

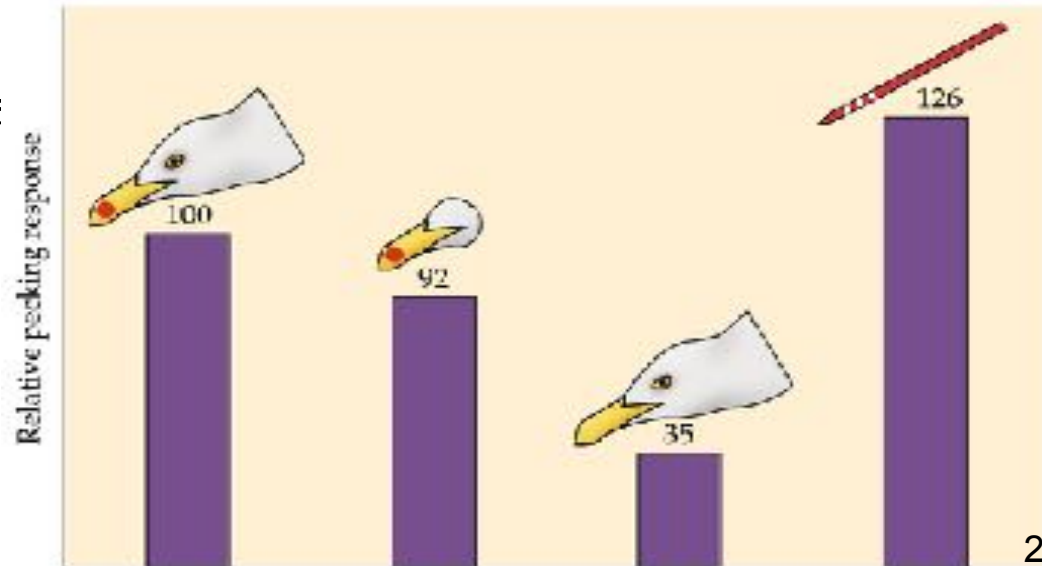
# Neural mechanisms



The Army's last-ditch effort to destroy Mothra.

# Instincts: minimal processing

- Fixed action patterns (FAPs)
  - Innate, stereotyped behavior triggered by stimulus
  - Carried out to completion once started
- Save time and energy in processing
- Examples
  - Human yawning
  - Beetles mating with bottle
  - Goose egg retrieval
  - <http://www.youtube.com/watch?v=>
  - Gull chicks begging



# Instincts: minimal processing

- Fixed action patterns
  - Innate
  - Carried out in a fixed order
- Save time
- Examples
  - Human
  - Beetle
  - Goose
  - <http://www.youtube.com/watch?v=...>
  - Gull chick

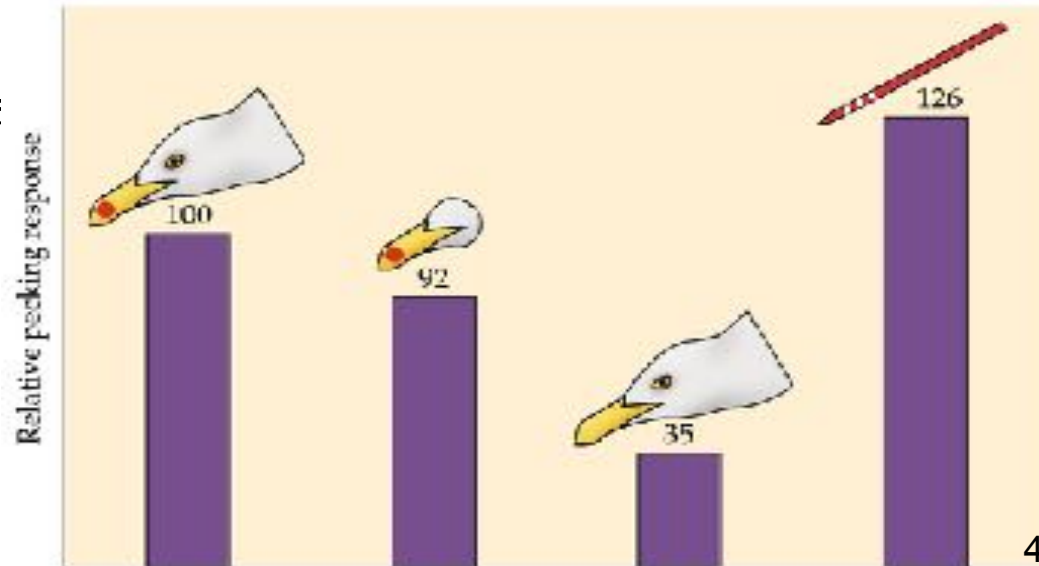


Relative Fe



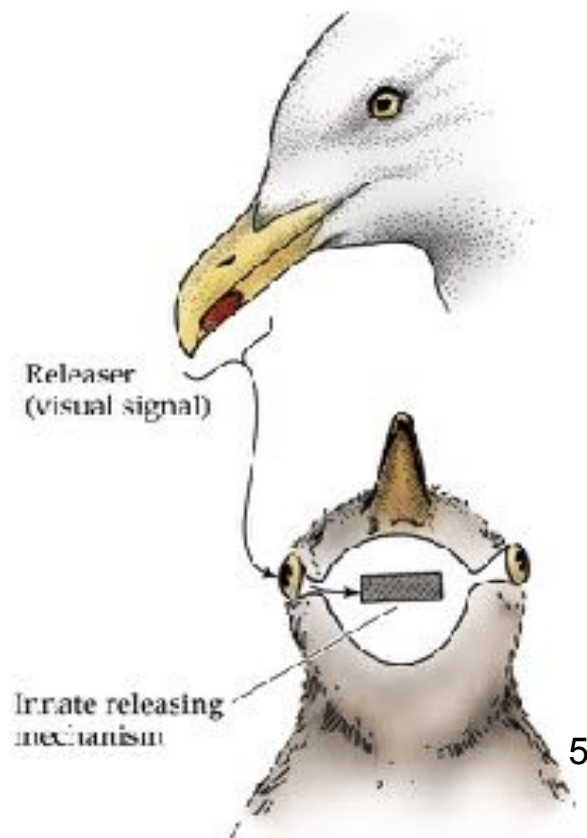
# Instincts: minimal processing

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# FAPs: Why act without flexibility?

- Benefits
  - Appears in fully functional form first time it is performed
  - Saves time and energy (reduced need to process and integrate)
- Cost – behavior is fixed
  - Can be exploited!



# Exploitation of FAPs: Code breakers

- “Code-breakers”
  - Once FAP evolves, it can be manipulated

## Brood parasites: lay eggs in nests of another species



Lay eggs in other birds nests,  
are fed by foster parents



Parasitism continues until  
natural selection changes neural  
mechanisms leading to FAP  
(sometimes host never evolves response)



BBC





# Exploitation of FAPs: Code breakers

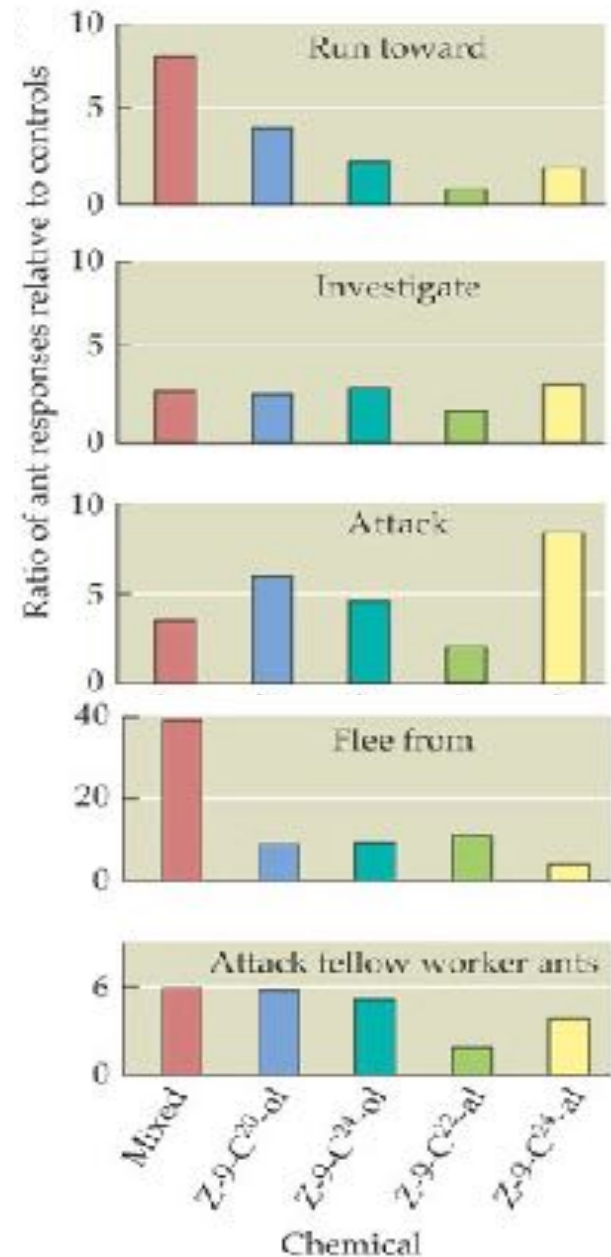
- Parasitoid wasp hunts butterfly larvae
  - Caterpillar protected by ants...
  - ...how does the wasp get to its victim?

## Via chemical assault!

- Various components repel ants and cause them to attack their own colony members!

