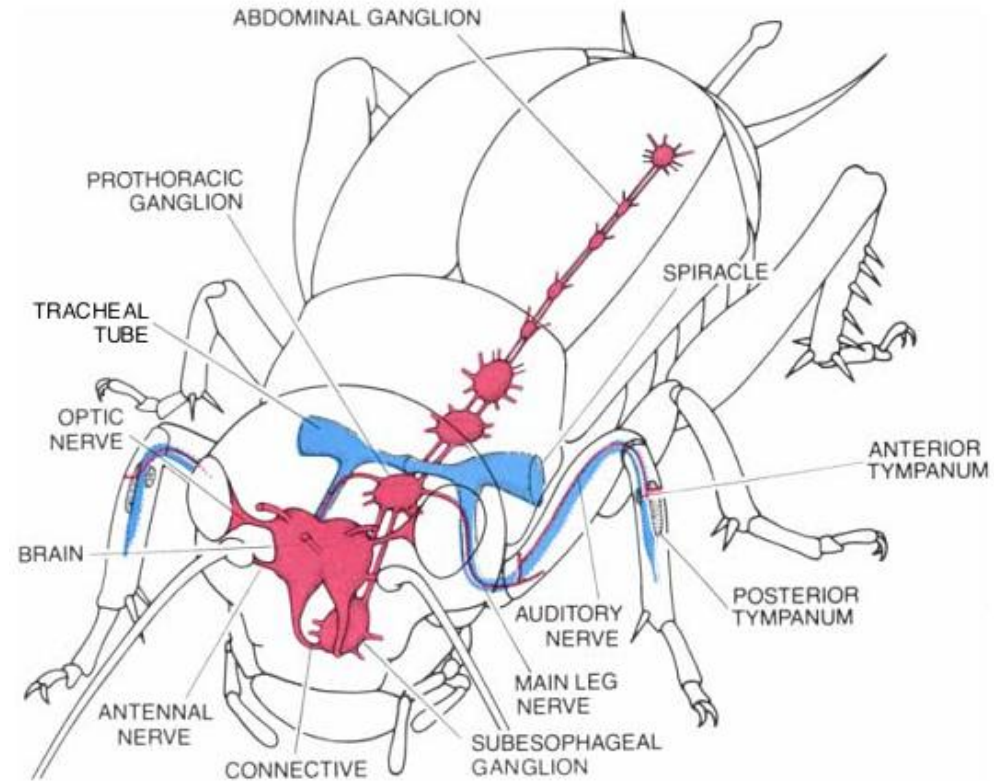
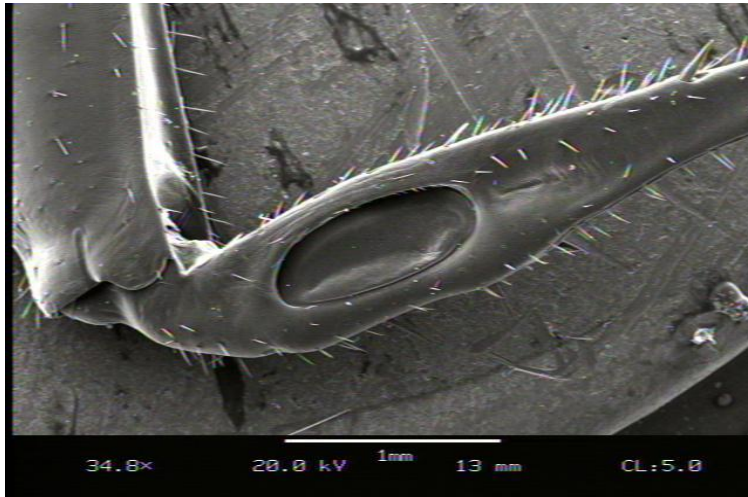


Gryllus pennsylvanicus (Thomas Walker @ U. Florida)

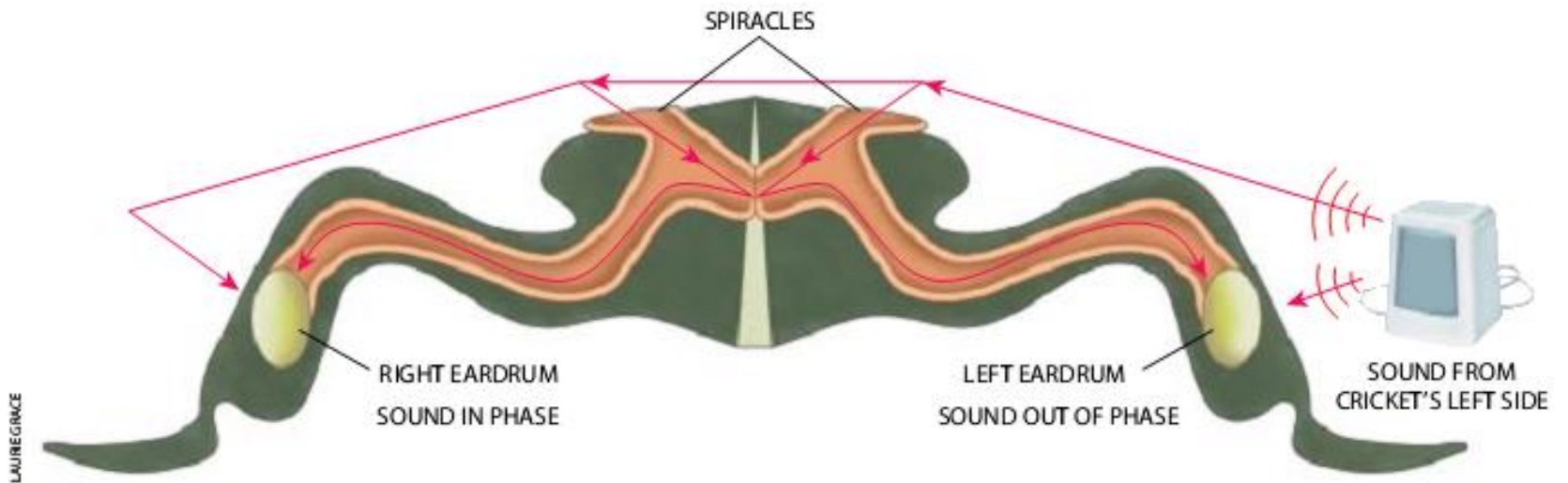
Courtship song



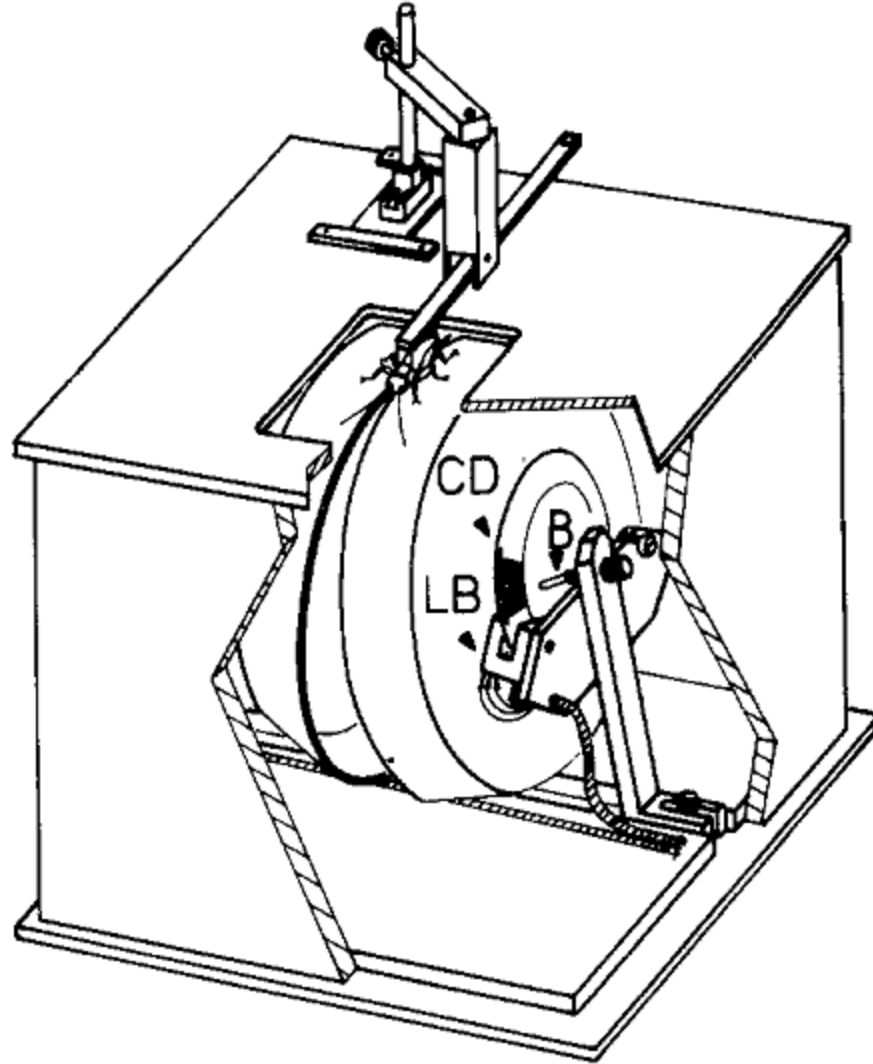
Cricket auditory system



Pressure-gradient receivers



Walking wheels



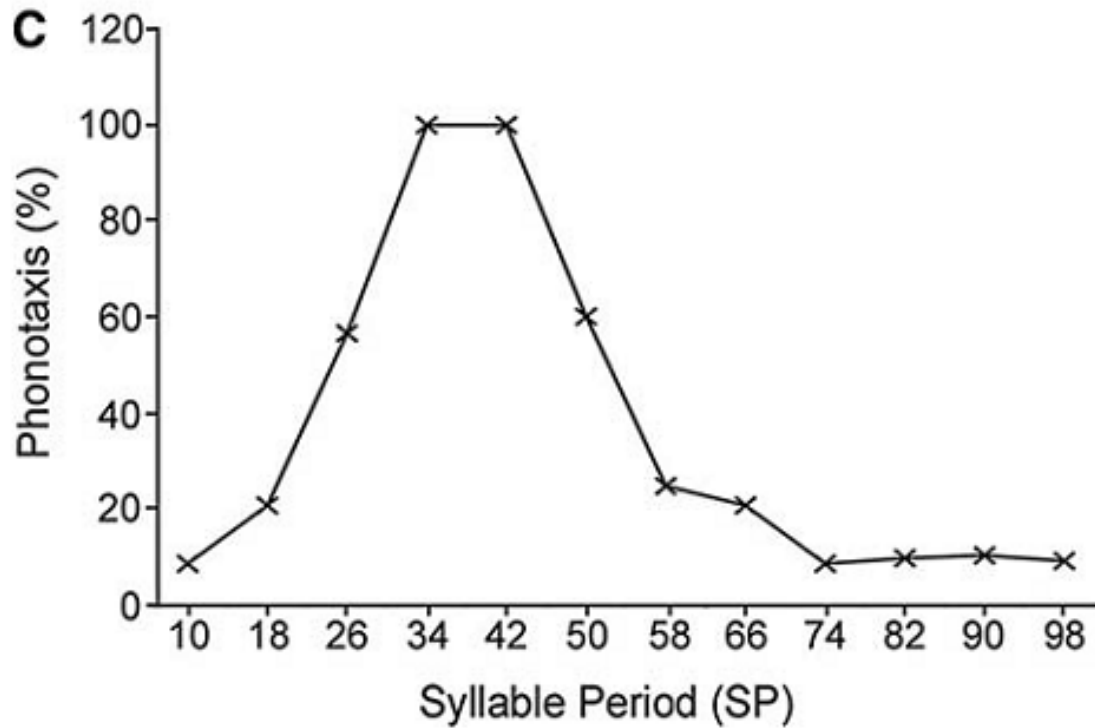
Stabel ... Scharstein (*J Comp Physiol A*, 1989)

Cricket trackball

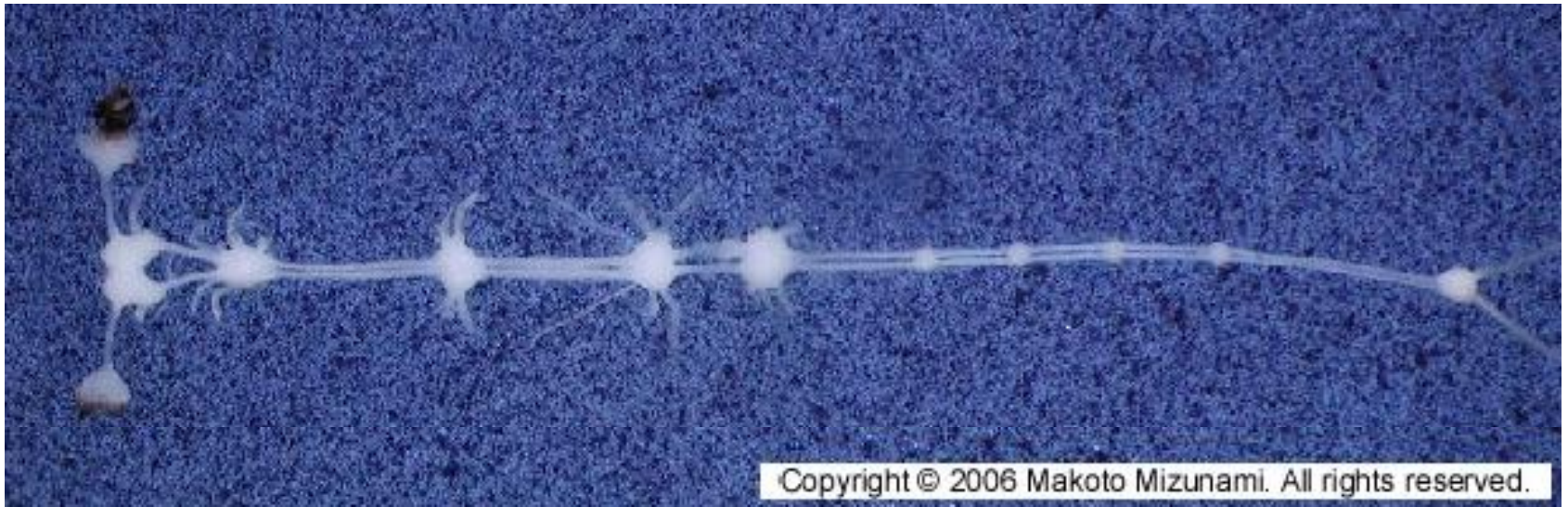


Huber ... Thorson (*Sci Am*, 1985)

Females prefer syllable rate of 30/s



Cricket nervous system



brain

SOG



thoracic
ganglion

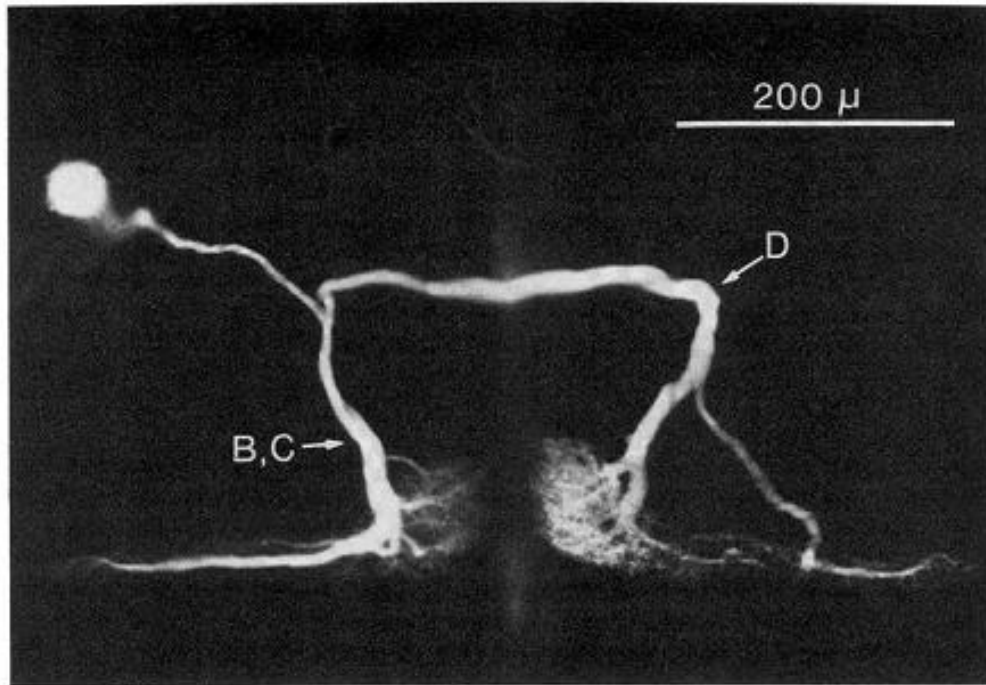


abdominal
ganglion

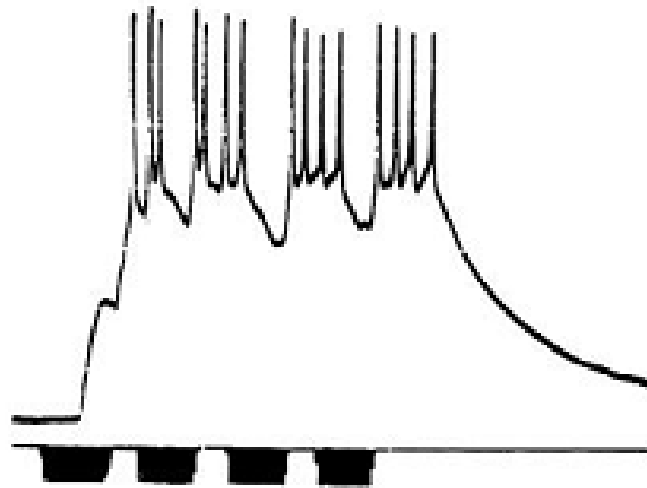
Gryllus bimaculatus

http://invbrain.neuroinf.jp/modules/newdb1/extract/50/thumbnail/img1/koro_zen.jpg

The Omega neuron (ON1)



Auditory response of the omega neuron



B

ipsilateral ear: excitation

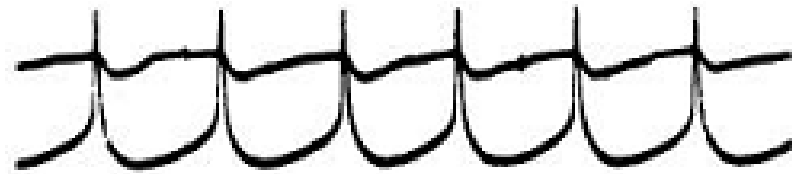
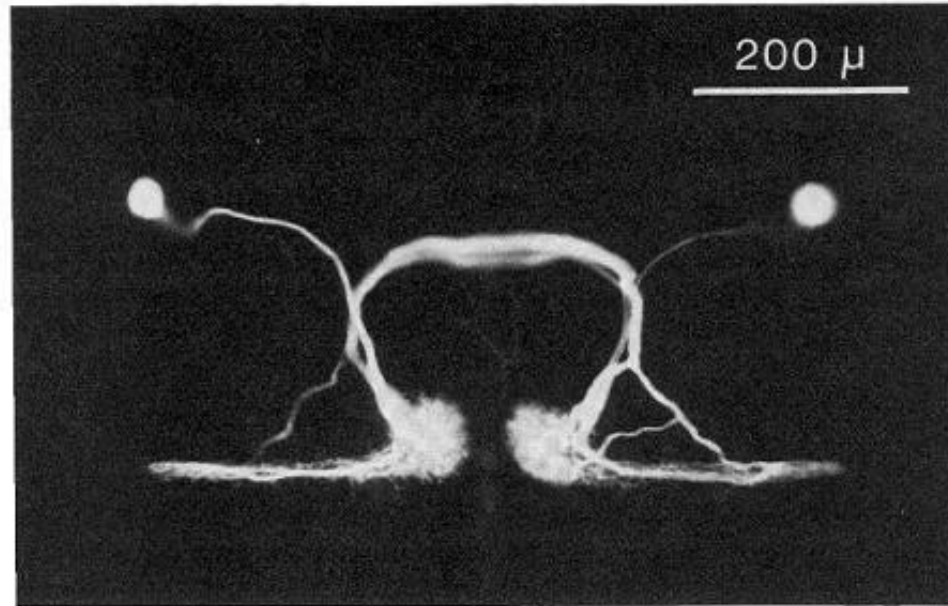