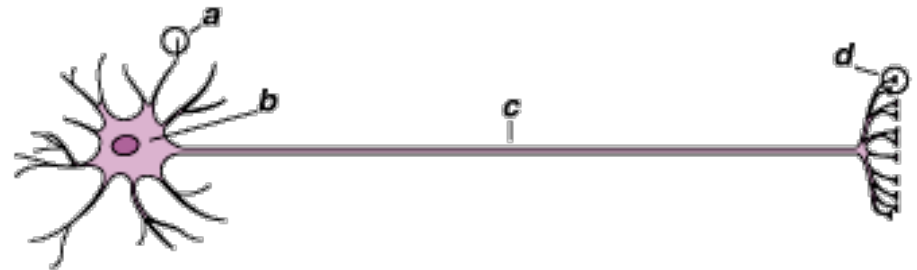


<http://www.youtube.com/watch?v=GCo2uCLXvhk>



# Control of behavior

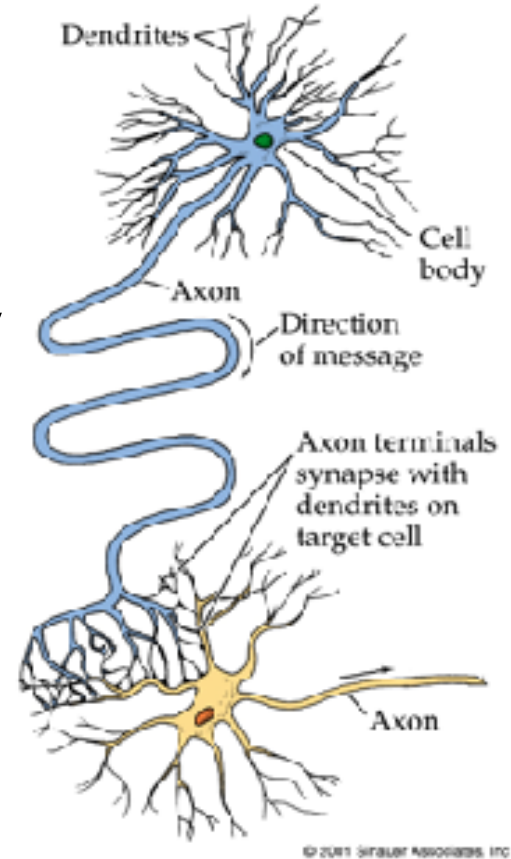
- Control involves ...
  - “Machinery”: nerves, muscles, sensory organs
  - Sensory biology: what cues/signals do animals perceive
  - Information processing: how an organism’s brain uses inputs to influence responses
  - Behavioral responses



- Neuroethology
  - Study of how the nervous system relates to behavior

# The nervous system

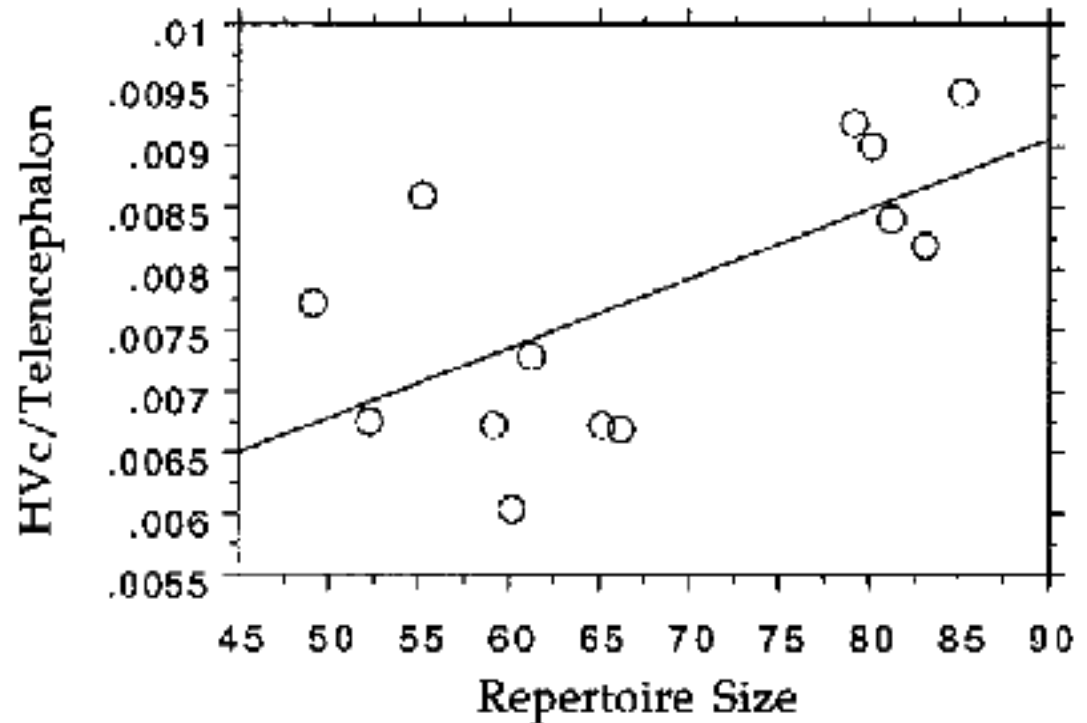
- Neuron
  - Dendrites: input
  - Soma/body: nucleus; basic machinery
  - Axons: output
  - Action potentials, synapses, neurotransmitters
- Types of neurons
  - Sensory/afferent: transmits from sensory cells to CNS
  - Motor/efferent: carry from CNS to glands/muscles
  - Interneurons: connect input to output, and process signal (many in brain) (99% of all neurons in humans)



# Higher Vocal Center: what does it do

## HVC and learned song

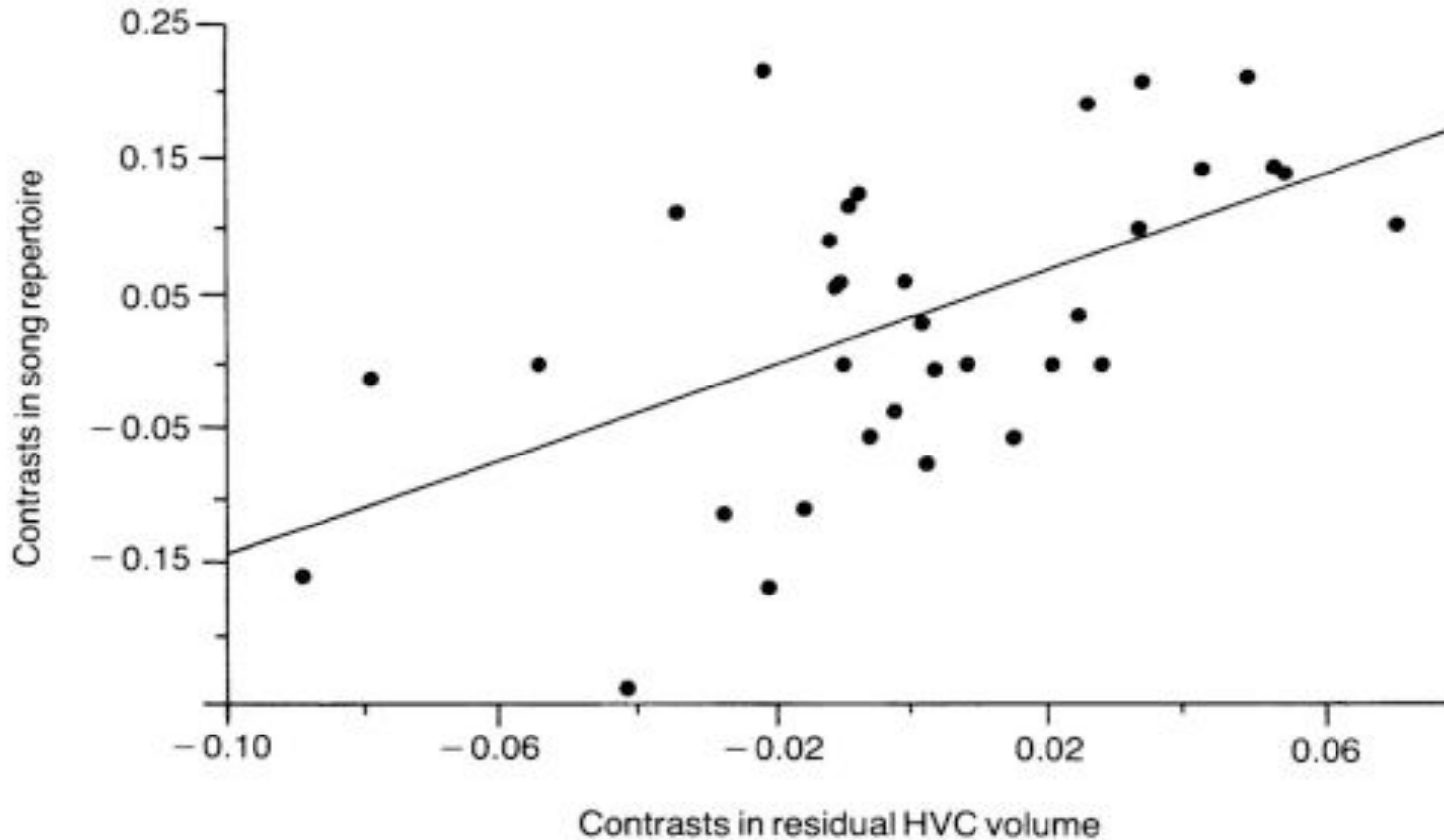
- Large HVCs are associated with large repertoires within species



# Higher Vocal Center: what does it do

## HVC and learned song

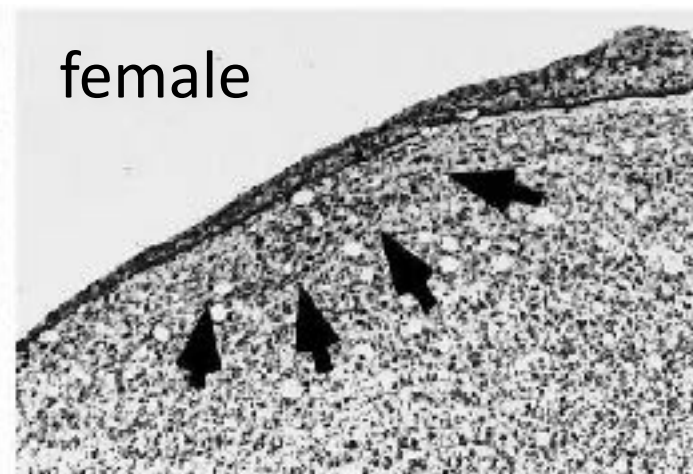
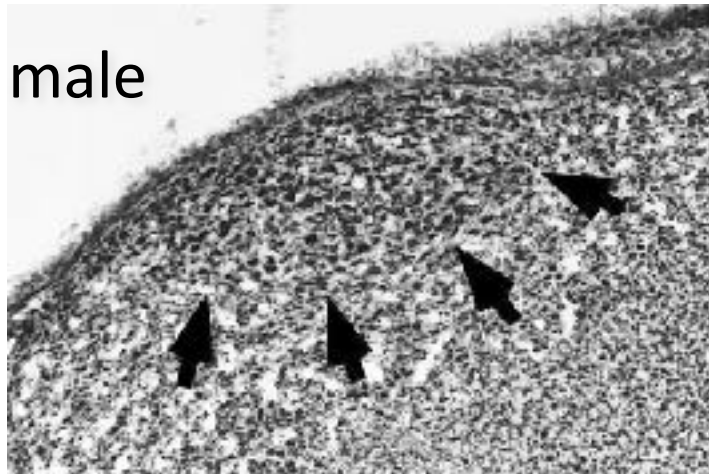
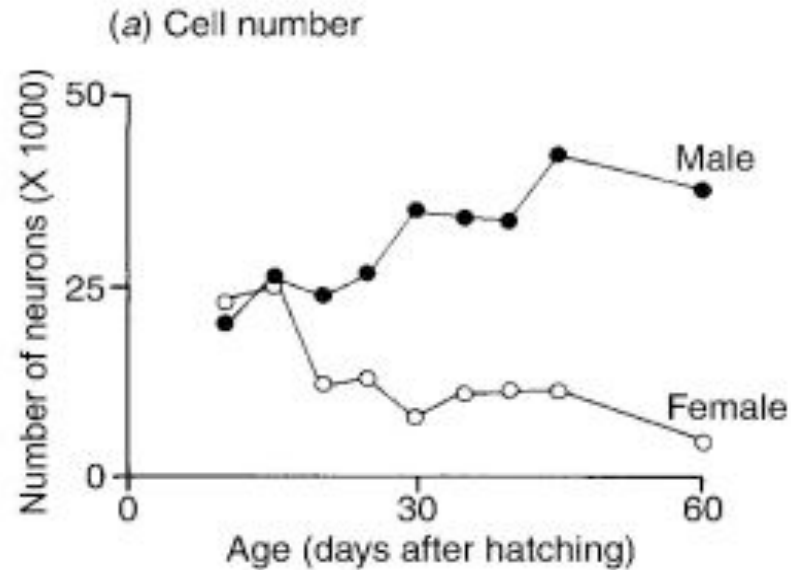
- Large HVCs are also associated with large repertoires across species



# Higher Vocal Center: what does it do

## HVC and learned song

- There is a marked sex differences in HVC size



# Higher Vocal Center: what does it do

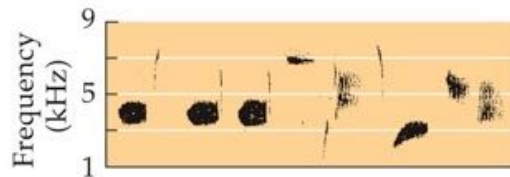


song sparrow

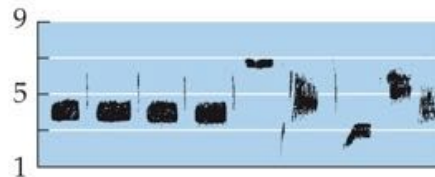
## Females prefer learned song with high fidelity

- Learned songs are honest indicators of quality because it is difficult to learn properly
  - Females display more to males that copy songs well

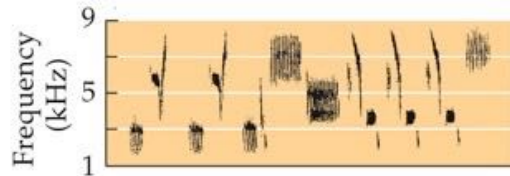
(A) Tape tutor song



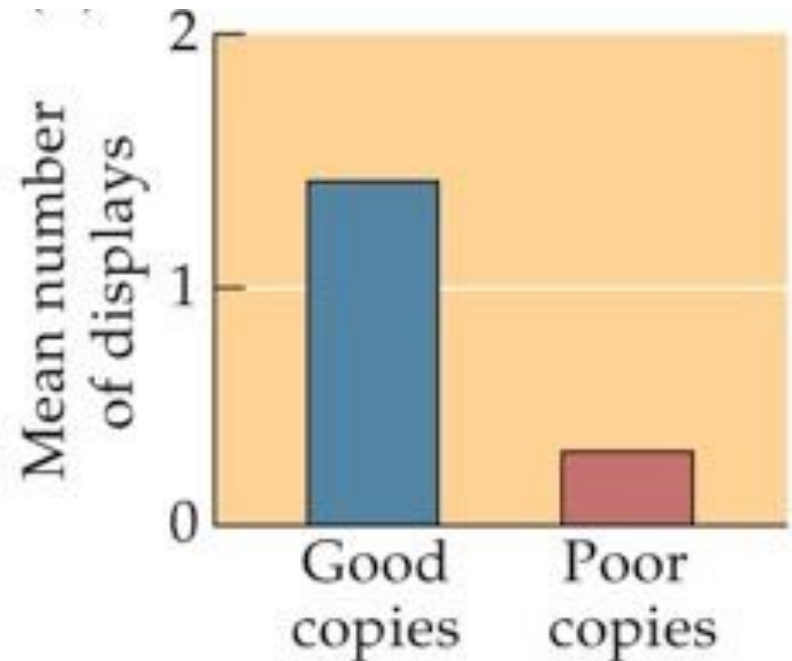
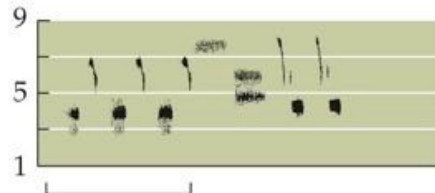
(B) Good copy of (A)



(C) Tape tutor song



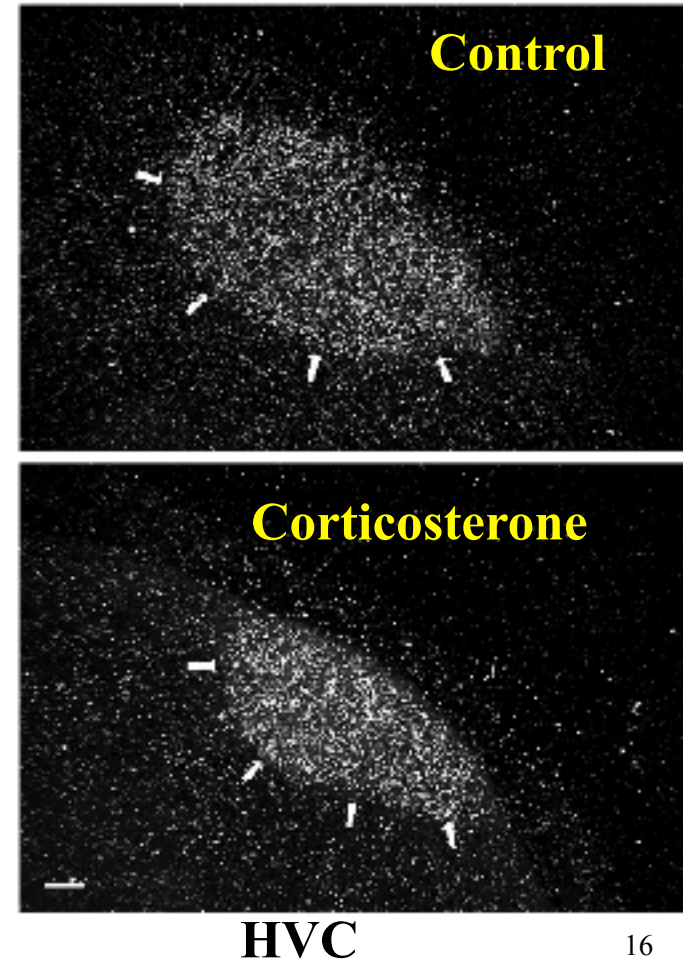
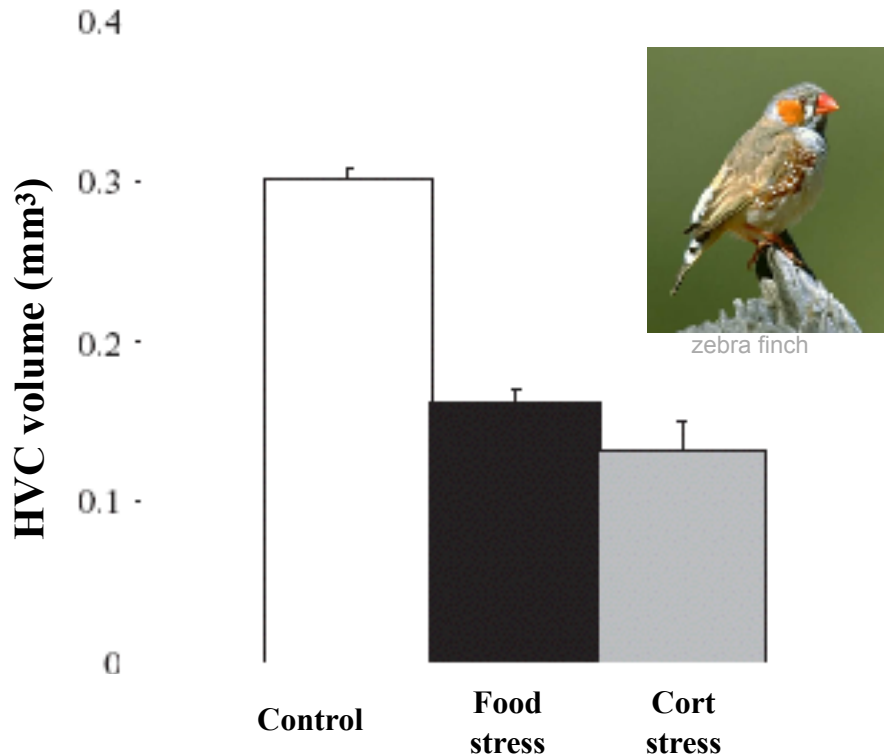
(D) Poor copy of (C)