C

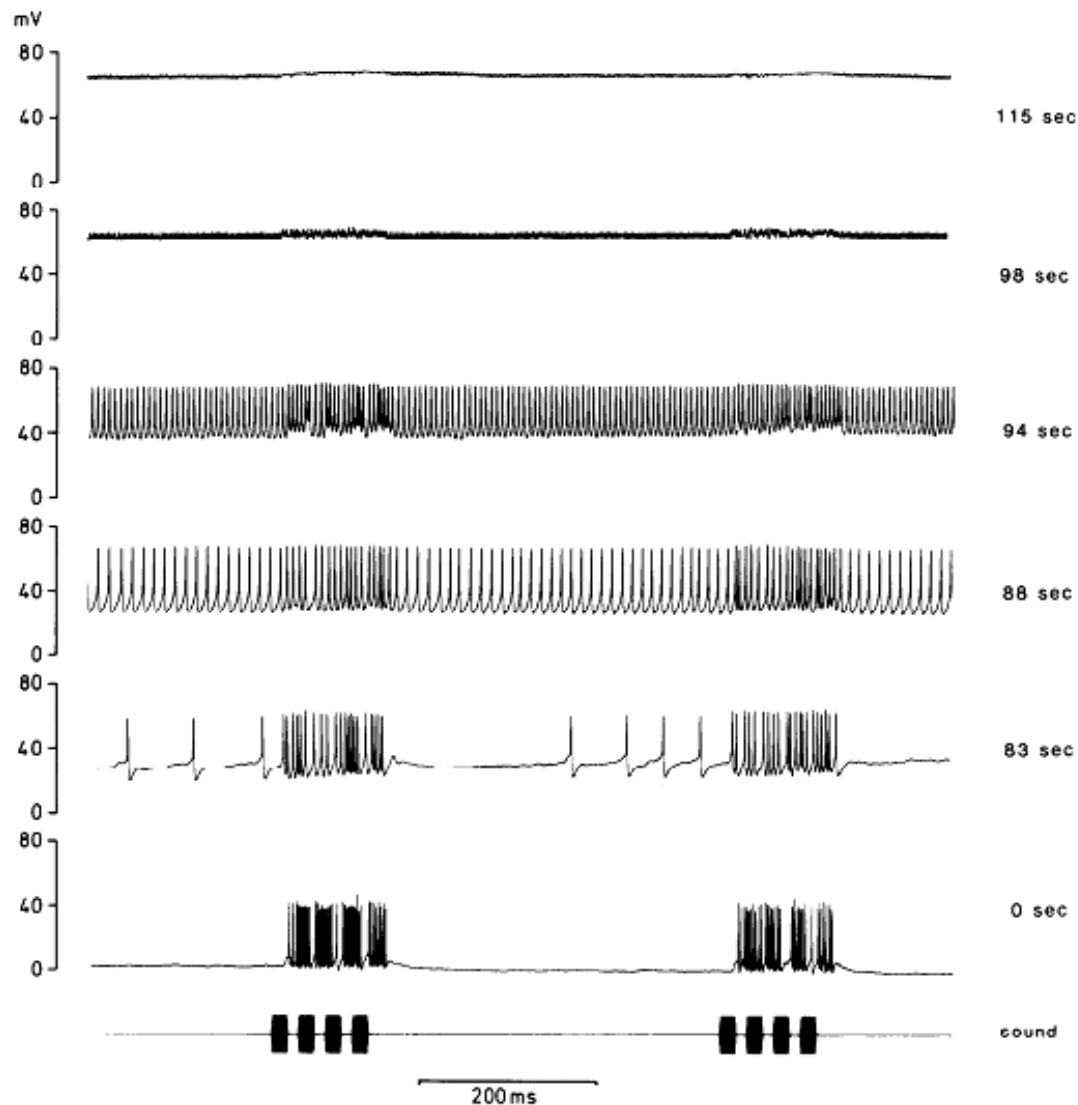
contralateral: inhibition

Paired recording shows IPSP

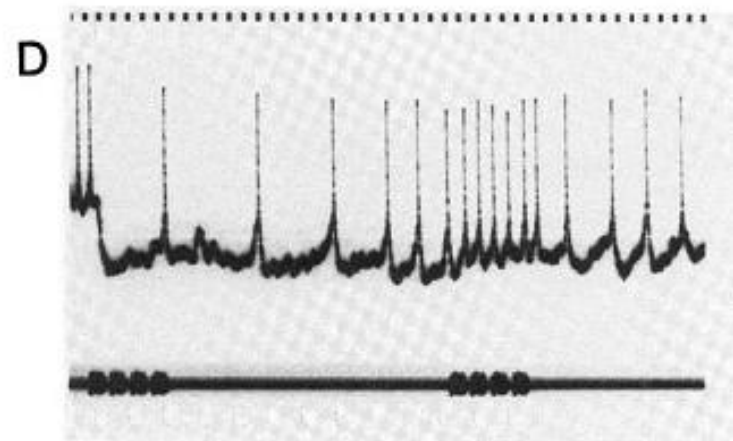
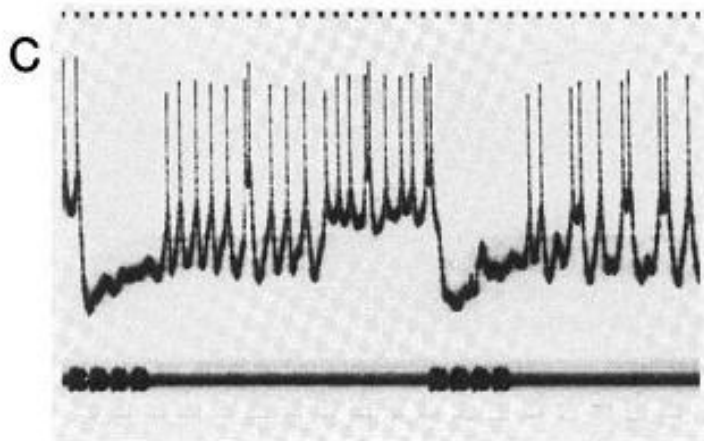
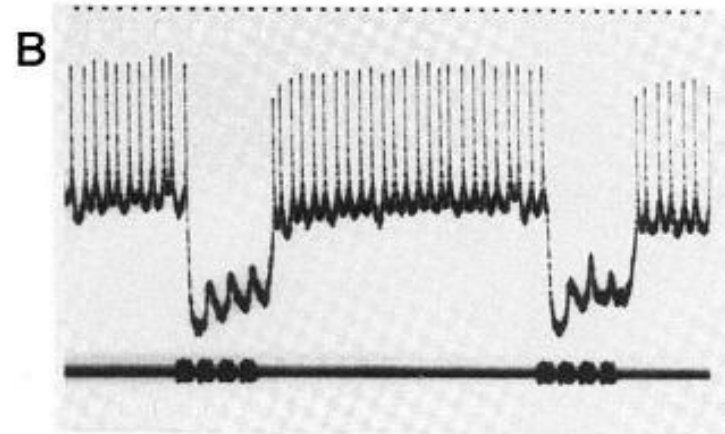
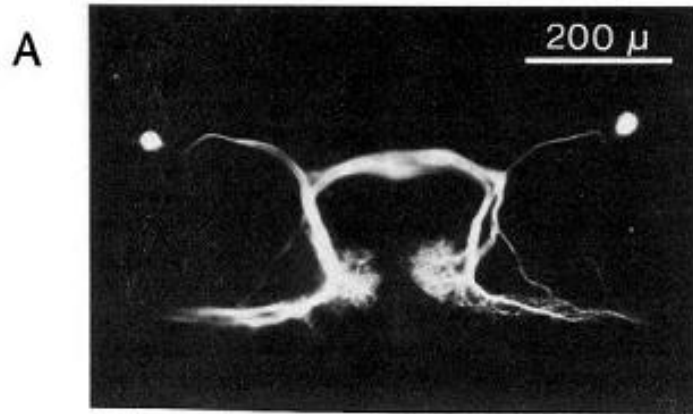
ON/1 PAIR



Photoinactivation of a neuron



Killing the other Omega neuron removes inhibition



Ascending neuron 1 (AN1)

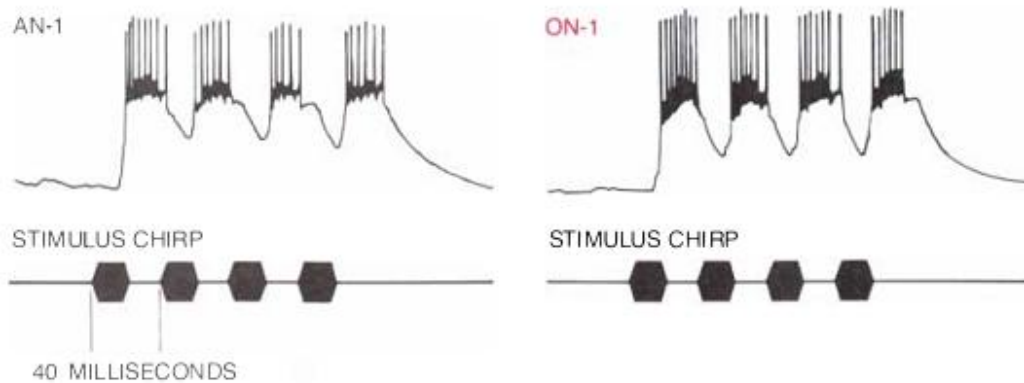
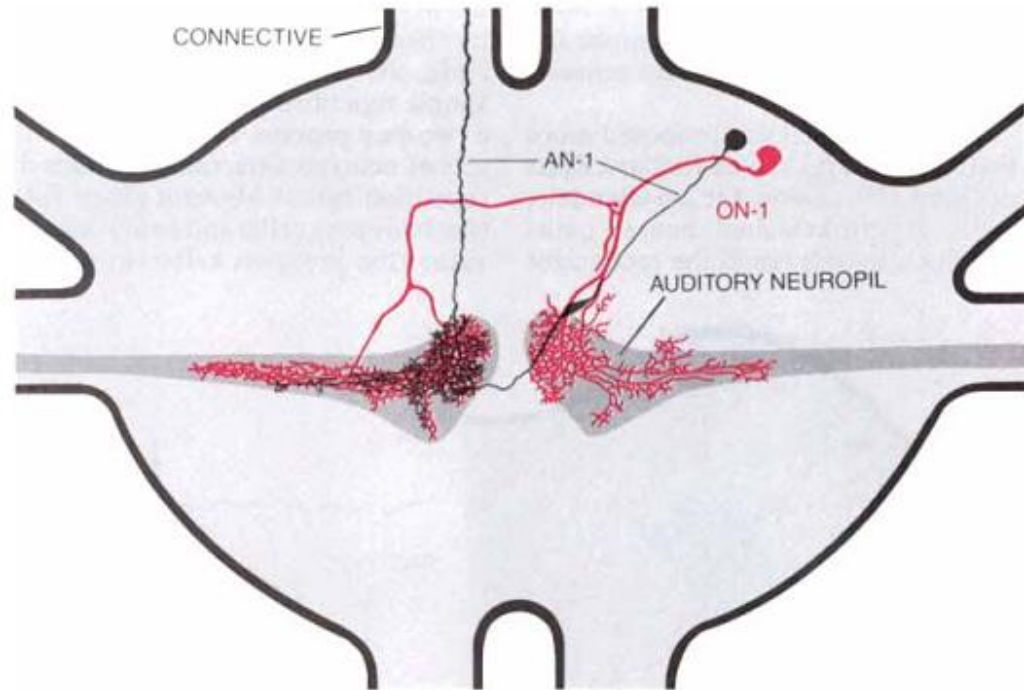
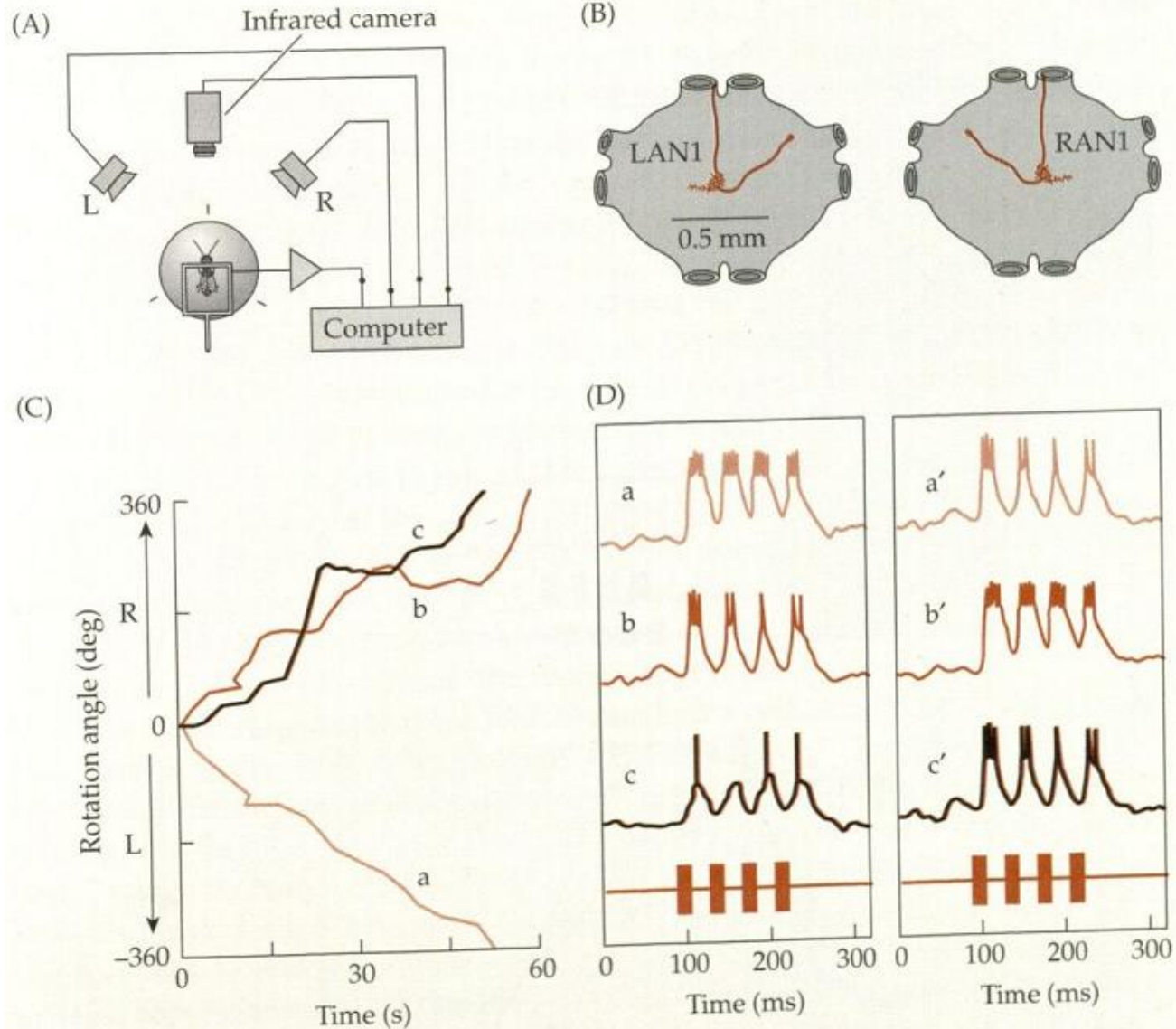
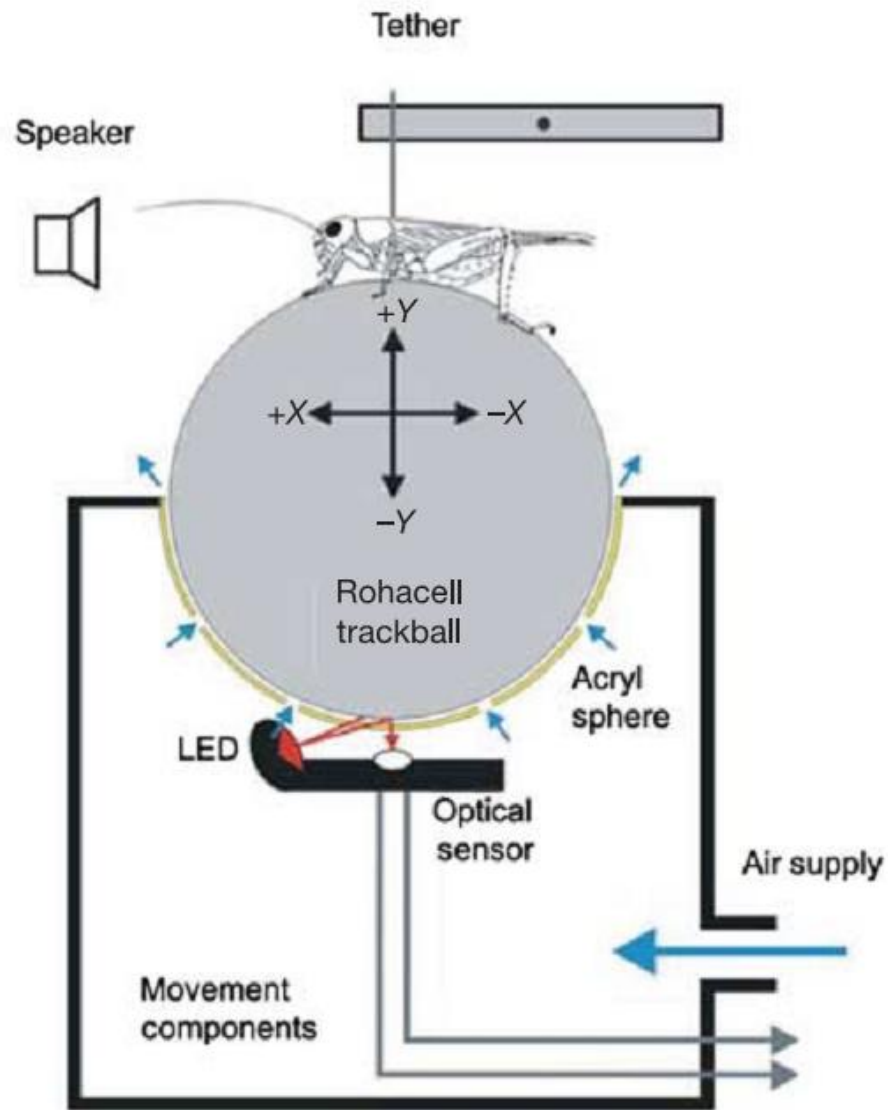