# Higher Vocal Center: what does it do

## Learned-song can indicate neural complexity

Food and hormonal stress during development reduce the size of the HVC

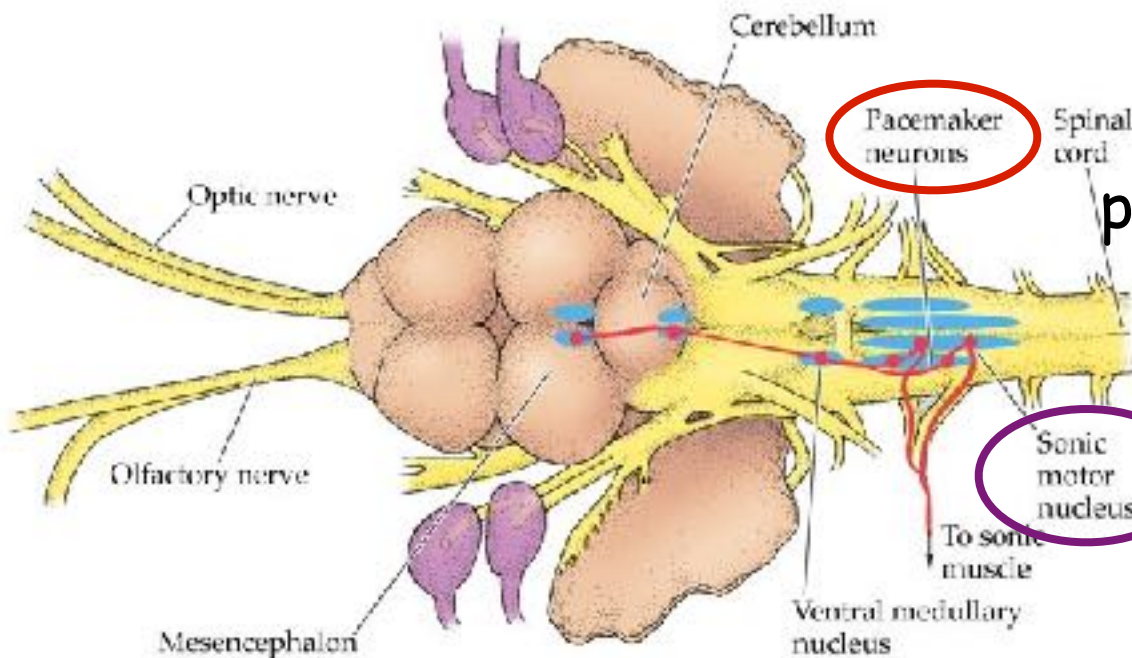
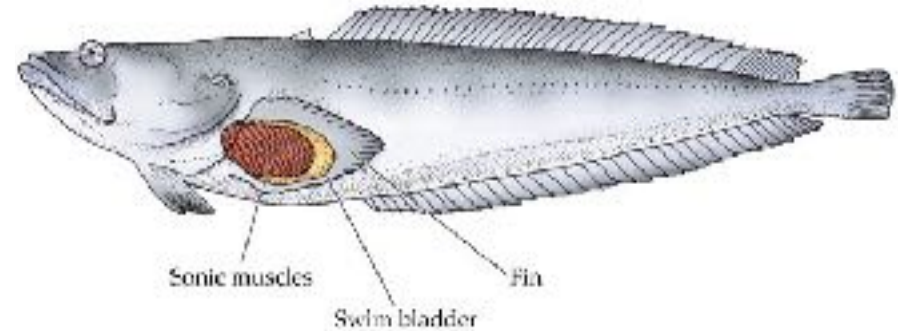




# Main points about control of behavior

(1) Neural mechanisms = proximate cause of behavior

- Input stimulus
- Information processing
- Output motor response

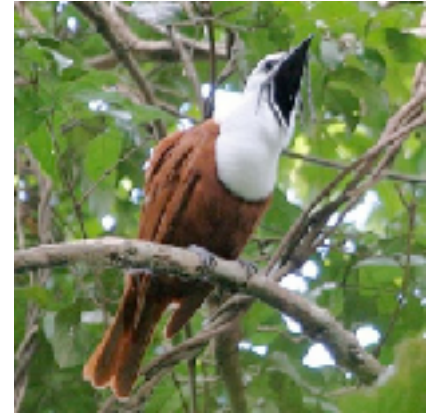


Central part of brain processes input (i.e., visual) and sends signal to **sonic** motor nuclei

Signal  $f$  modulated by **pacemaker** neurons

# Main points about control of behavior

- (2) Neural mechanisms vary among species
  - Explains why behavioral responses vary



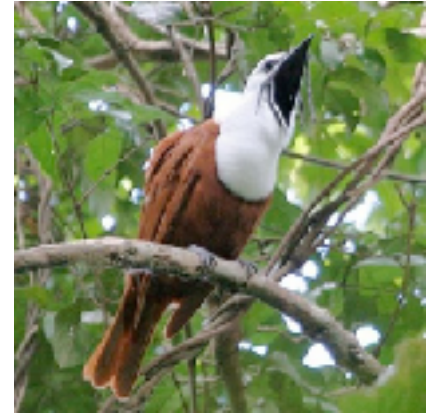
# Main points about control of behavior

(2) Neural mechanisms vary among species

- Explains why behavioral responses vary

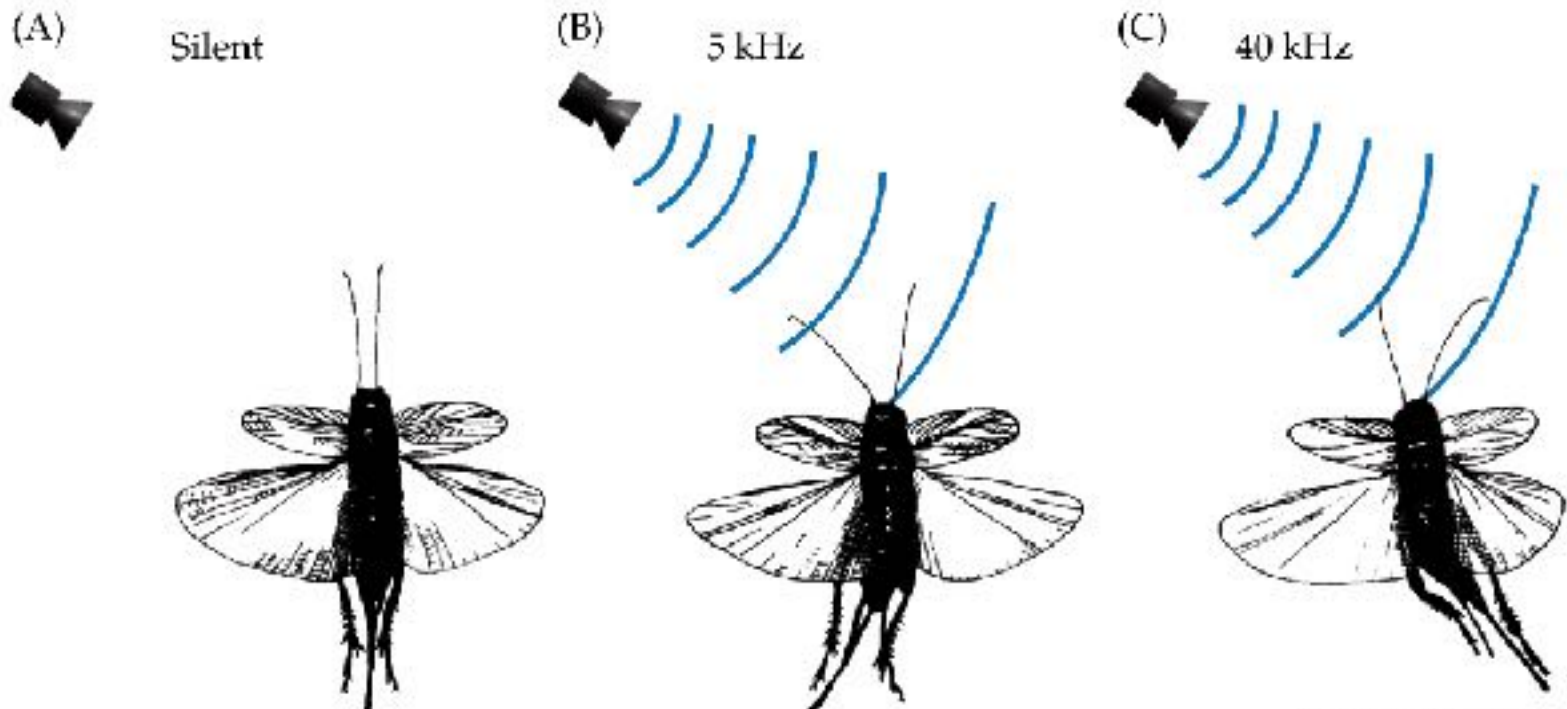
(3) Neurons are often “tuned” to particular inputs

- Stimulus/Sensory filtering: different responses across range of input. Allow animals to ignore certain elements while focusing on only relevant info



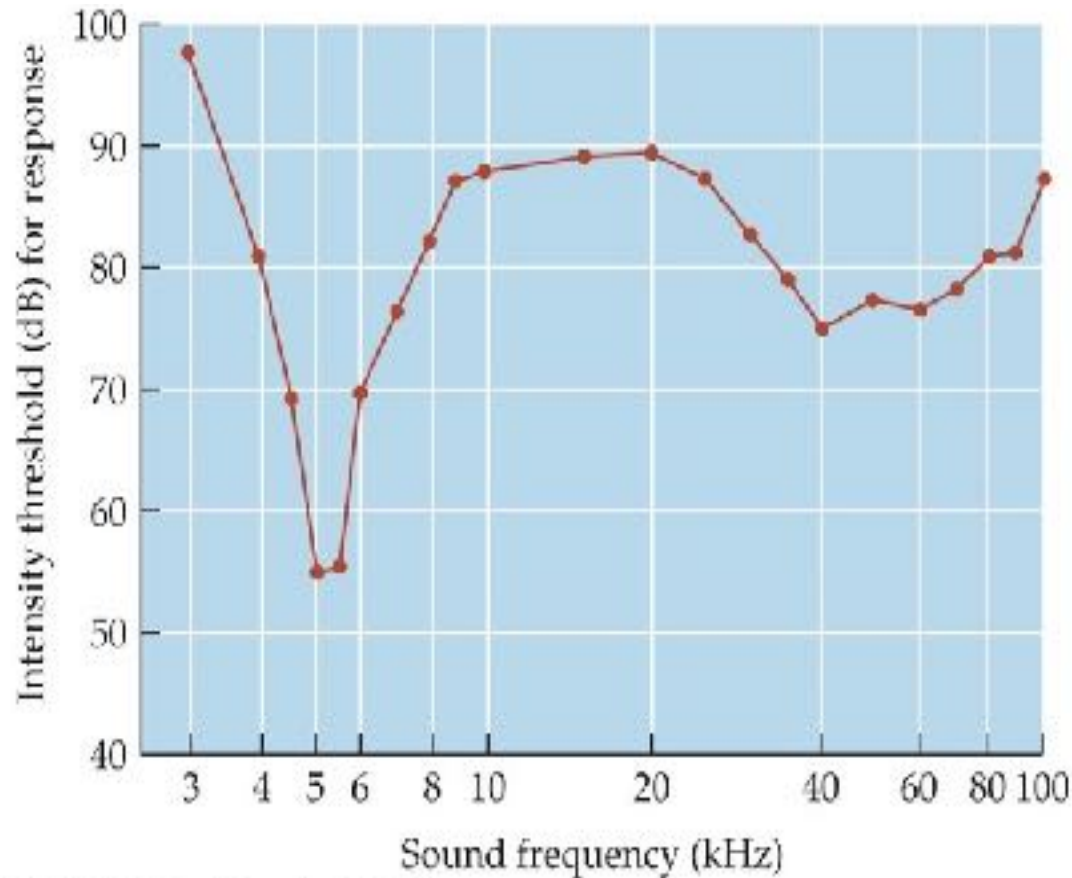
# Sensory filtering: Auditory

- Night-flying insects respond to bats
  - Female crickets show negative phonotaxis to bats, but positive phonotaxis to male songs
    - Neuron int-1 responds to sound frequencies 5-100 kHz in each ear (ears located on legs!)
    - Provides info on frequency, and location of source



# Sensory filtering: Auditory

- Telling the difference between a bat and a cricket
  - Tuning curve (lowest volume to hear a frequency)



Male  
cricket

Bat!