Figure from Huber & Thorson (*Sci Am*, 1985)

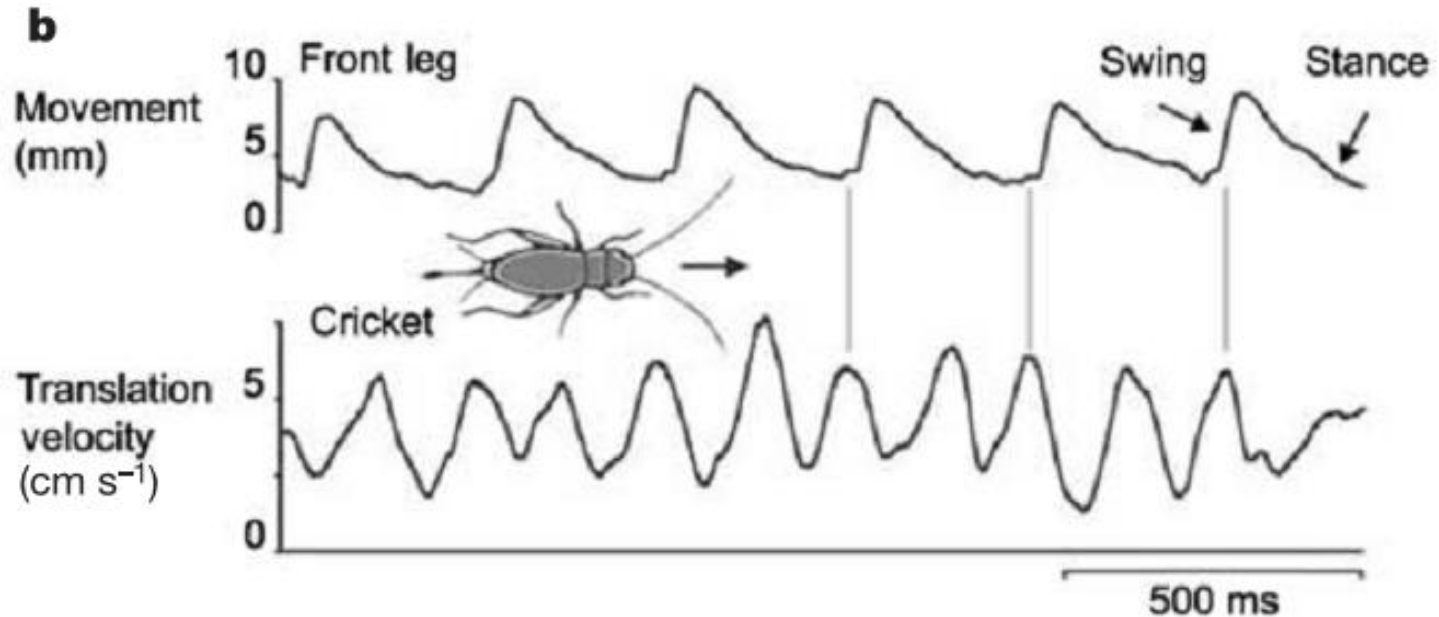
Effect of AN1 on phonotaxis



Trackball with high spatial, temporal resolution

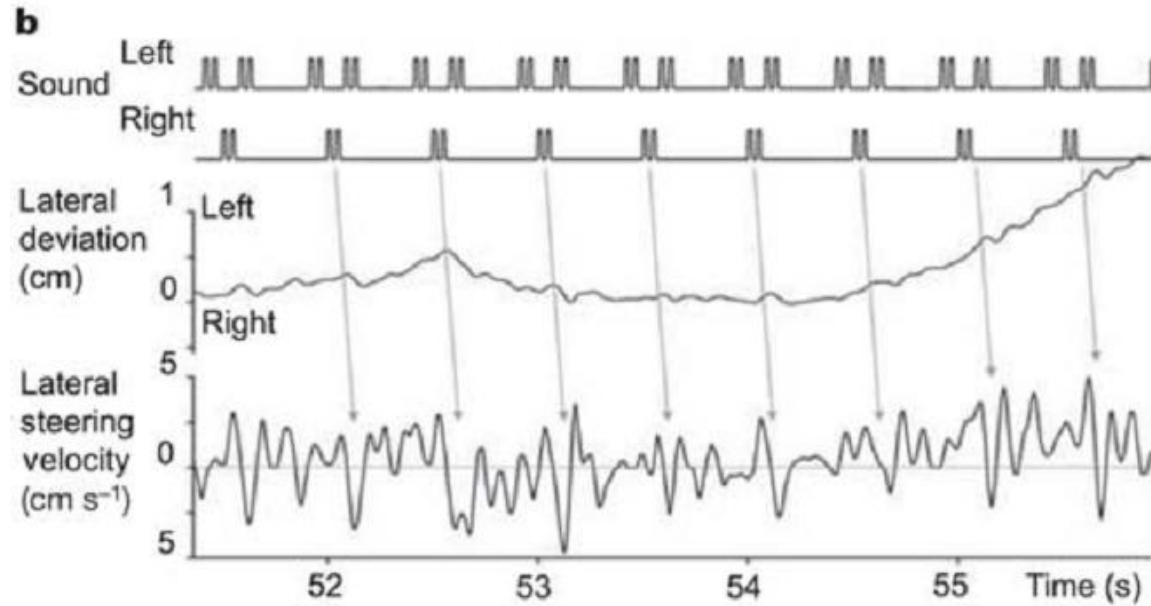


The track ball can detect individual steps

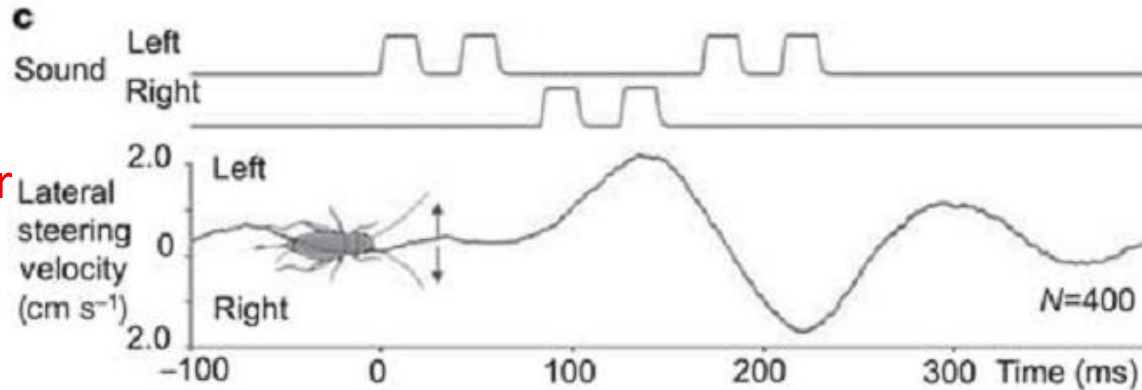


Rapid reactive steering to sound

raw trace

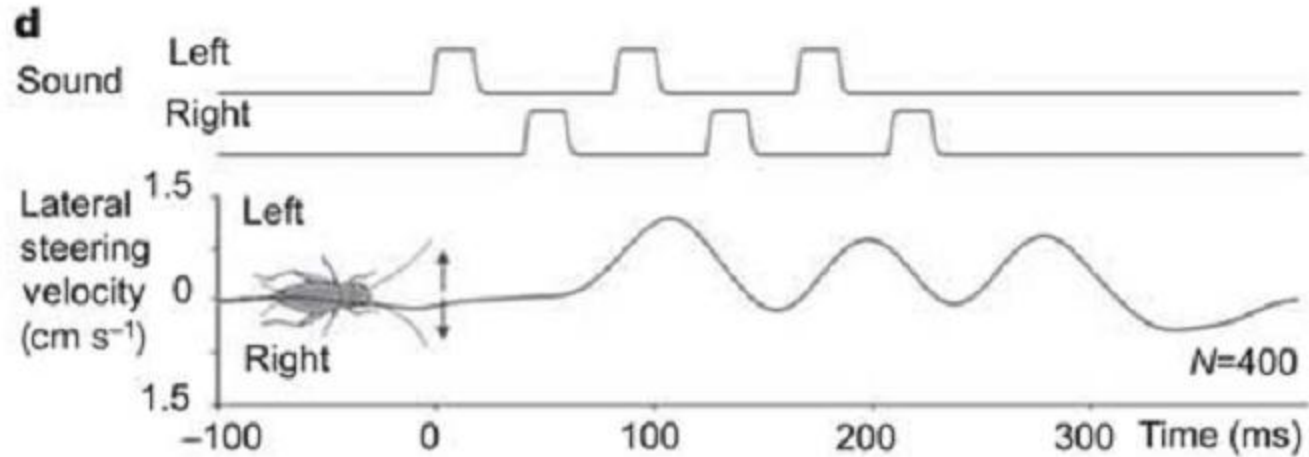


averaged over
400 trials

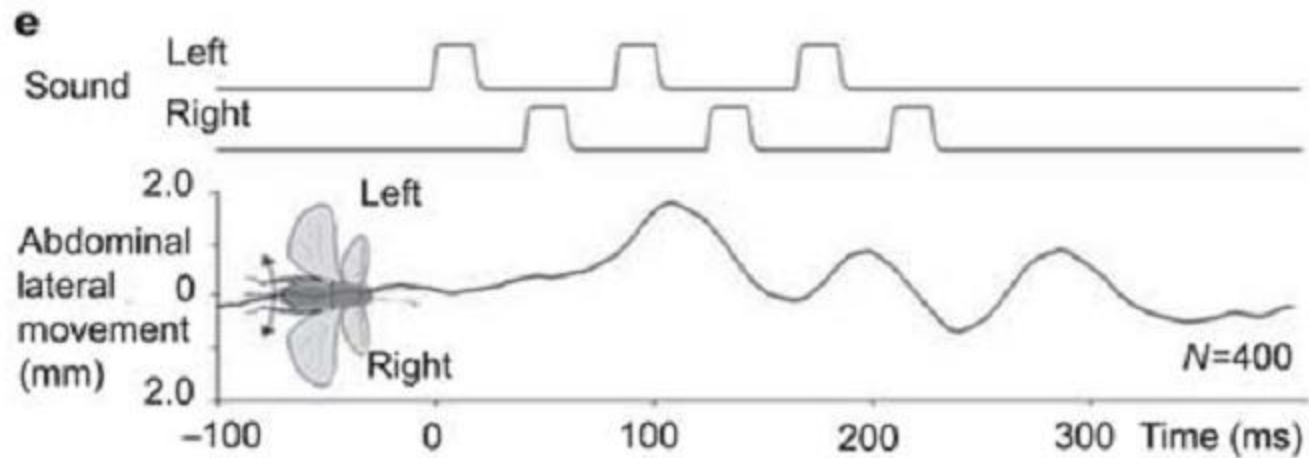


Even a single pulse can trigger steering!

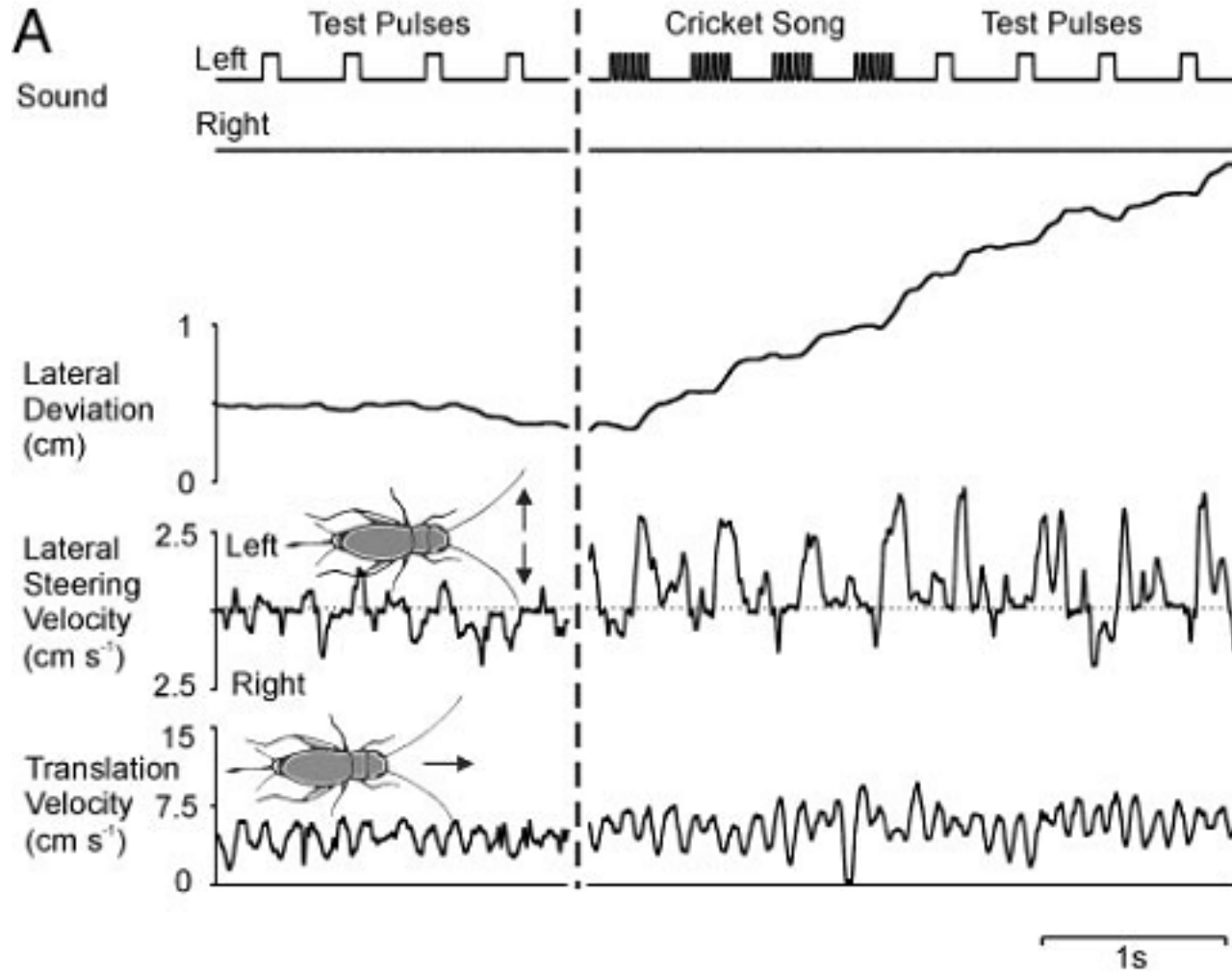
walking



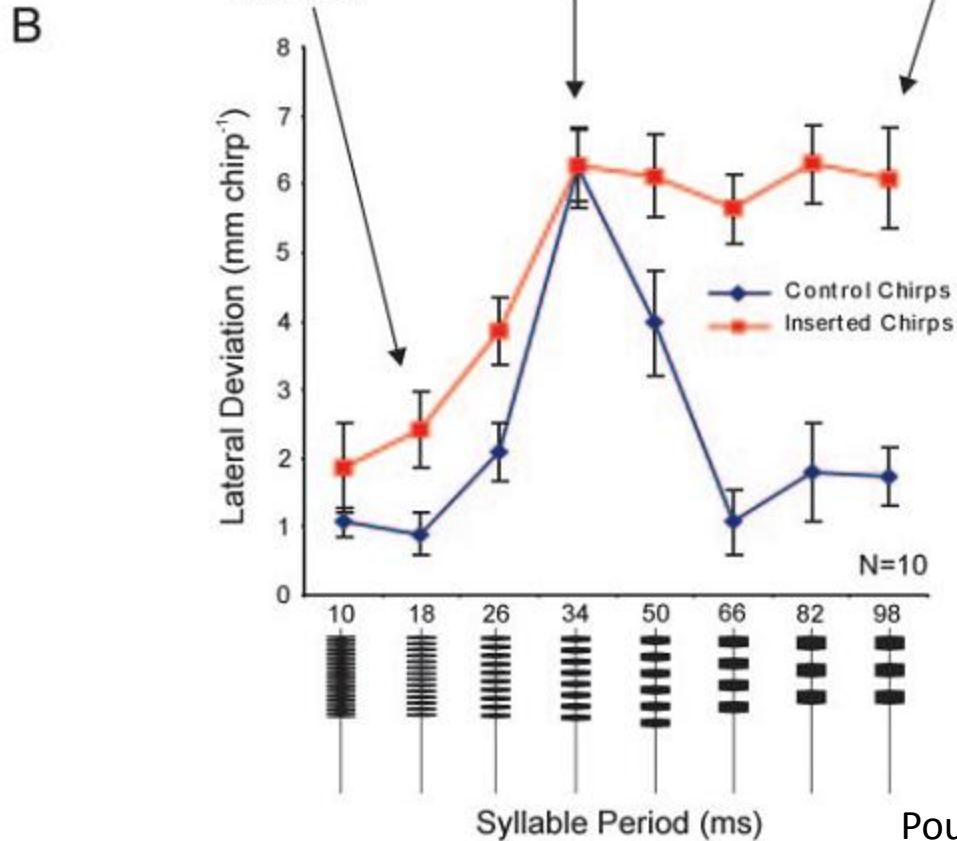
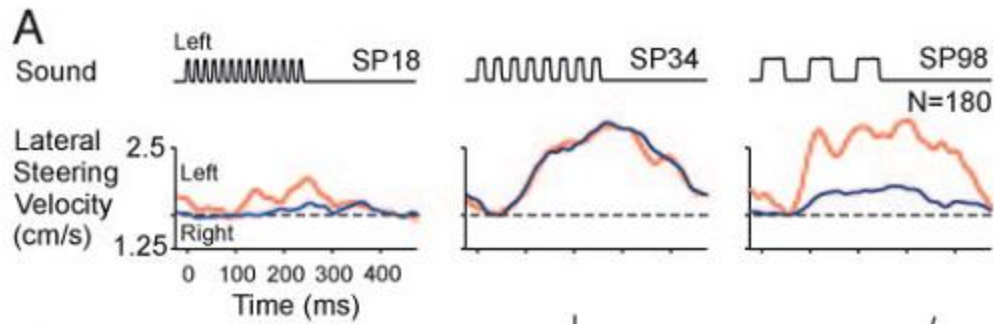
flying