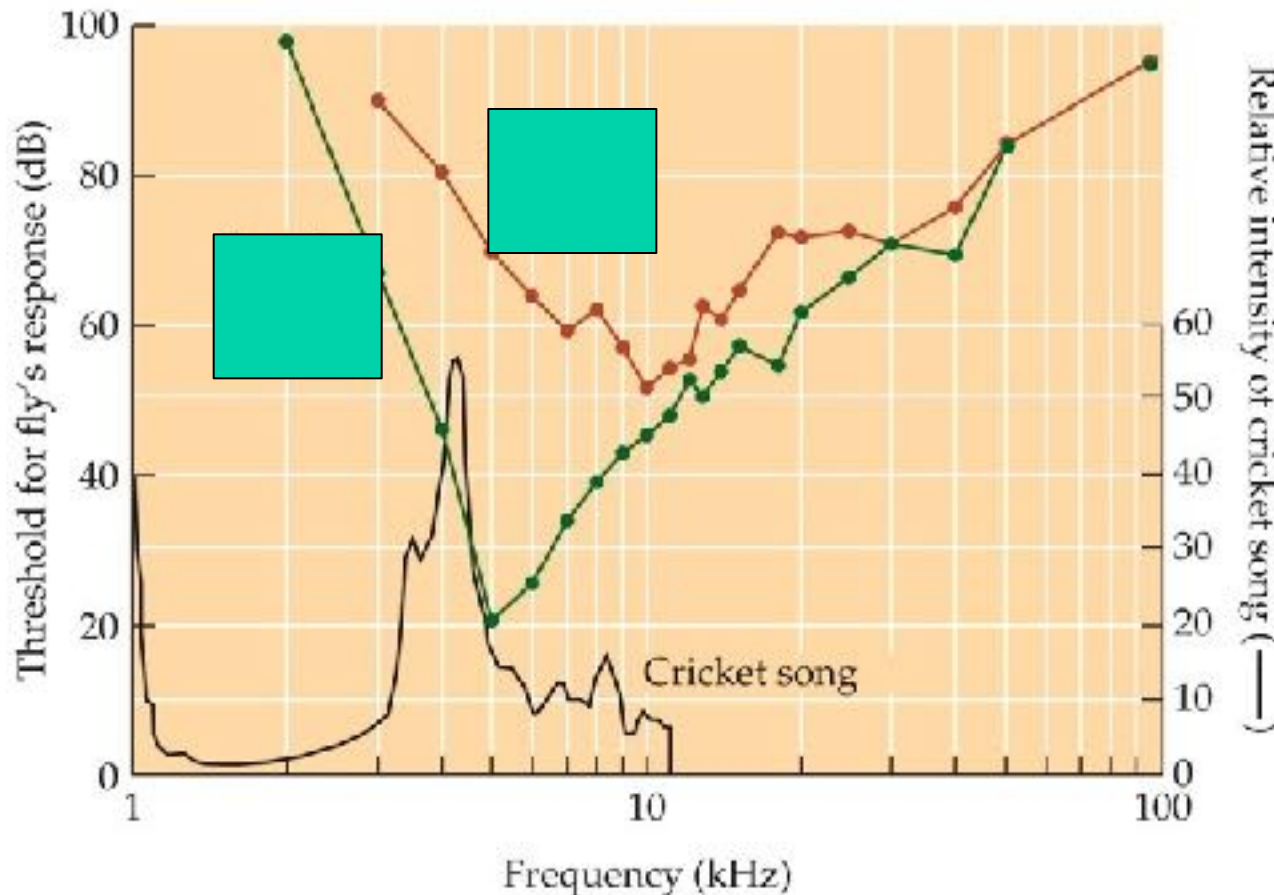


# Sensory filtering: Auditory

- Sex differences in auditory filtering:  
Only female flies parasitize crickets

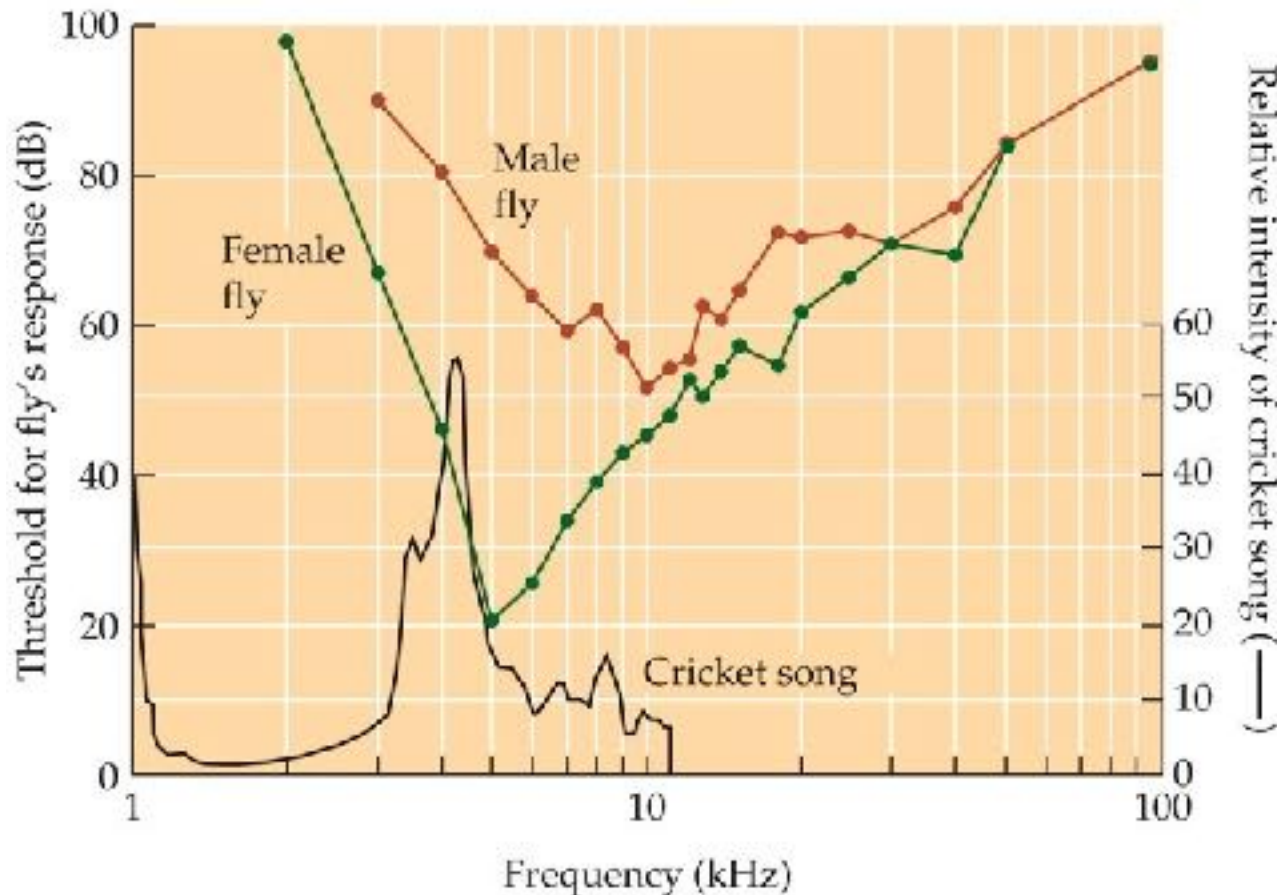


Ormia fly



# Sensory filtering: Auditory

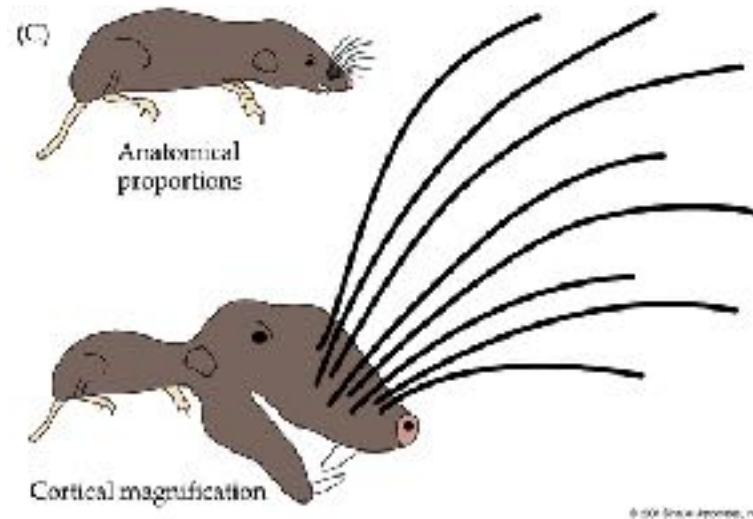
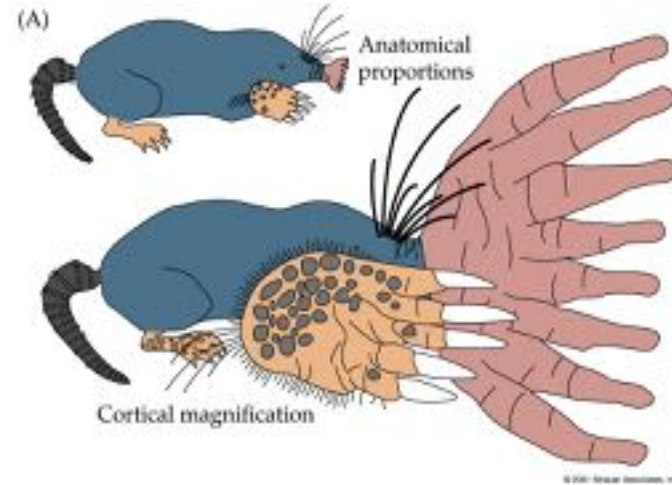
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Ormia fly

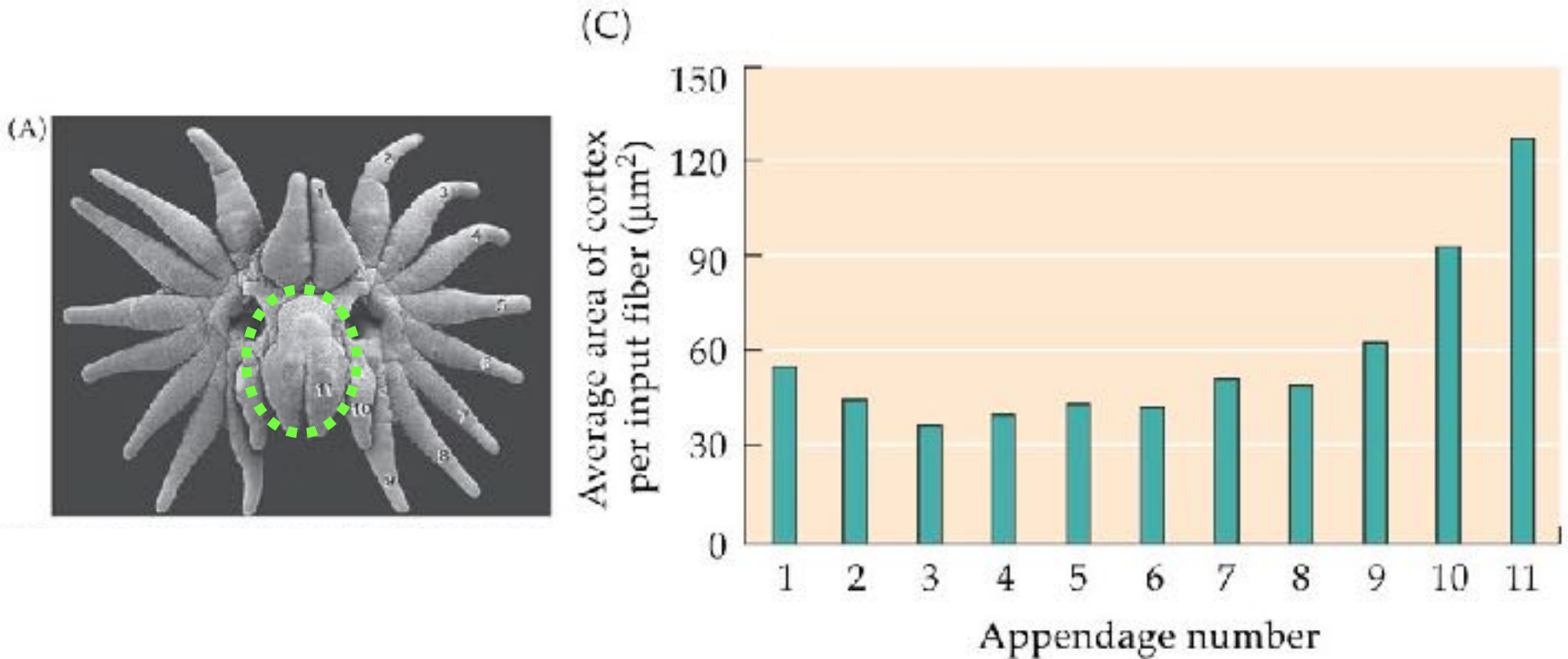
# Sensory filtering: Tactile

- Species differ in cortical-sensory map





# Sensory filtering: Tactile



JANAL. 82(4)R30, Epub Ahead of Print 21 © 2016 Elsevier Academic, Inc.

**A nose that looks like a hand and acts like an eye!**

STATUS

NOTE  
PLAY

FRAME #

-01732

TIME OF FRAME

-005764 MS

EVENT NUMBER

1022

SETUP

F/SEC RECORD

500

SHUTTER SPEED

5K

TRIGGER POINT

100% V

F/SEC PLAY

500

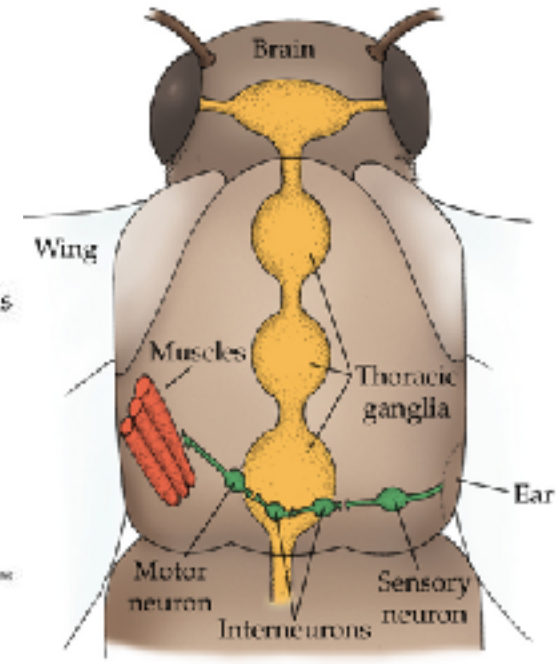
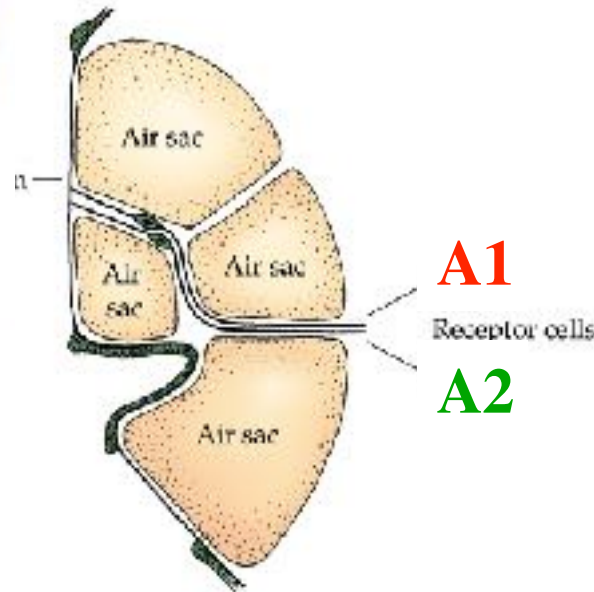


# Sensory filtering: Auditory

- Noctuid moths and bats

- Moth hearing:

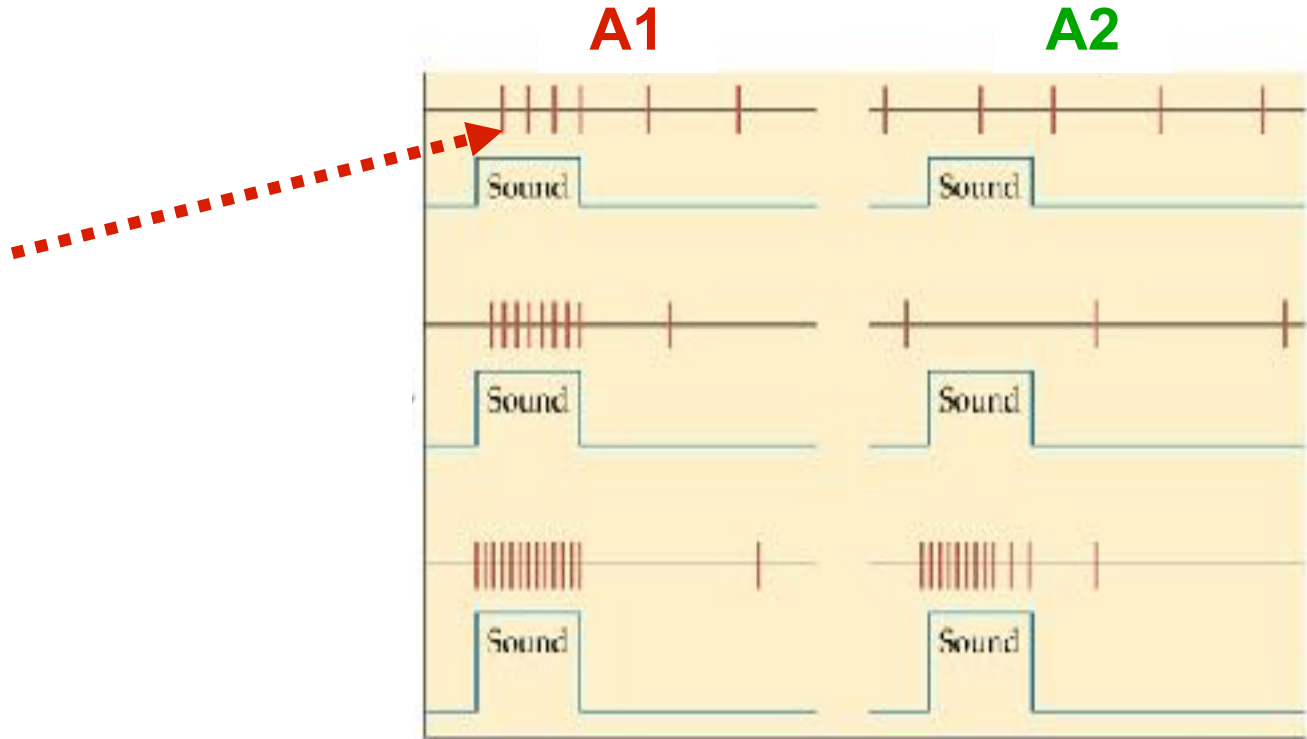
- Ear (tympanic membrane) on both sides of body
    - Two receptors: **A1** and **A2**