Species-specific song increases the gain



Species-specific song increases the gain

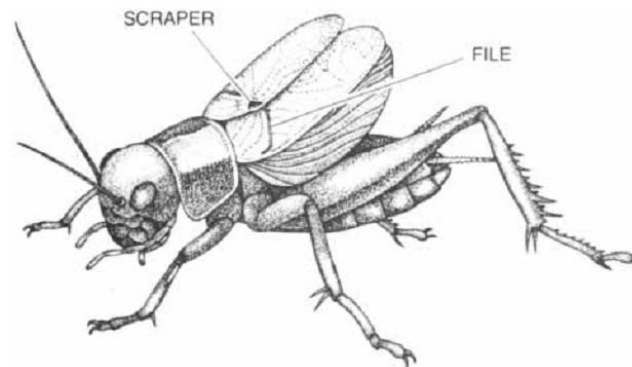
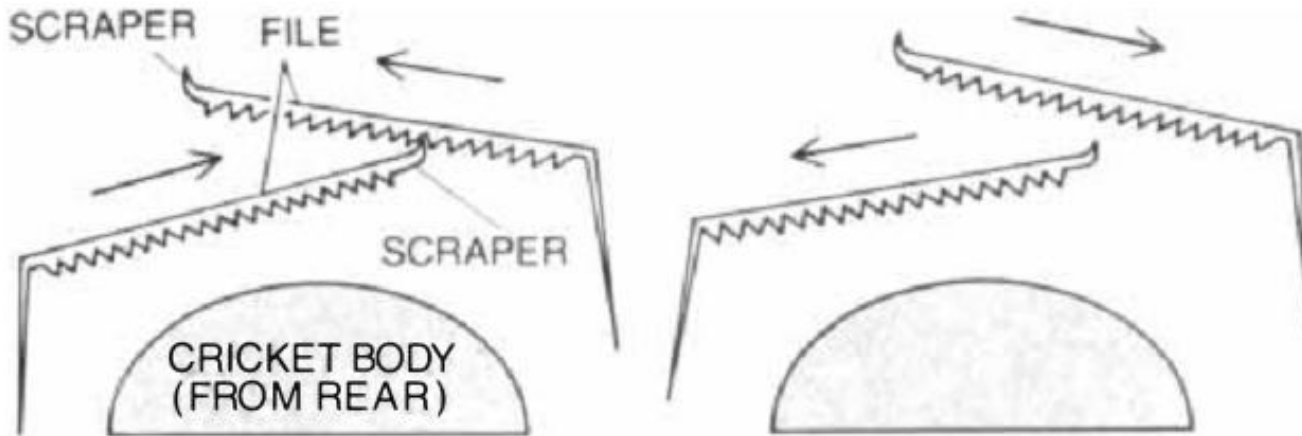


Male song production

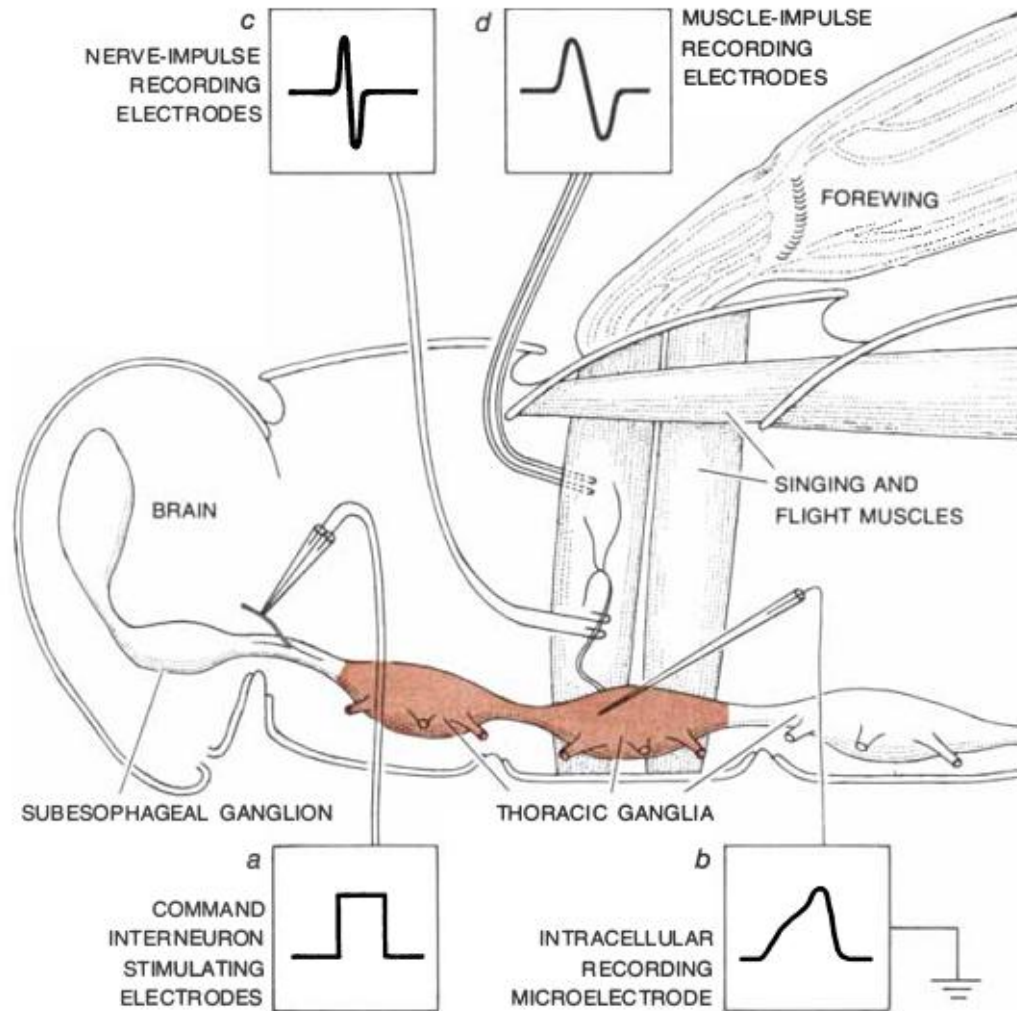
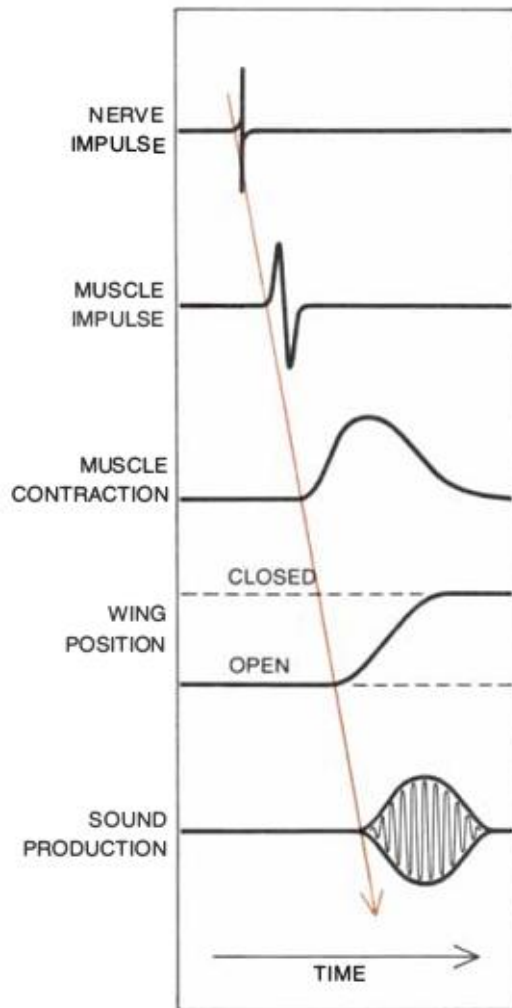
Song production mechanism

CLOSING

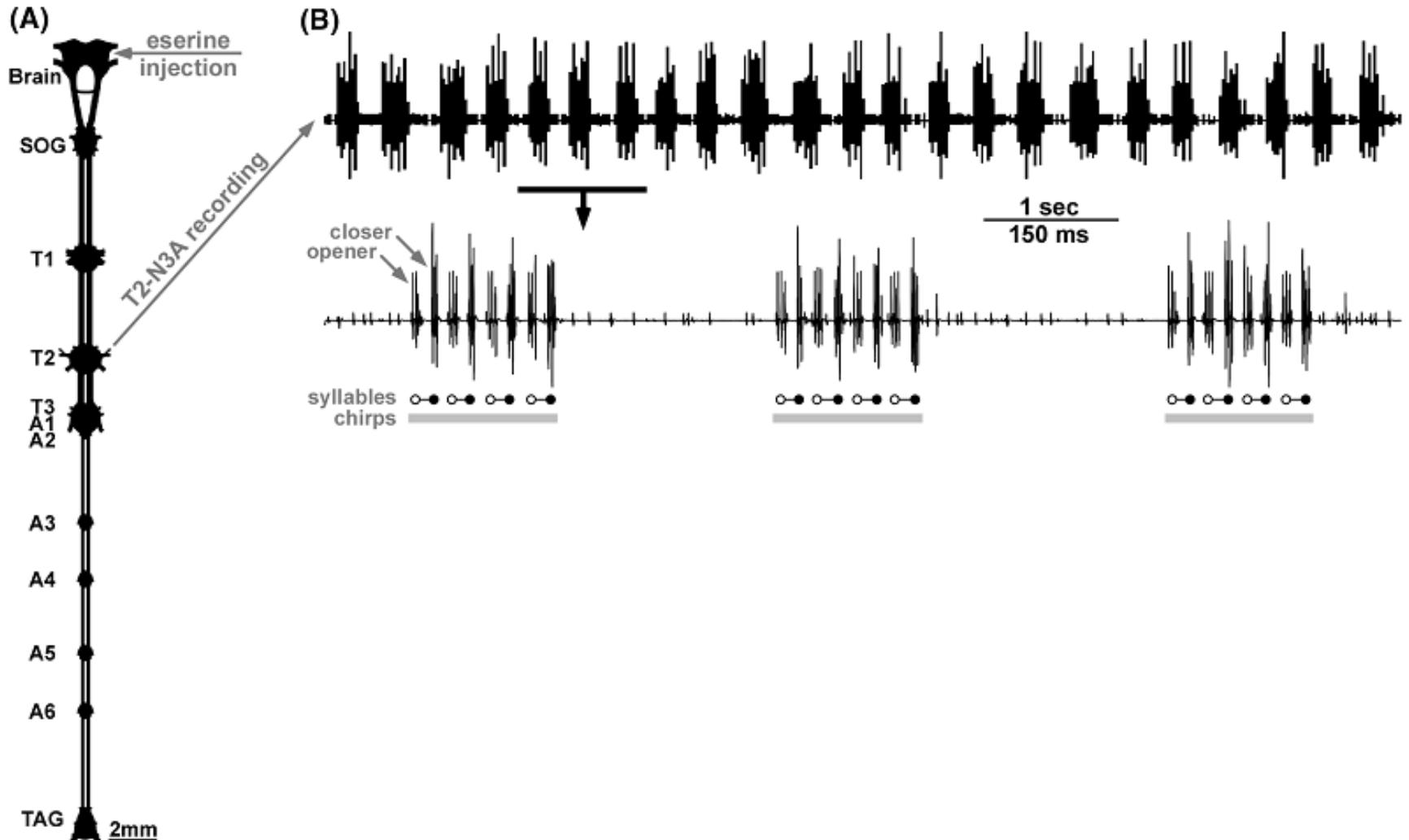
OPENING



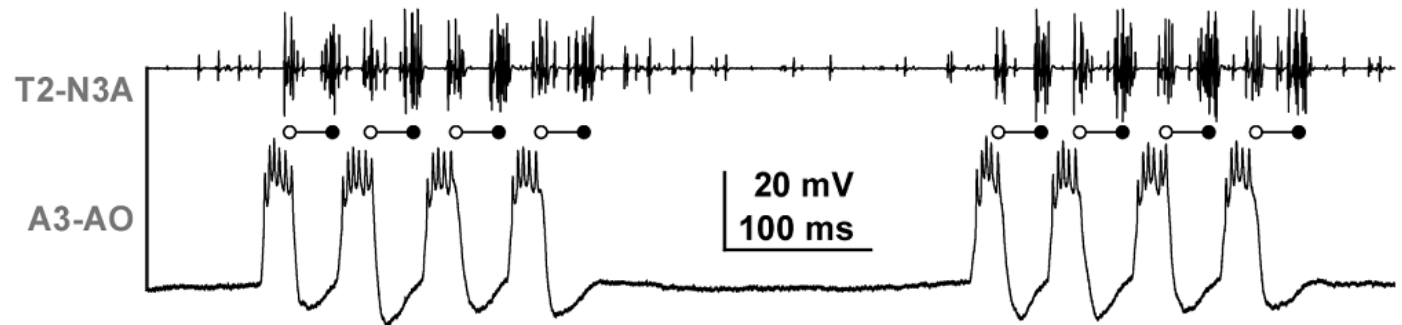
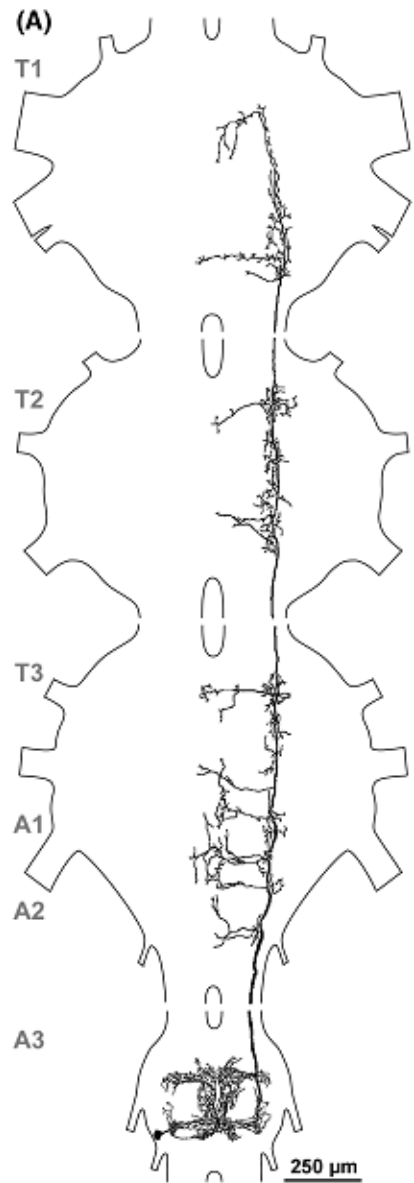
From motor neuron to song output



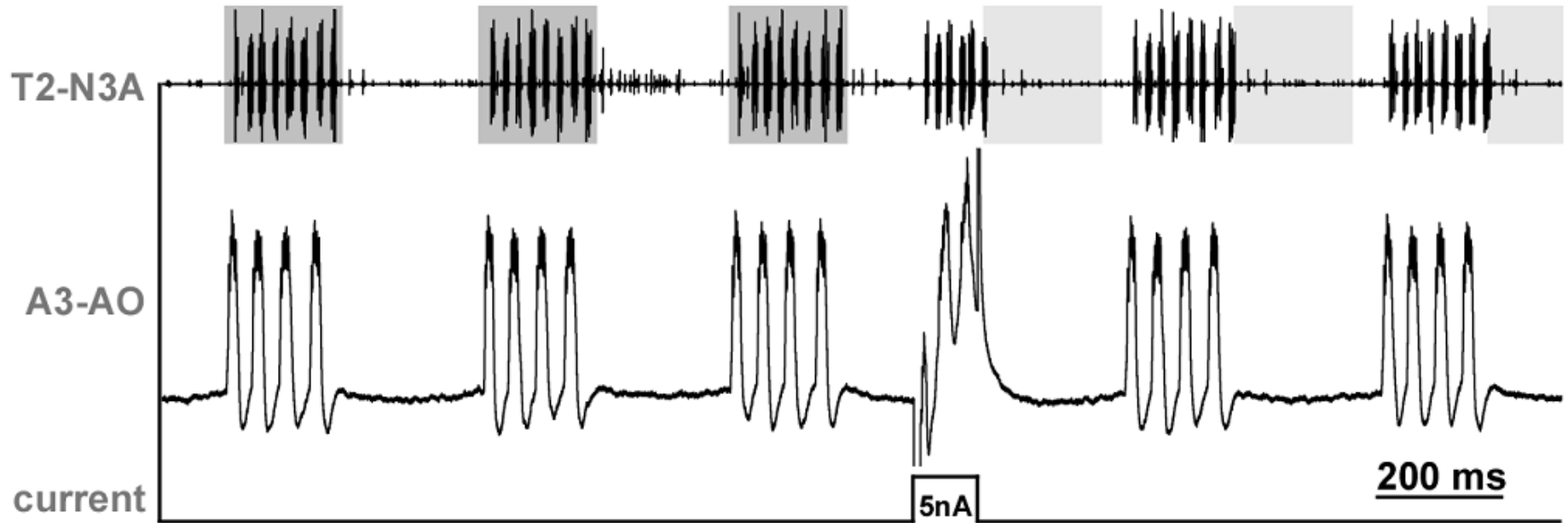
Fictive singing is produced by rhythmic activity of wing opener and closer motor neurons



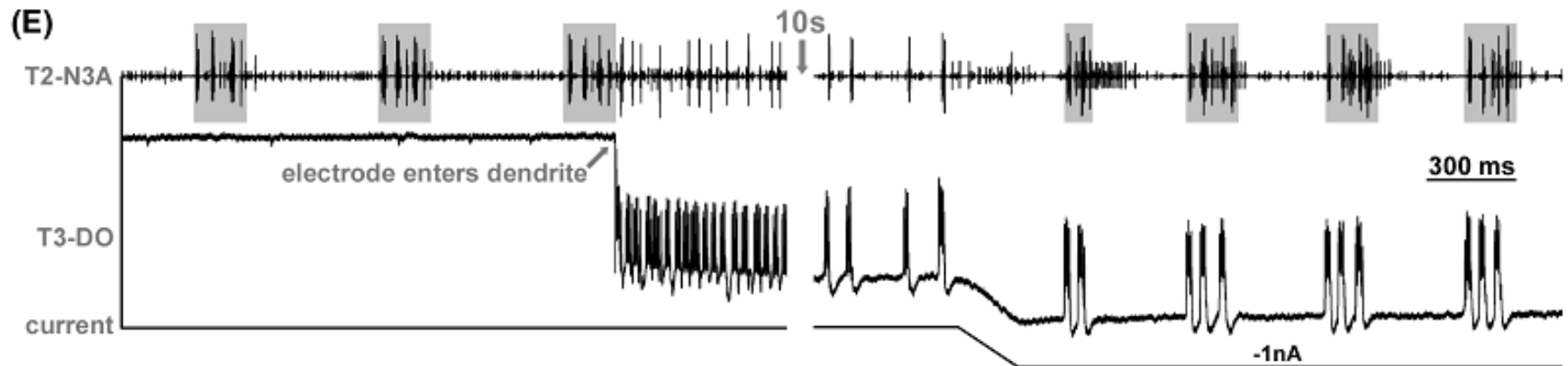
A3-A0 is rhythmically active during fictive singing



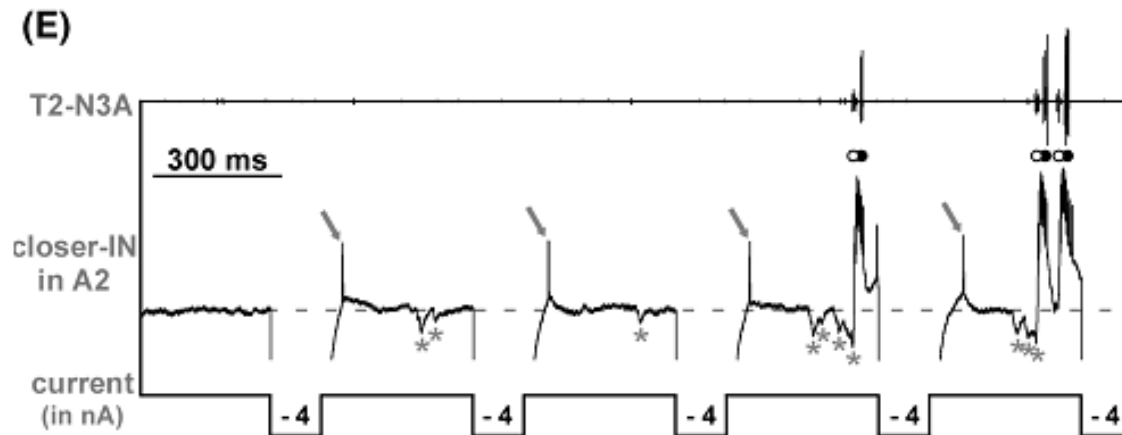
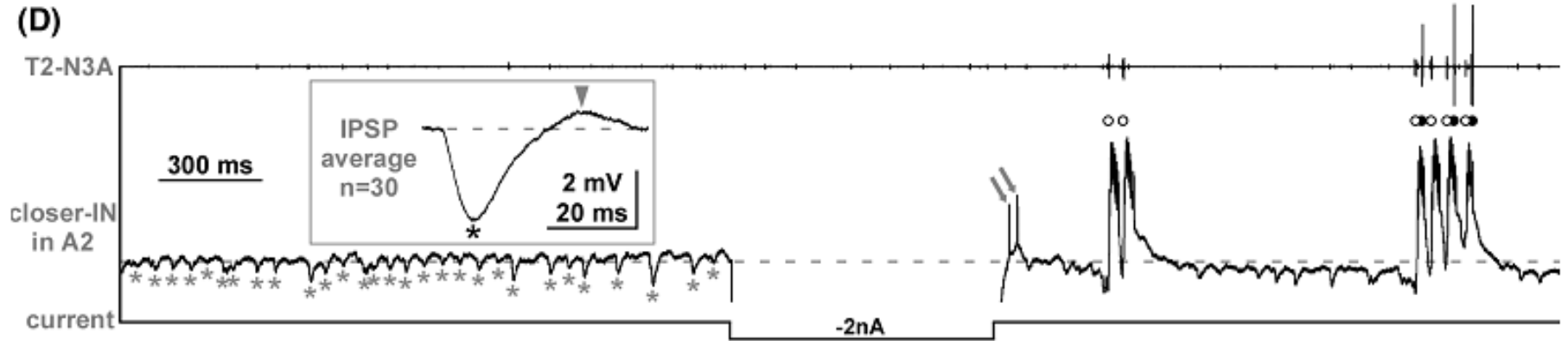
A3-A0 passes the reset test!



Is activity of these neurons necessary for fictive singing?



Post-inhibitory rebound was observed



Interneurons important for singing

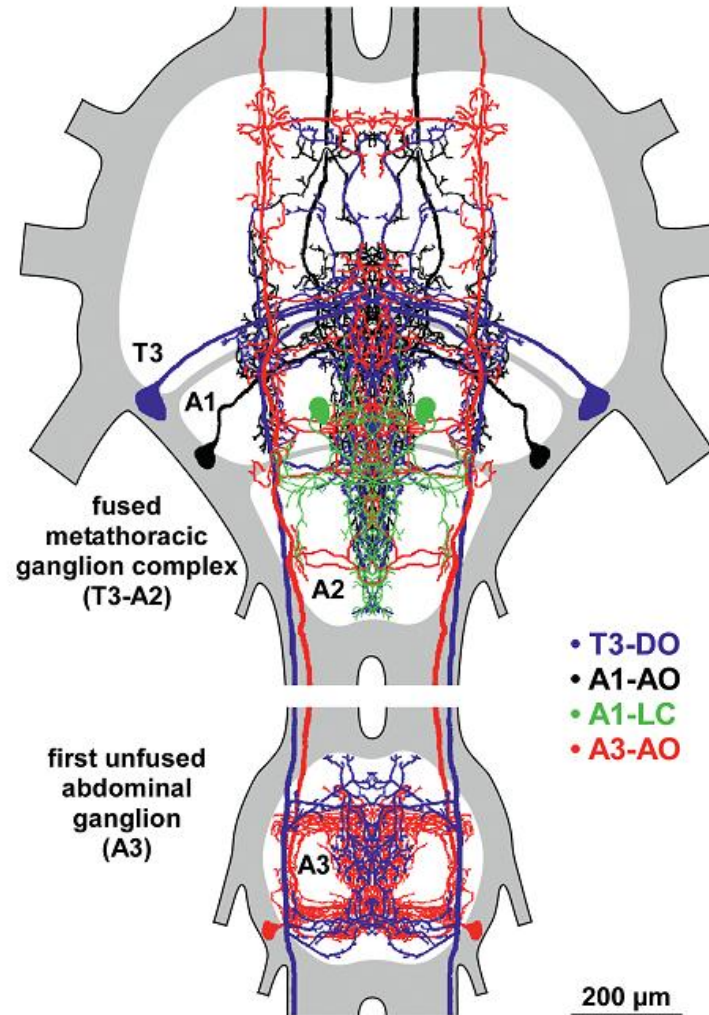
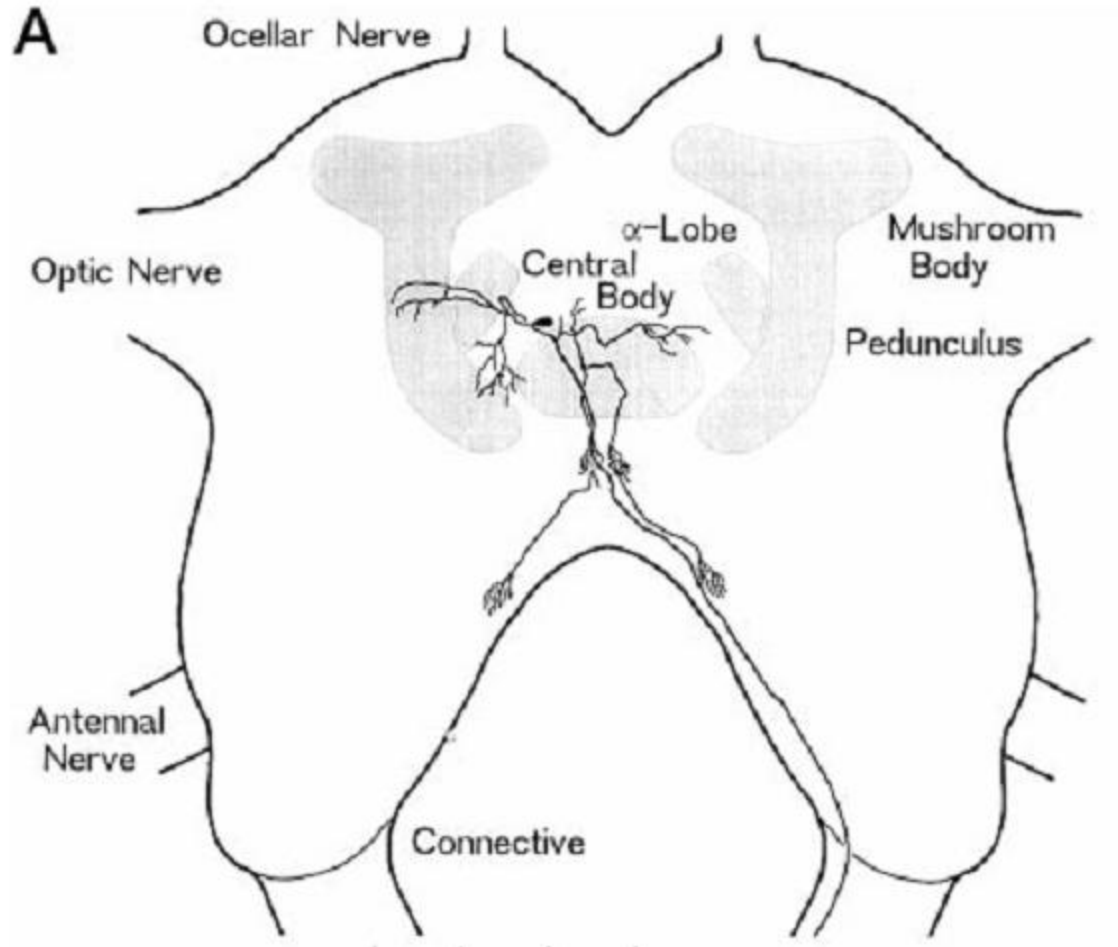
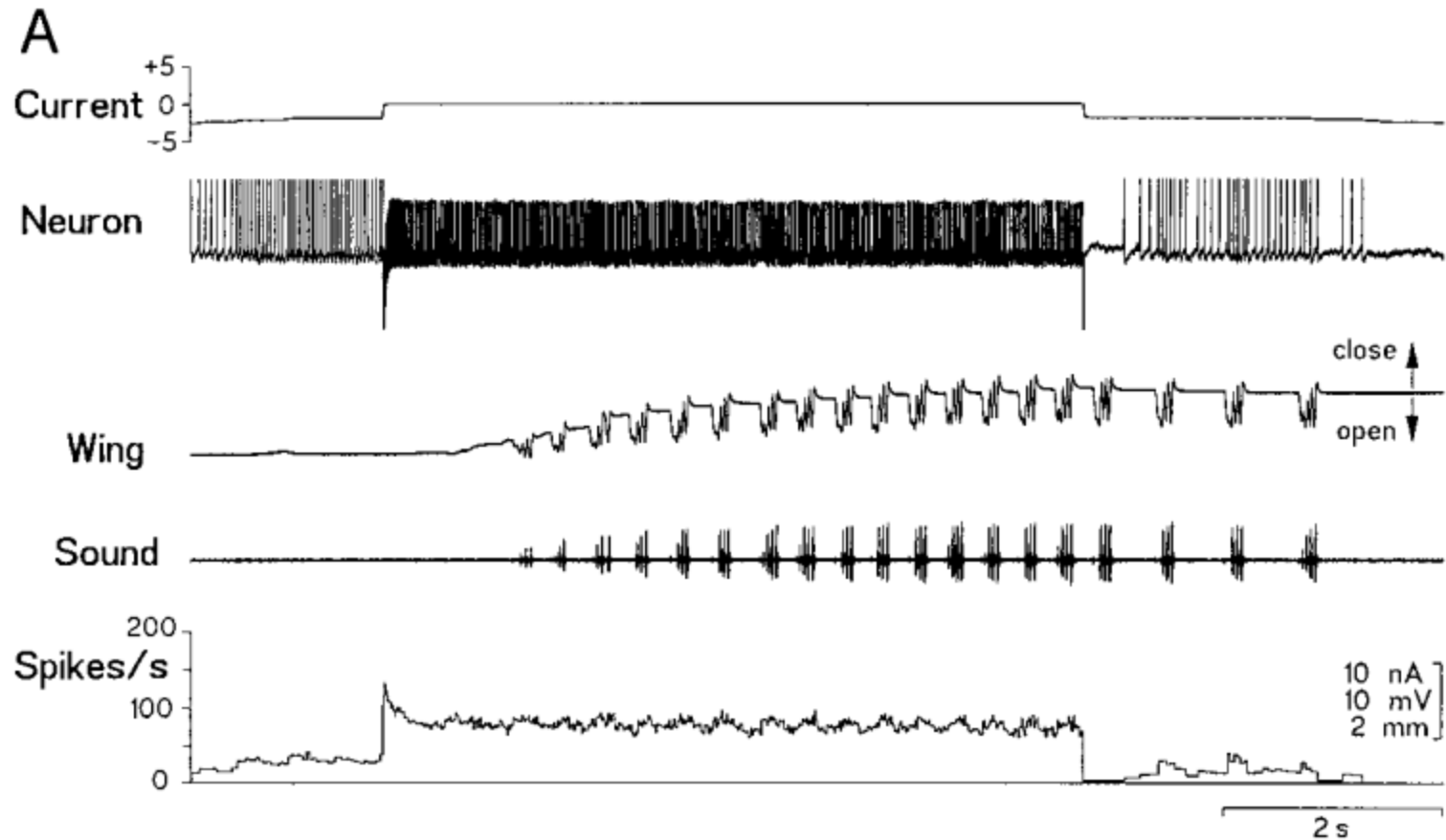


Figure 10. Overlay drawing of dendritic and axonal arborizations of singing interneurons in the metathoracic ganglion complex and abdominal ganglion A3. The conspicuous concentration of arborizations in the dorsal midline neuropiles of the metathoracic and first three abdominal neuromeres point toward these neuropiles as the location for singing pattern generation.

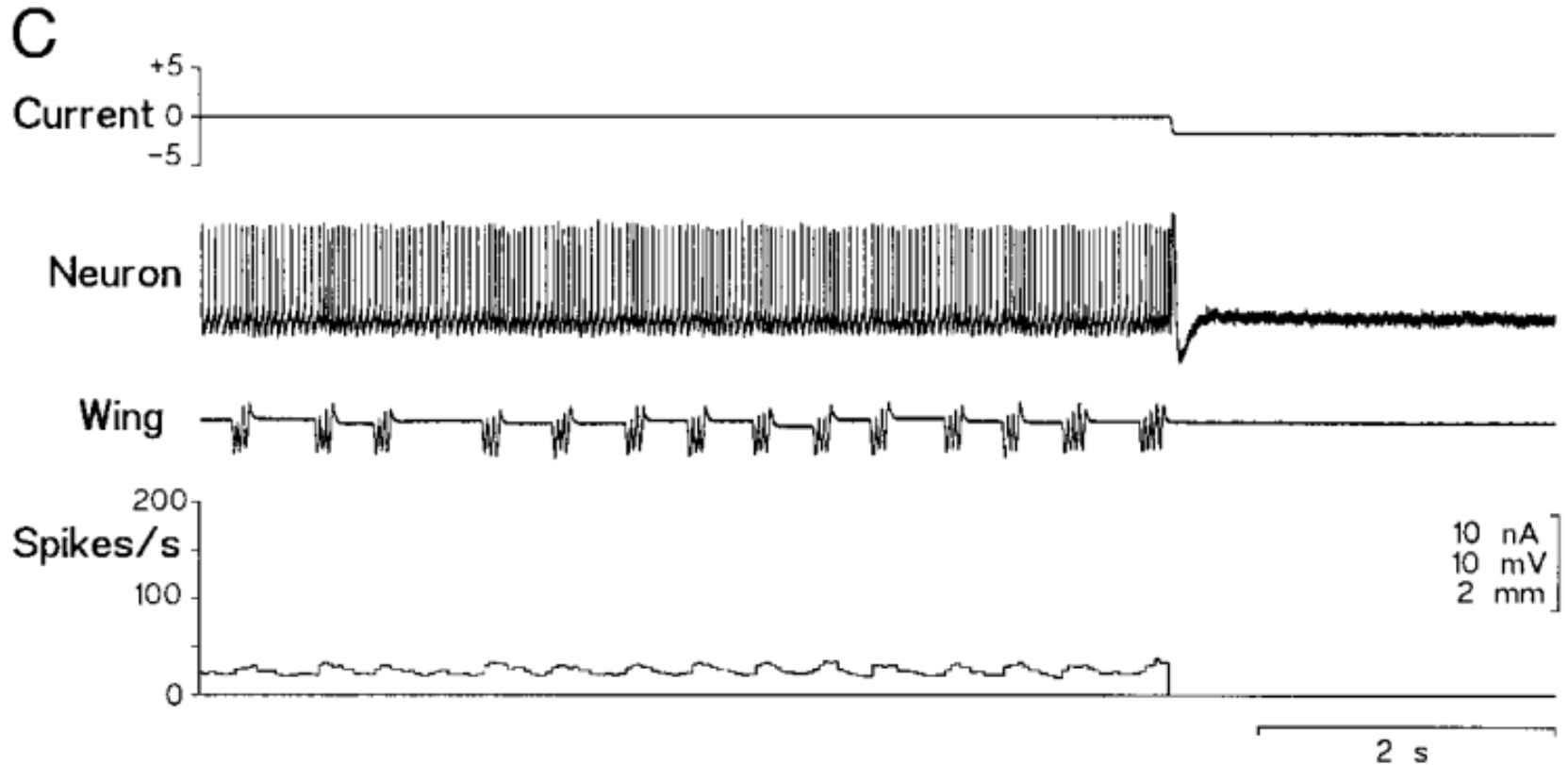
Command neuron for singing



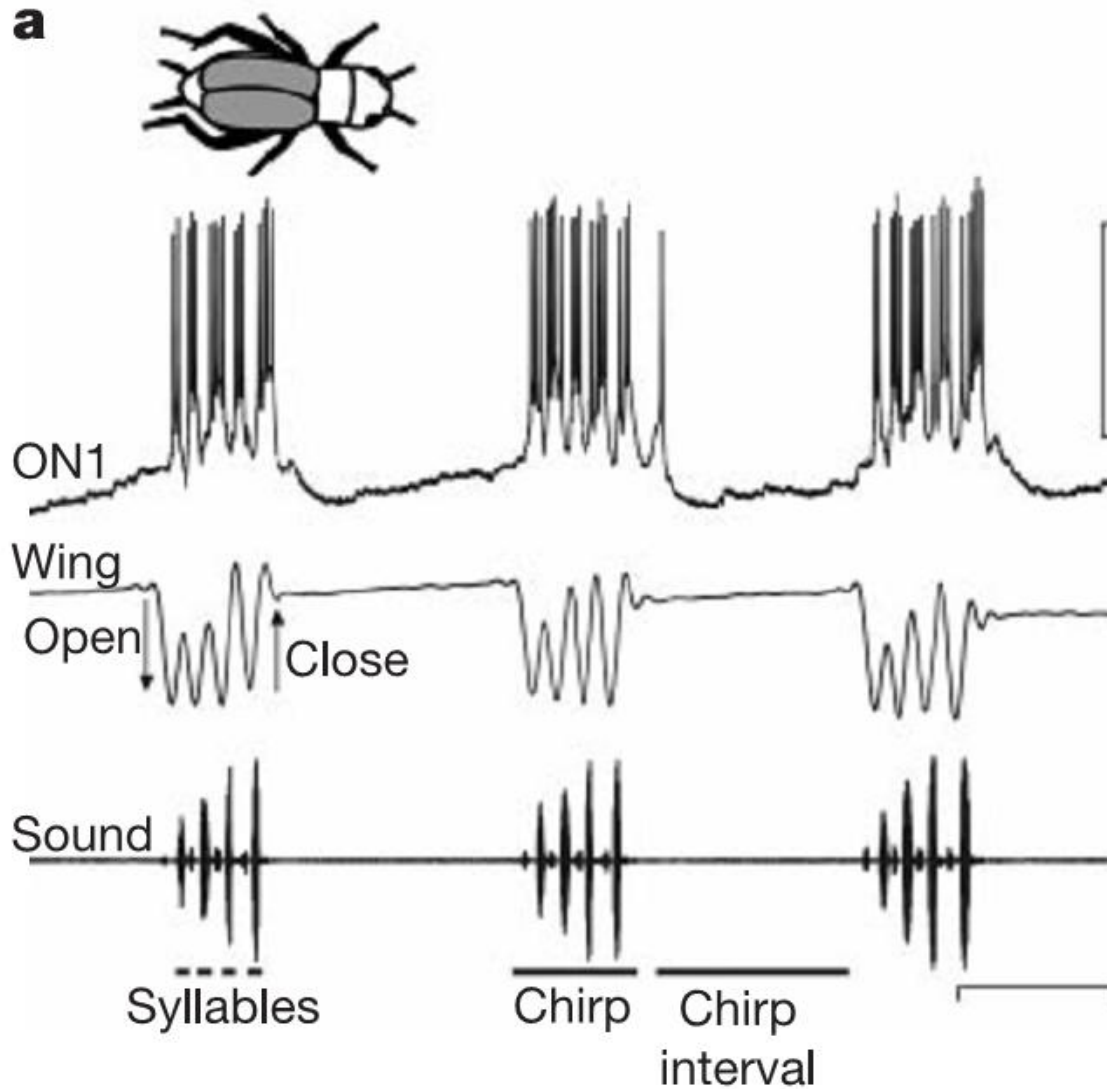
Activation of this neuron is sufficient to elicit singing



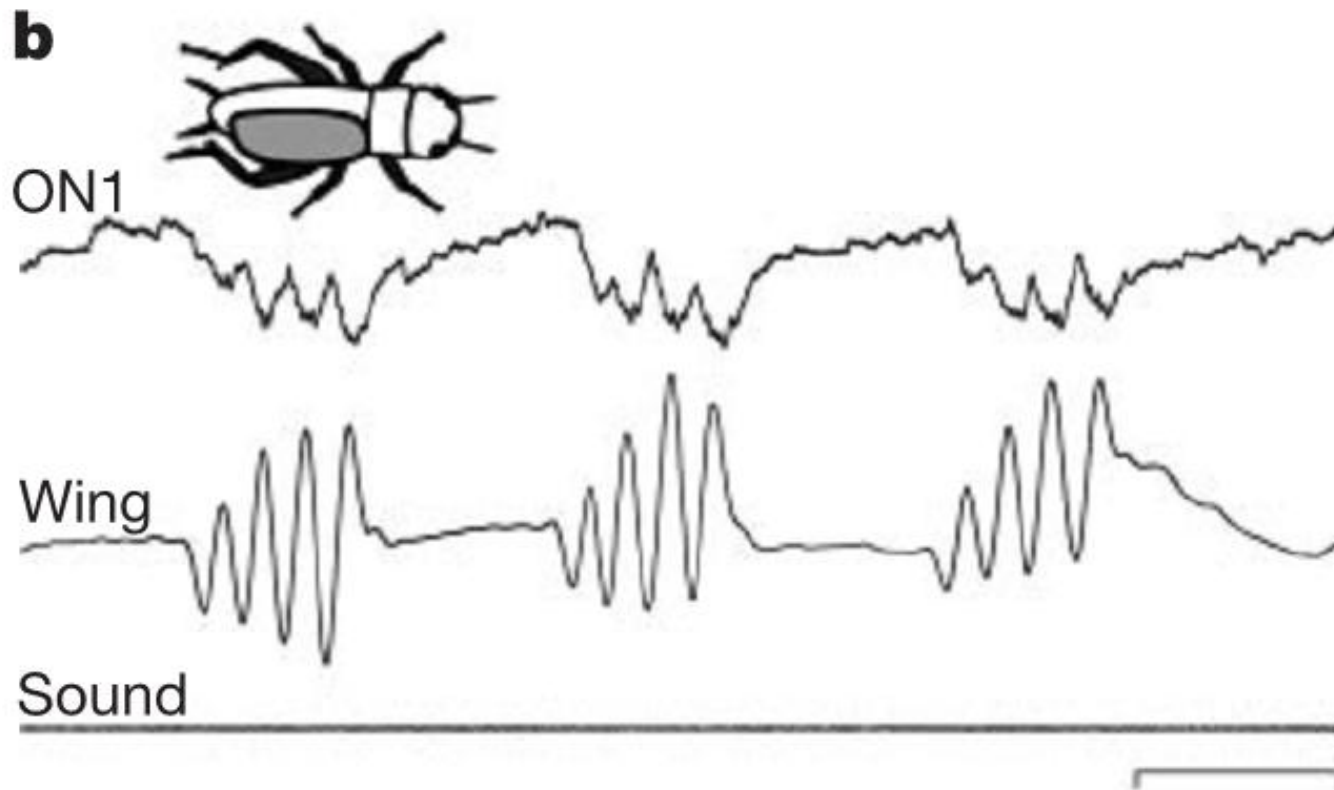
Hyperpolarization of this neuron stops the song



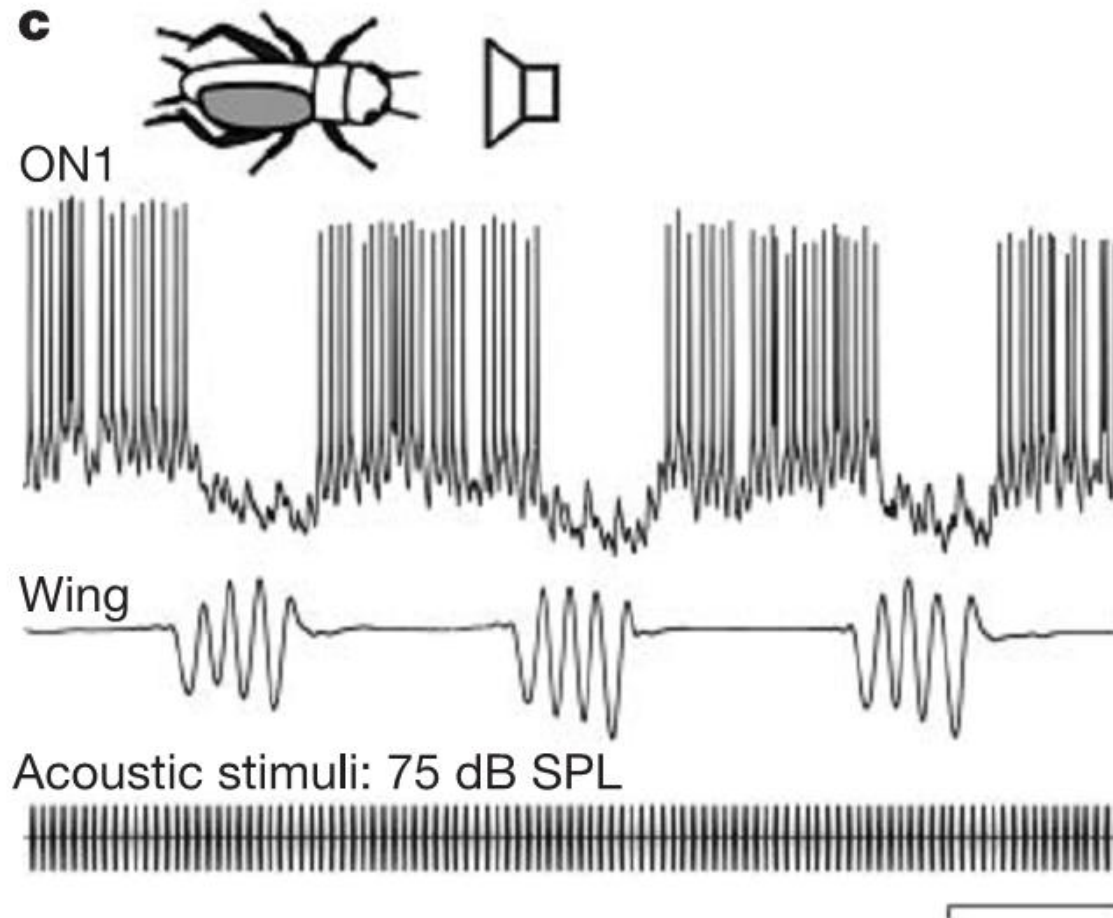
During singing, ON1 responds to syllables



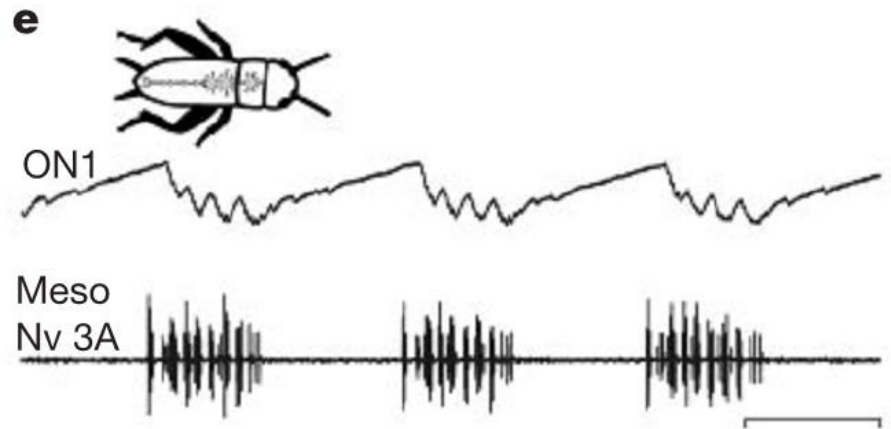
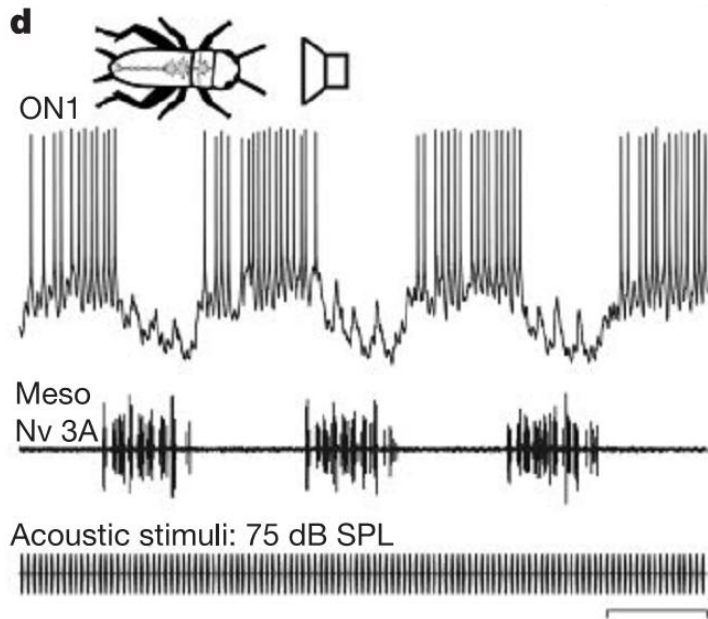
During silent singing, ON1 shows IPSPs



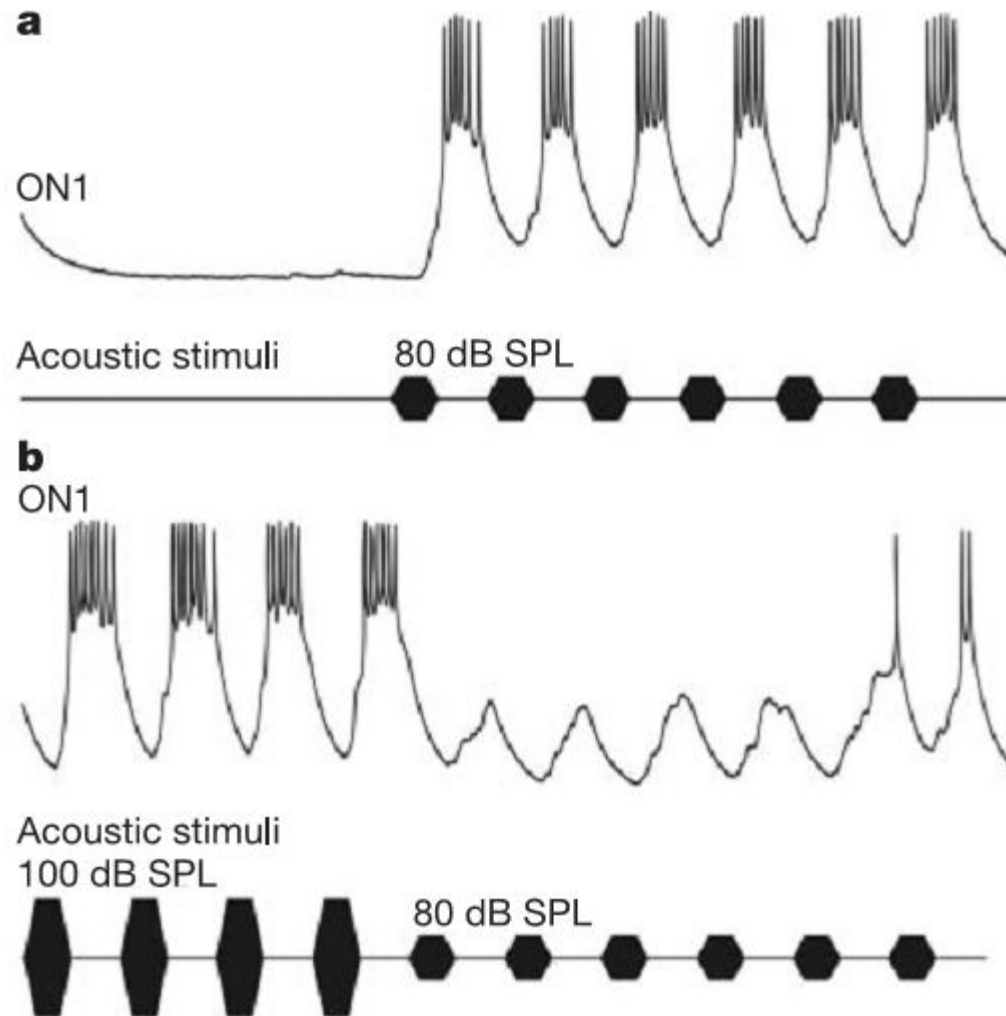
Auditory response is inhibited during singing



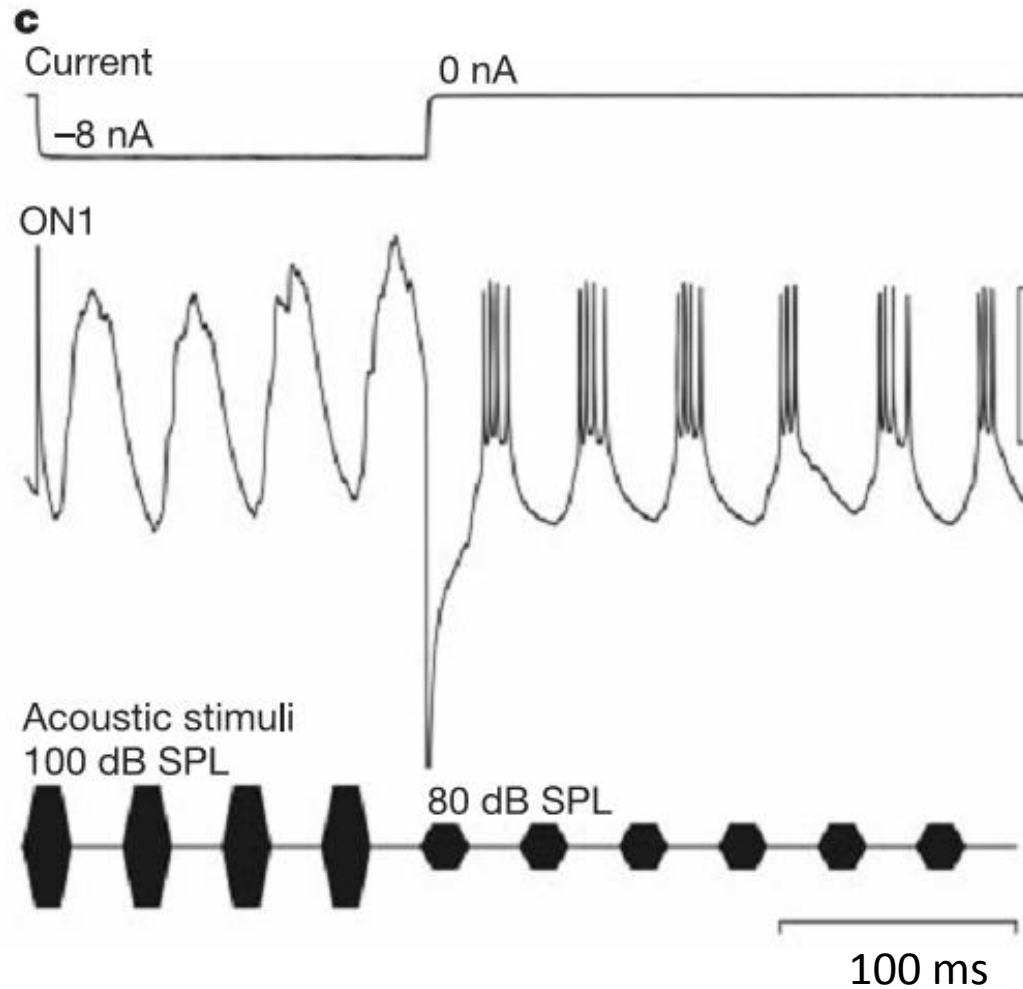
The inhibition is not coming from sensory FB nor from the ears



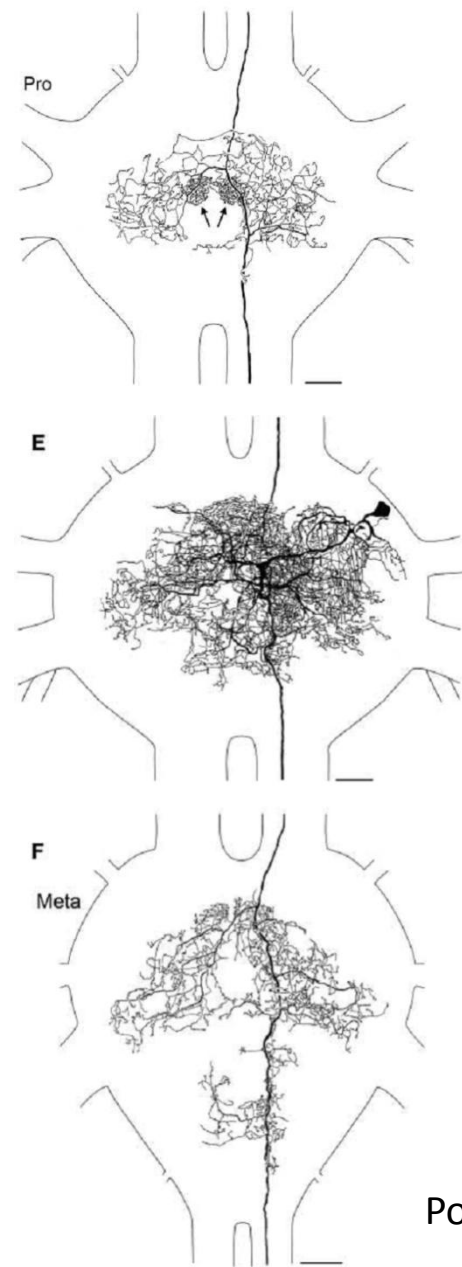
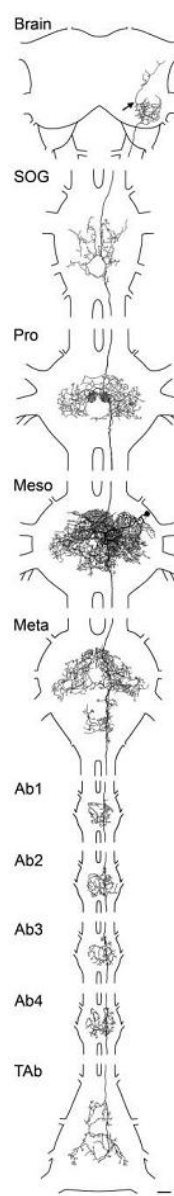
Desensitization after singing



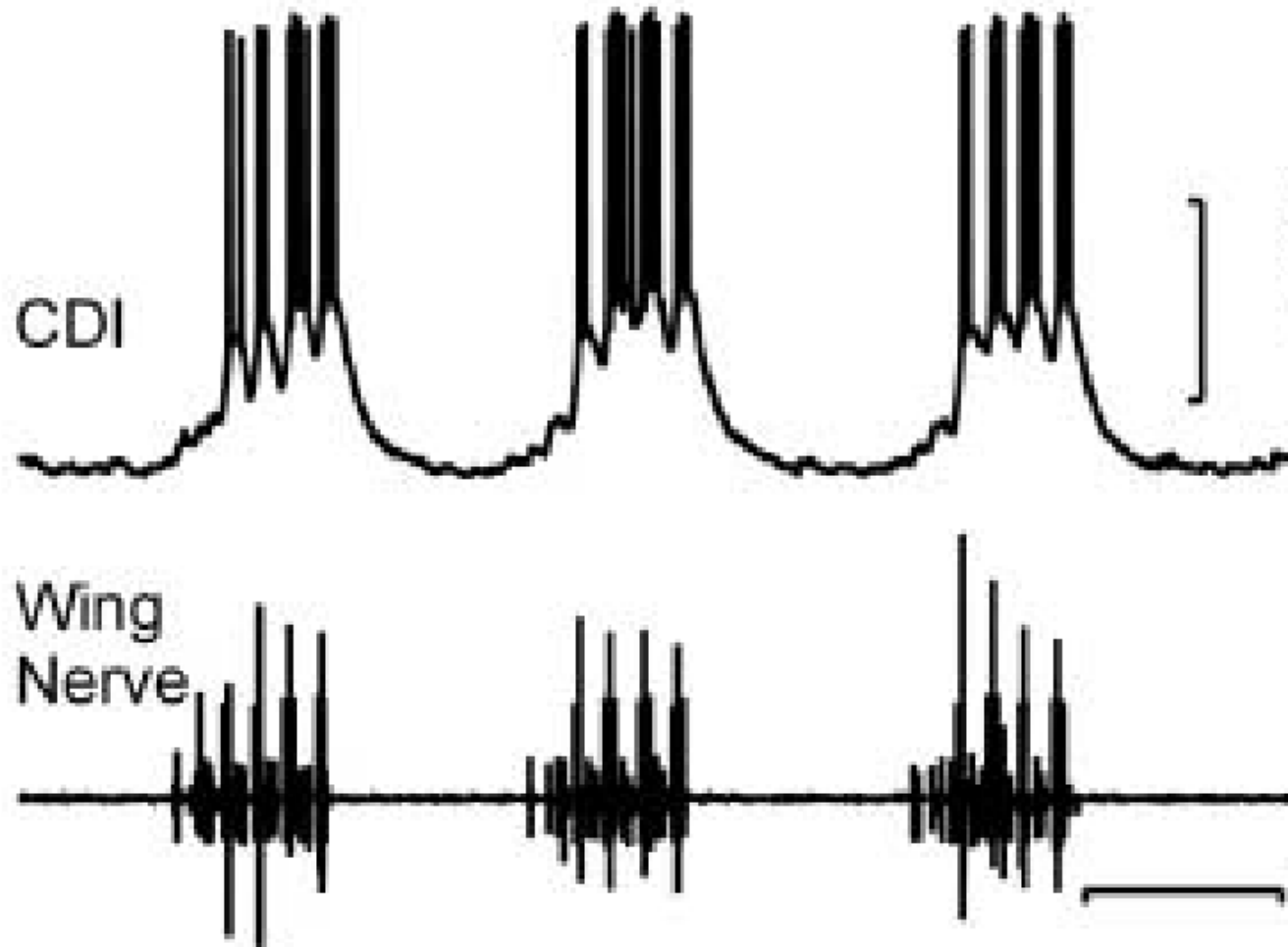
Inhibition protects from desensitization



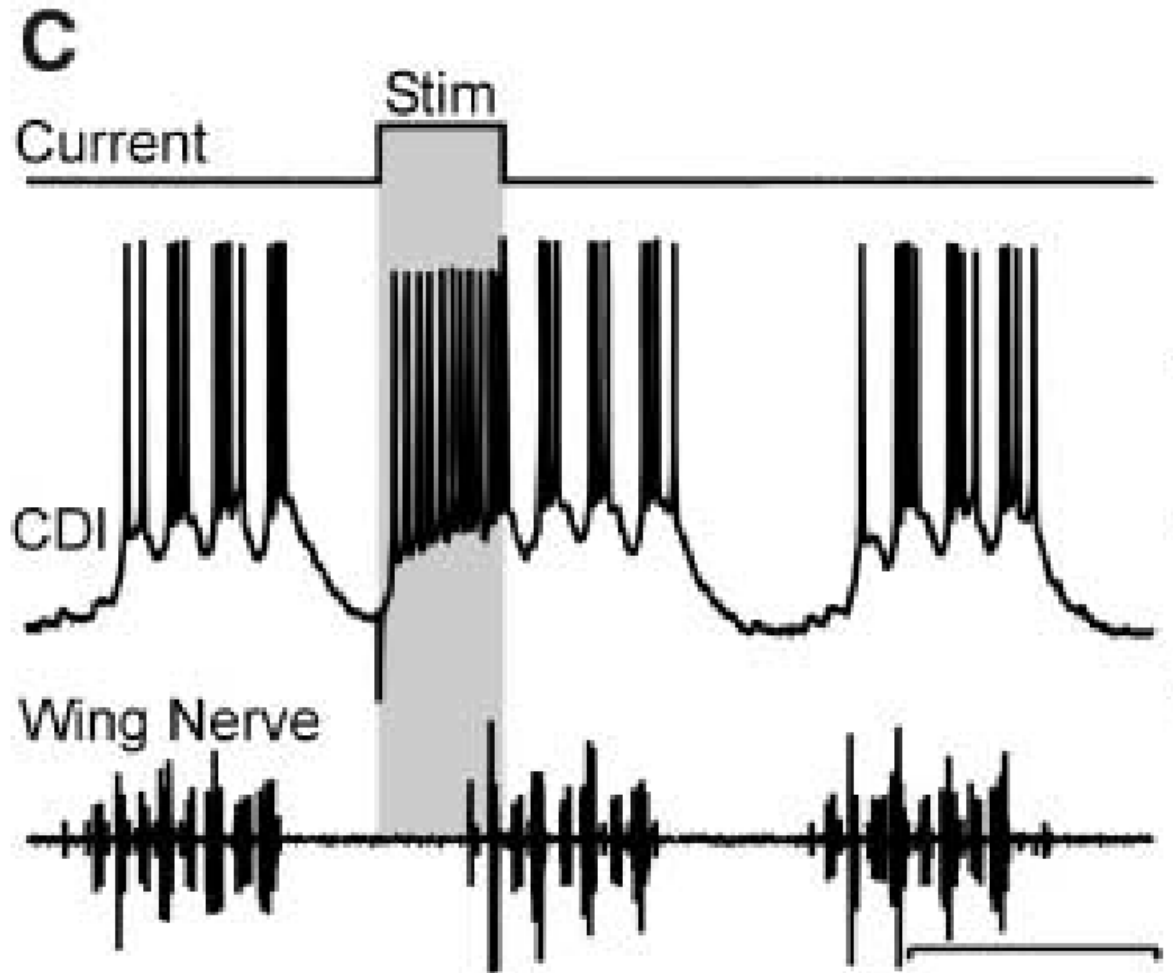
The corollary discharge neuron!



CDI is rhythmically active during fictive singing

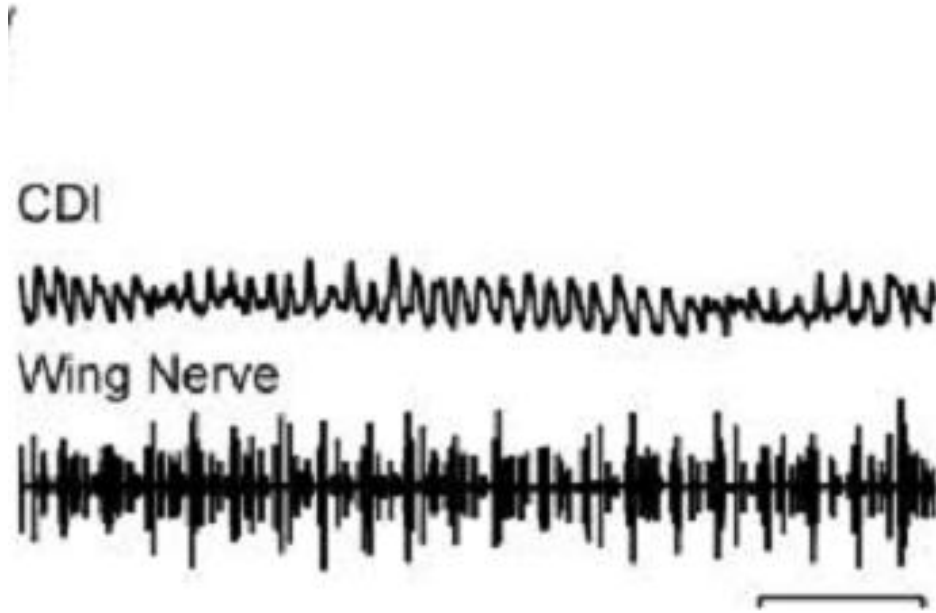


CDI does not pass the reset test

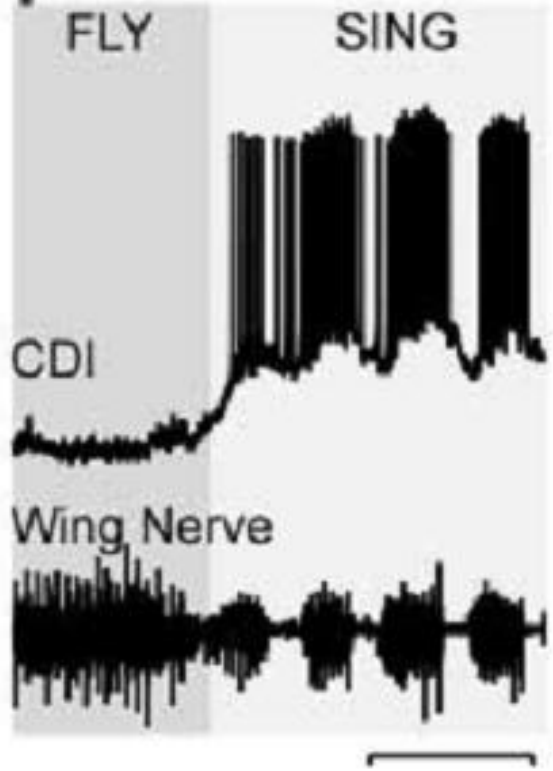


CDI is not active during flight

E



F

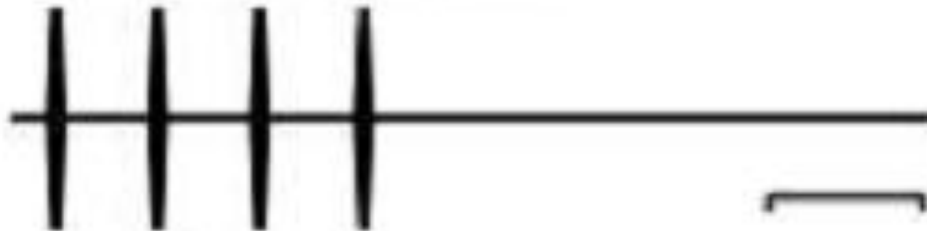


CDI is not auditory

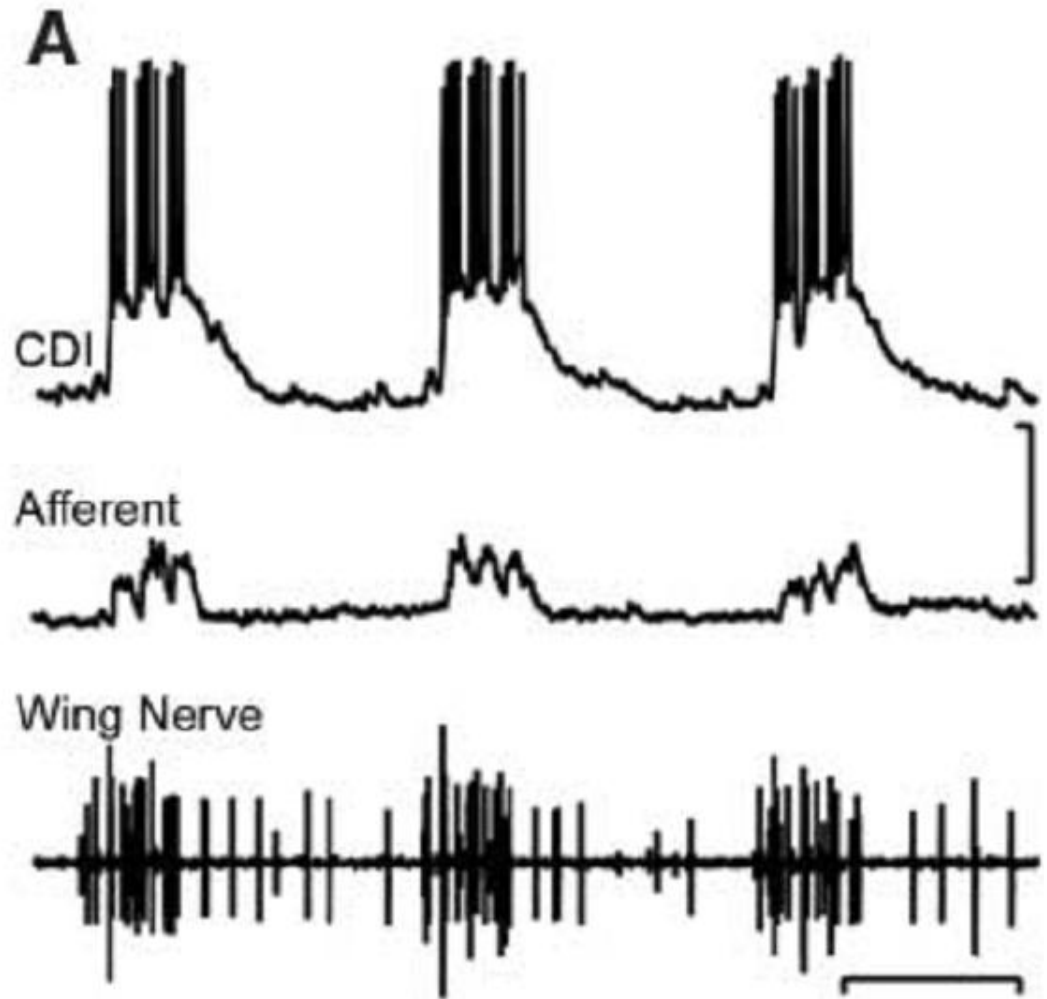
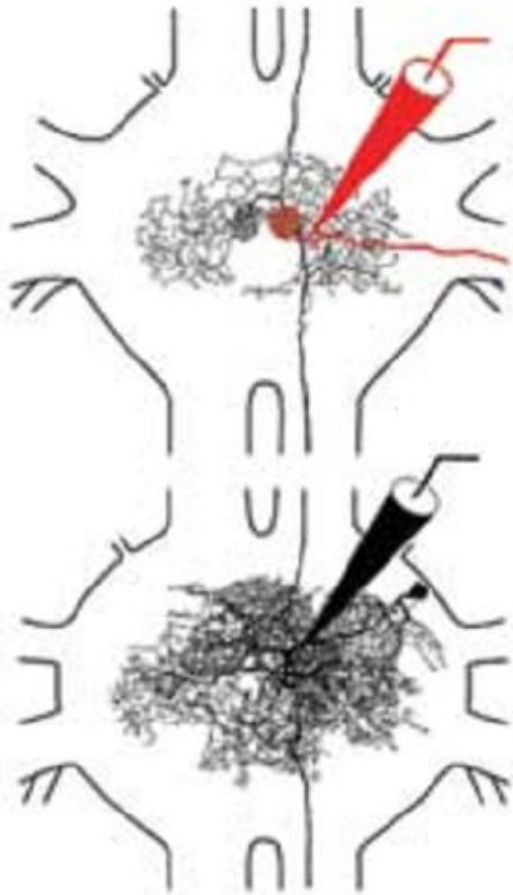
CDI



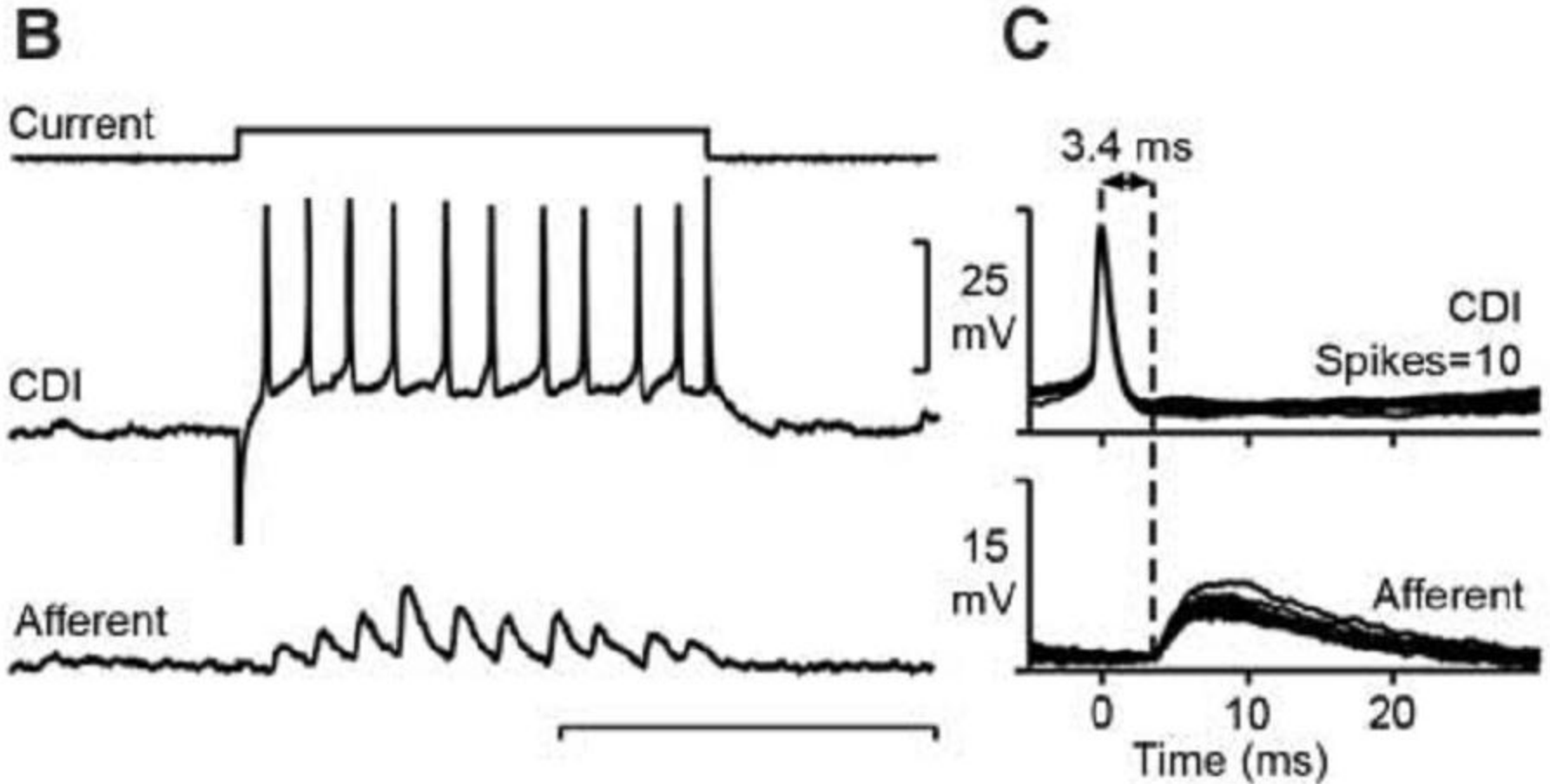
Acoustic Stimuli:
4.8 kHz 85 dB SPL



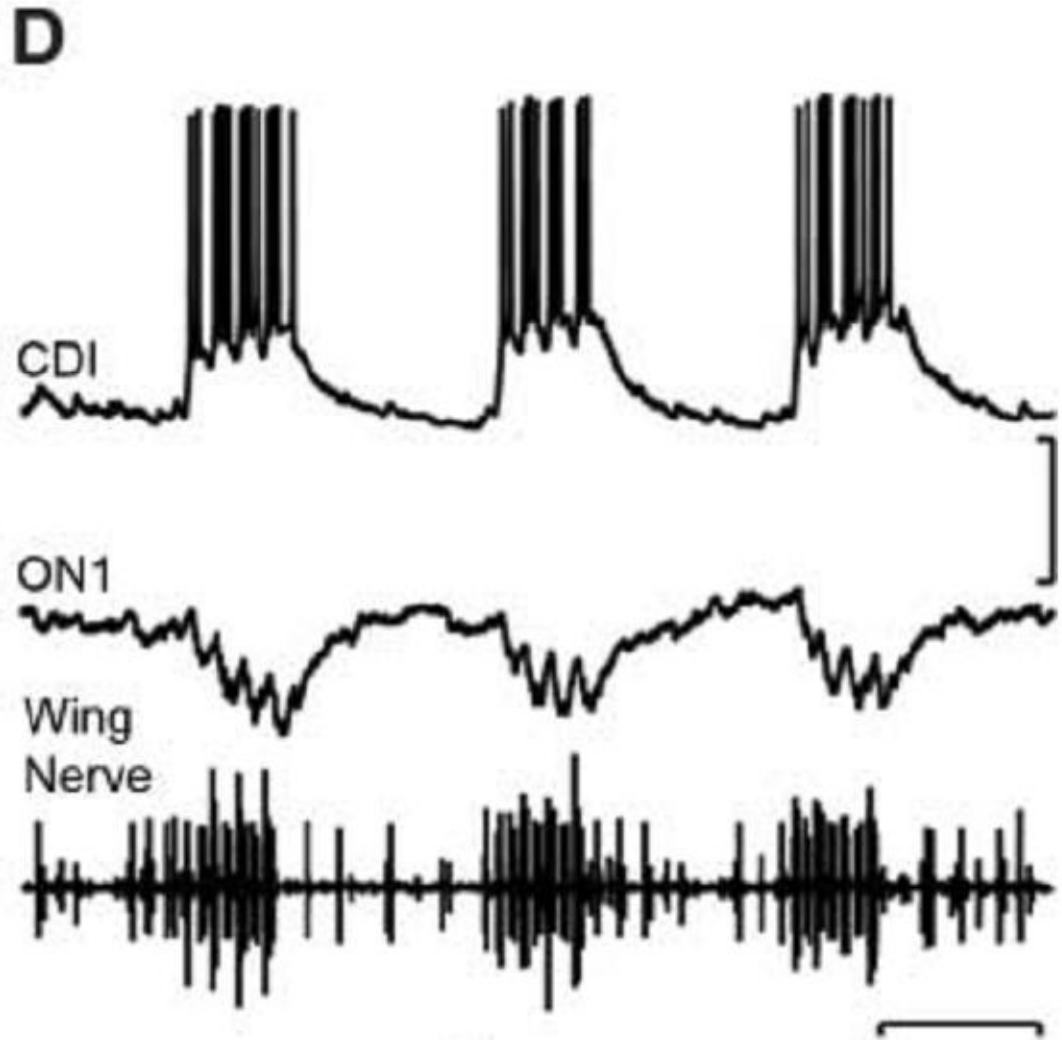
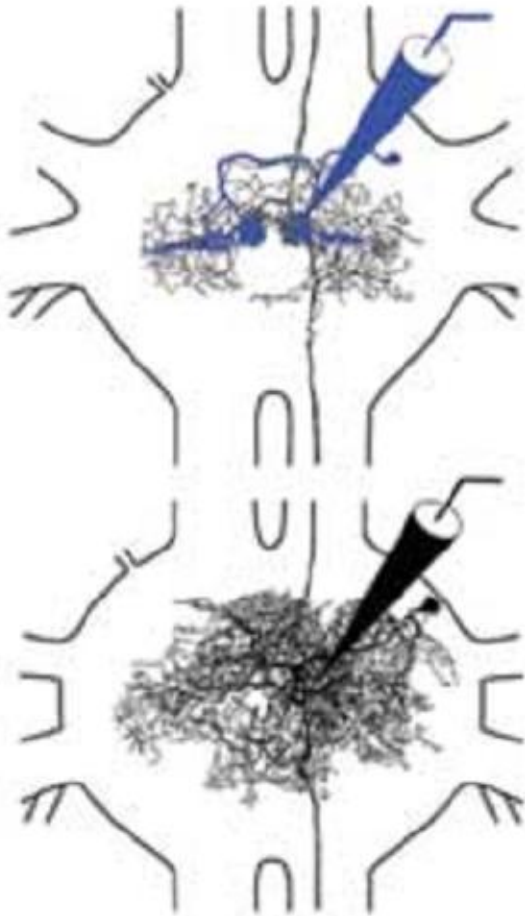
Paired recording between CDI and auditory afferent



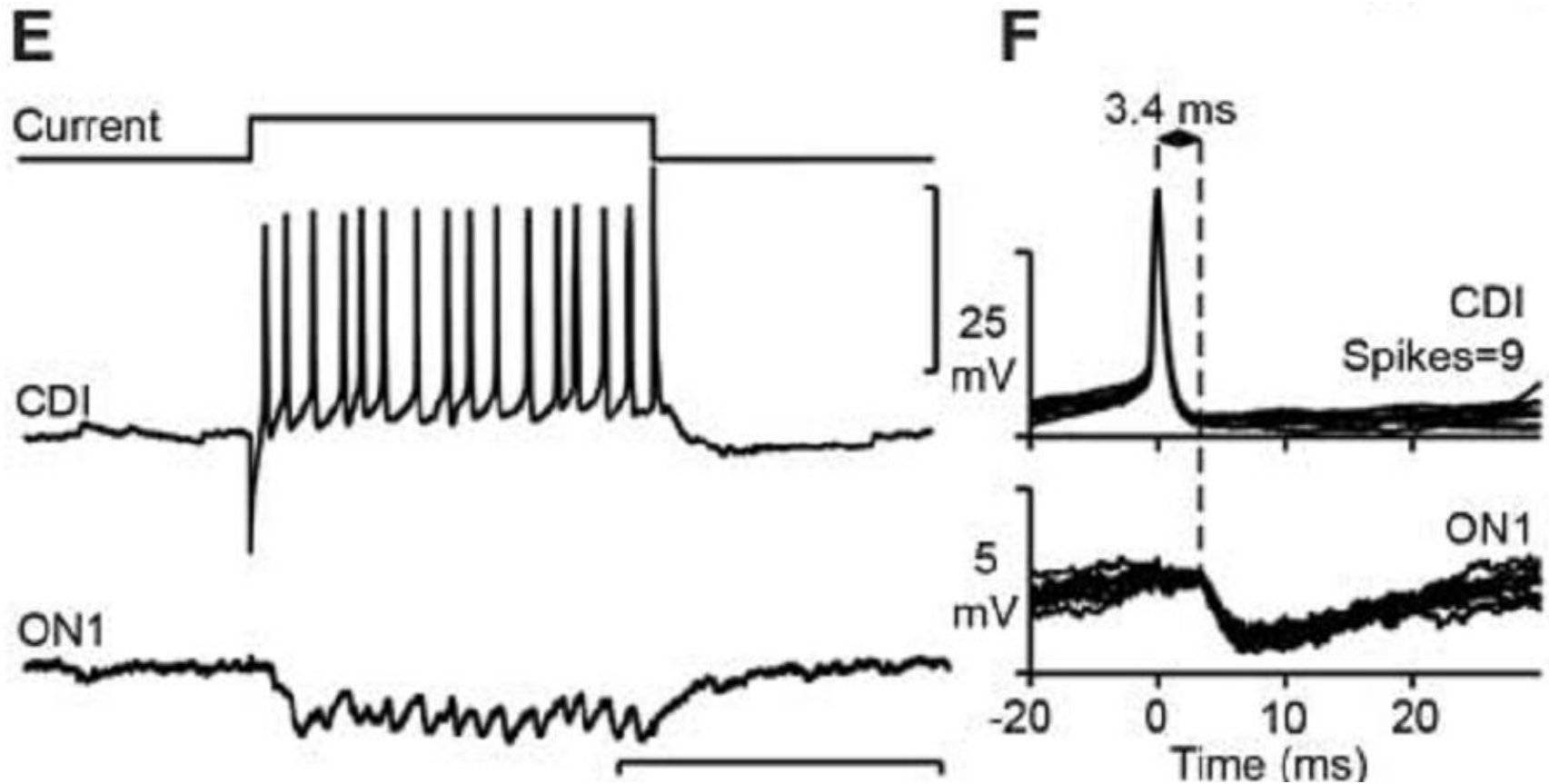
CDI causes PAD in the auditory afferent



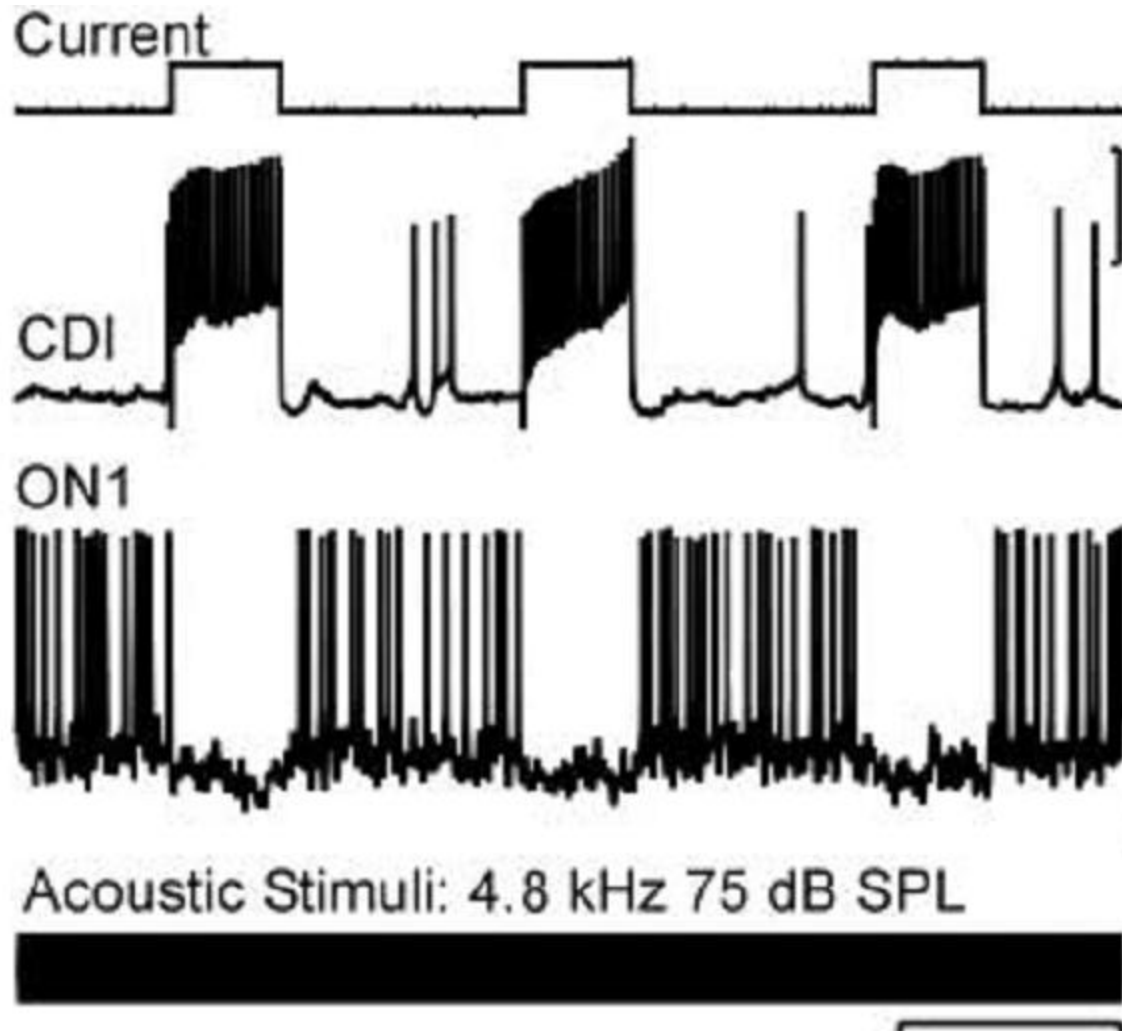
Paired recording between CDI and ON1



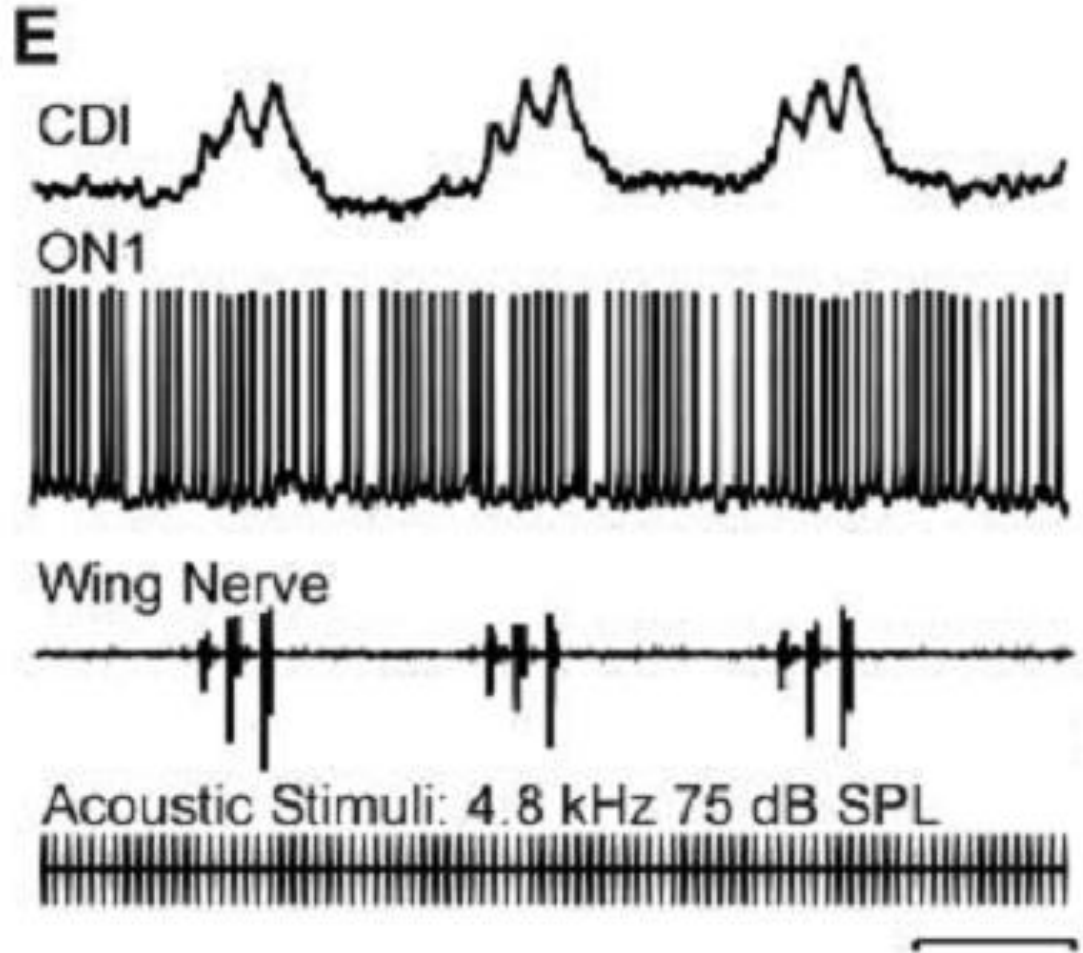
CDI causes an IPSP in the ON1



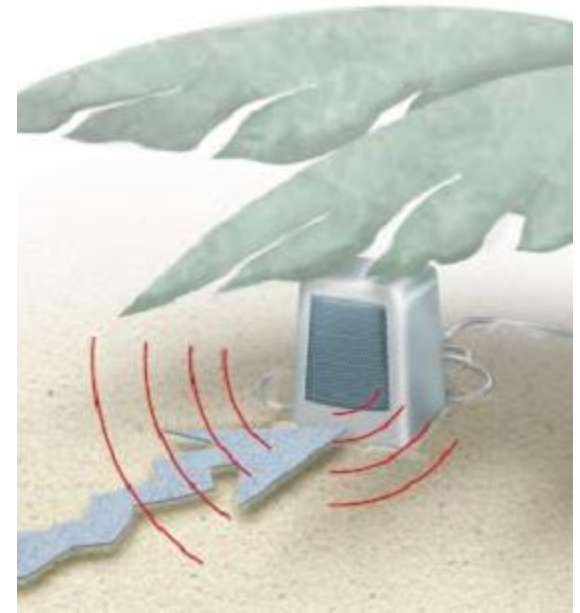
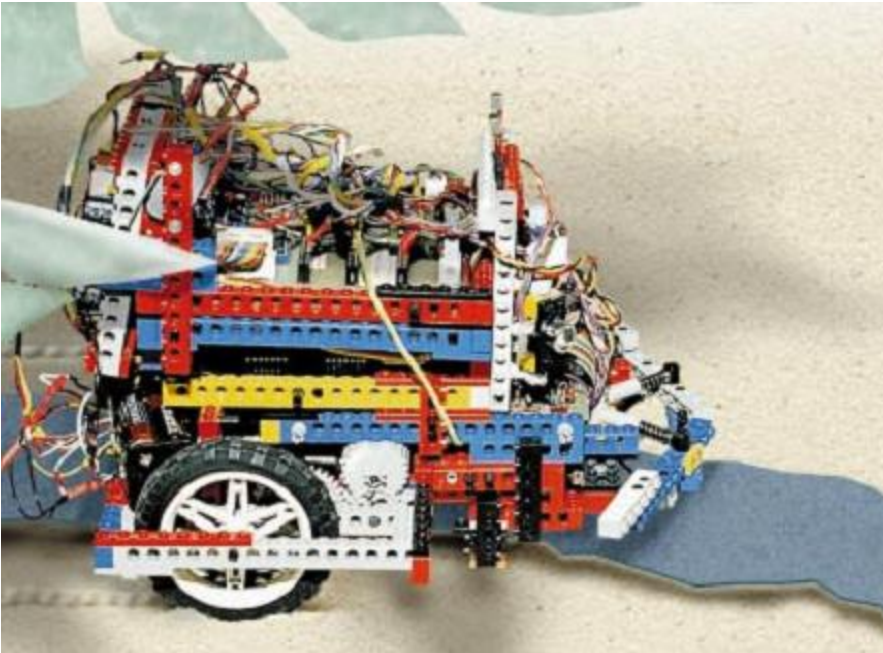
Activation of CDI inhibits auditory response in ON1



Activity of CDI is necessary for inhibition



Cricket robot



Webb (*Sci Am*, 1996)