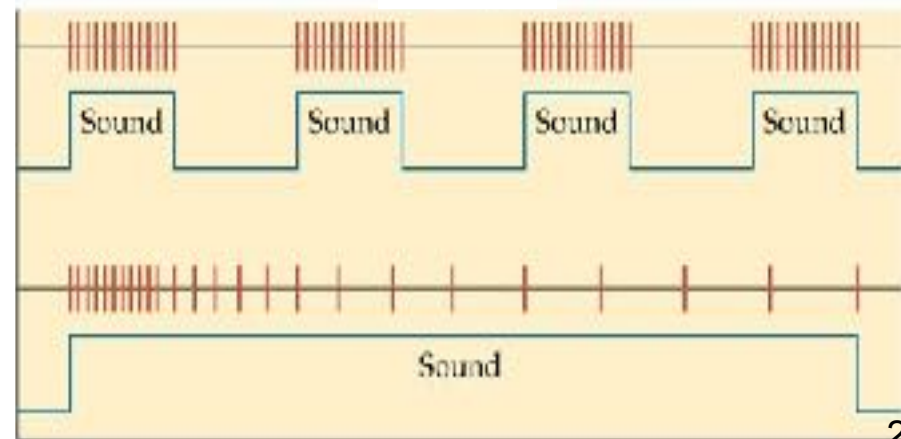
# Sensory filtering: Auditory

**A1**

- sensitive to low intensity sounds



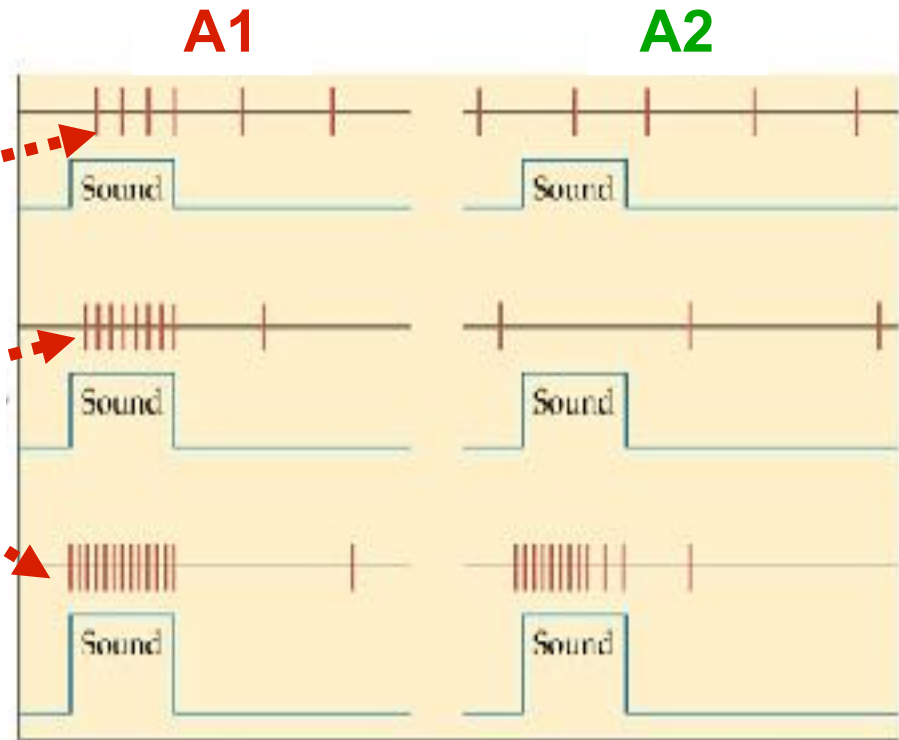
**A1**



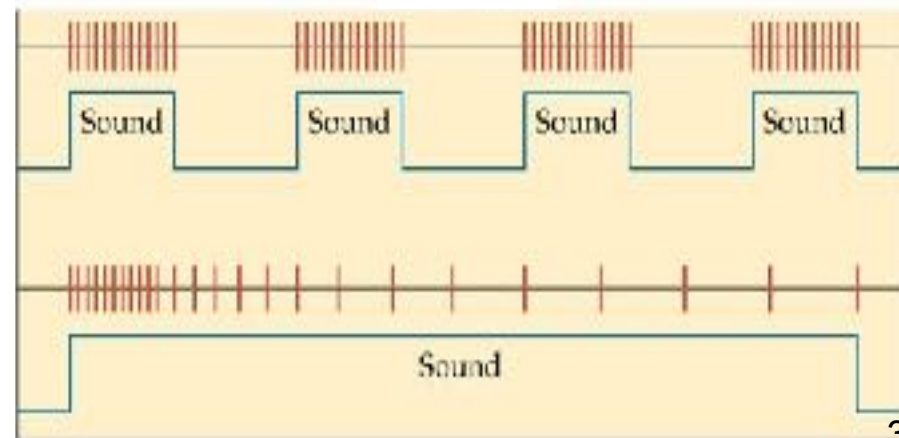
# Sensory filtering: Auditory

**A1**

- sensitive to low intensity sounds
- more firing with greater sound intensity



**A1**



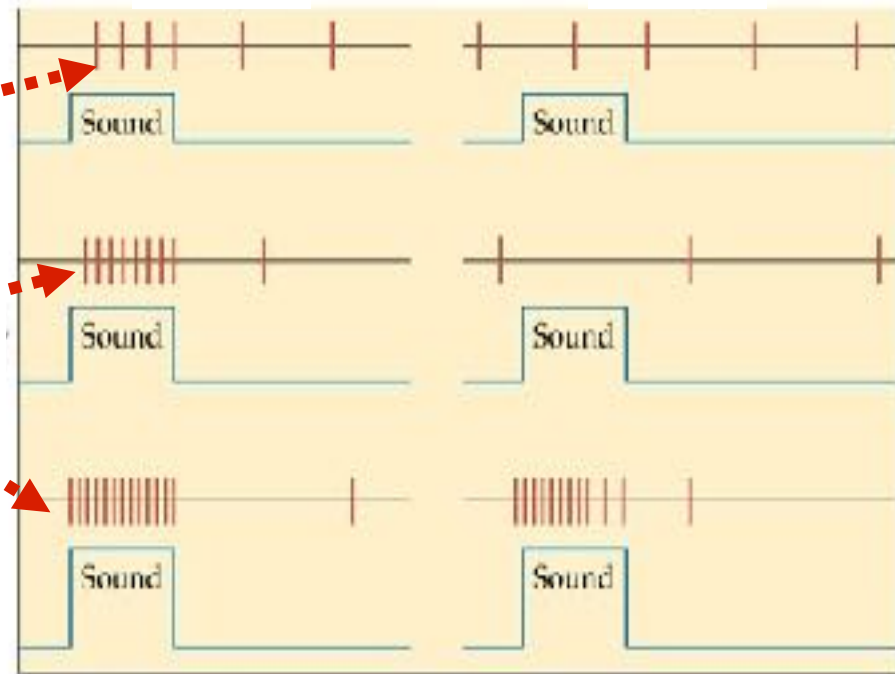
# Sensory filtering: Auditory

## A1

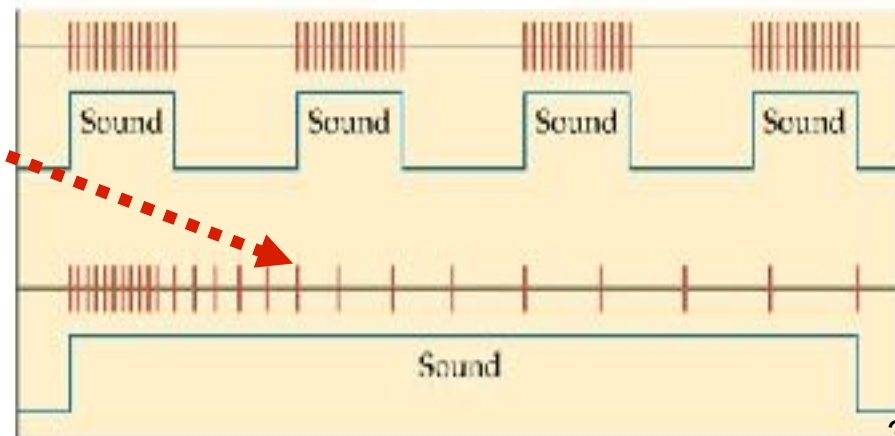
- sensitive to low intensity sounds
- more firing with greater sound intensity
- only responds to pulsed ultrasound; habituates to constant sound

## A1

## A2



## A1



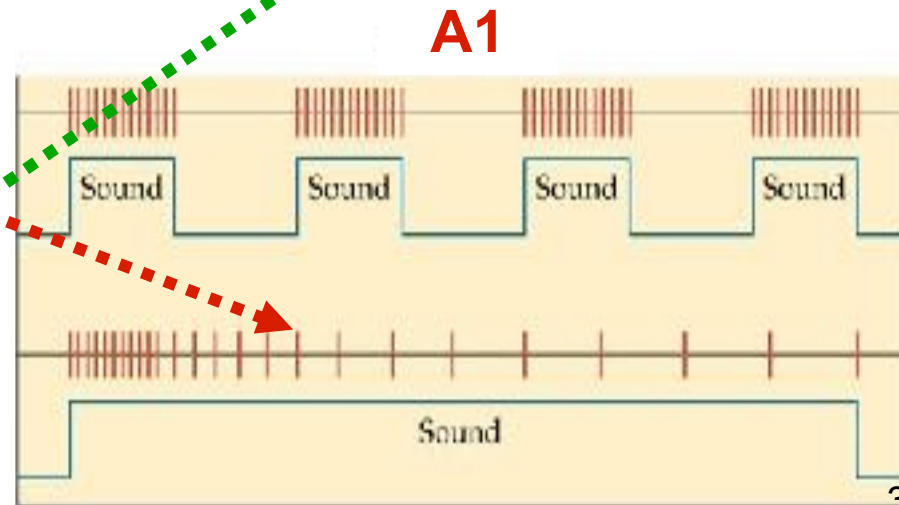
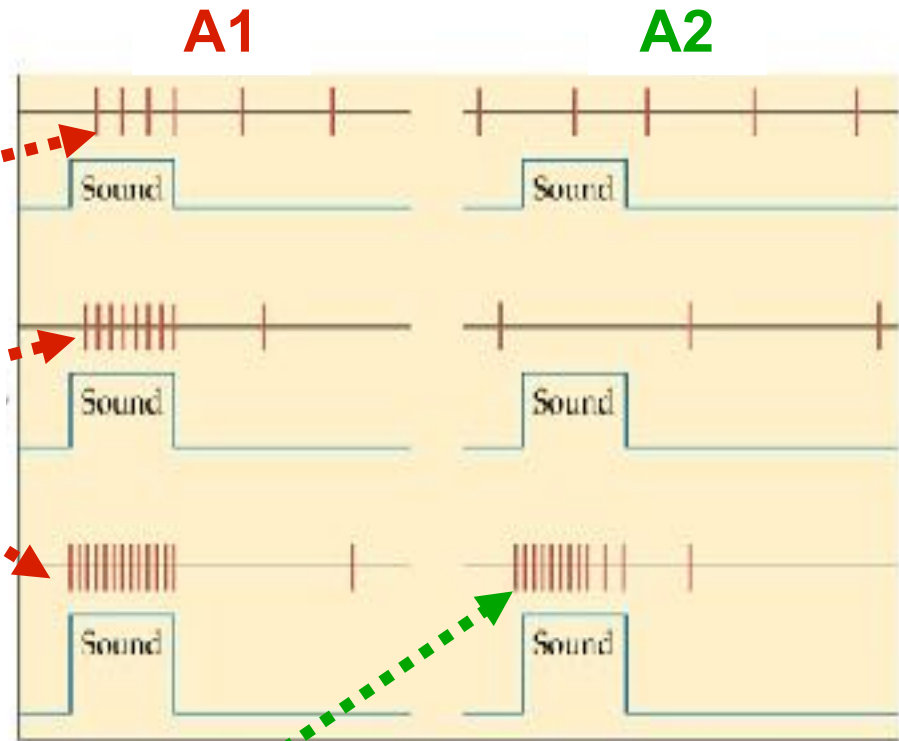
# Sensory filtering: Auditory

**A1**

- sensitive to low intensity sounds
- more firing with greater sound intensity
- only responds to pulsed ultrasound; habituates to constant sound

**A2**

- only responds to high intensity sounds





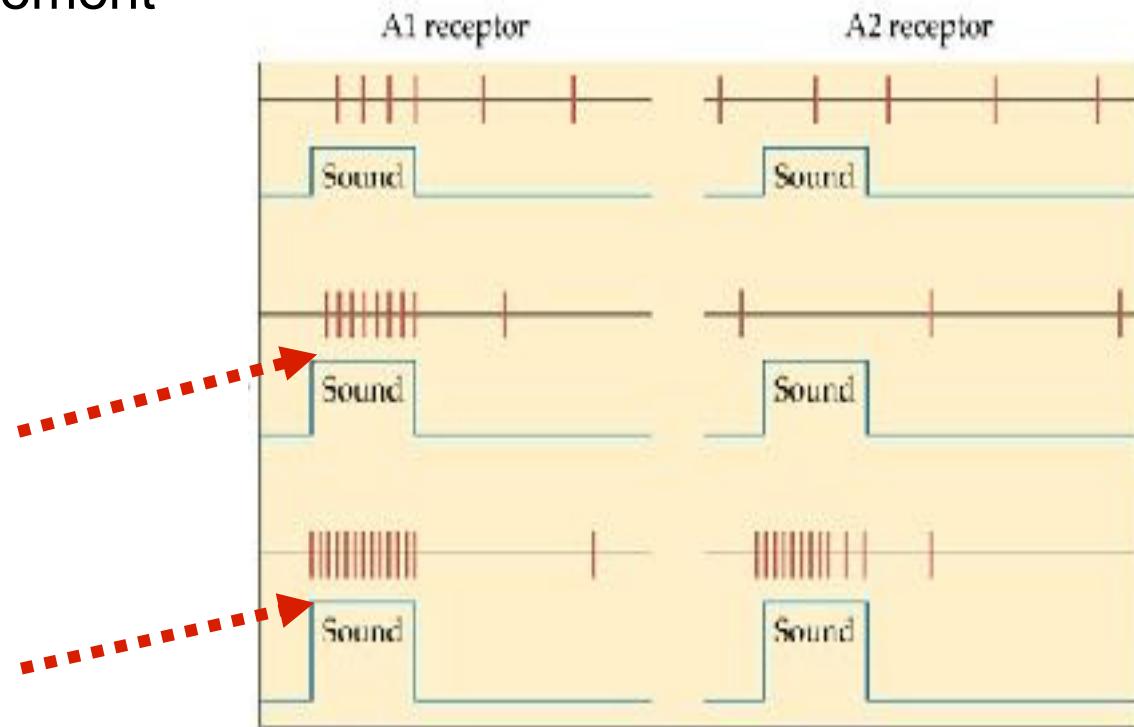
# Sensory filtering: Auditory

- Noctuid moths and bats

- Perception of sound:

- Range (Is the bat closing in?)

- **A1** provides information on distance and movement



# Sensory filtering: Auditory

- Noctuid moths and bats
  - Perception of sound:
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      - **A1** provides information on distance and movement
    - Localization (Where is it?)
      - Left/Right: **A1** in closer ear fires first, and more frequently
      - Above/Below: If bat above, wings block sound on downstroke



# Sensory filtering: Auditory

- Noctuid moths and bats
  - Perception of sound:
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      - **A1** provides information on distance and movement
    - Localization (Where is it?)
      - Left/Right: **A1** in closer ear fires first, and more frequently
      - Above/Below: If bat above, wings block sound on downstroke
    - Behavior
      - **A1** fires: turn to equalize signal in both ears fly in direction causing intensity to be reduced
      - **A2** fires: DIVE! DIVE! DIVE!



# Sensory specialization

- Animals must have evolved mechanisms for responding to only relevant stimuli
- Sensory system for species defines its *umwelt*
  - Lots of fascinating examples of how other species perceive the world
  - Humans are mainly visual; things we don't notice:
    - Chemical
    - Tactile
    - Electrical
    - Magnetic
    - UV
    - Polarized light



# Sensory specialization

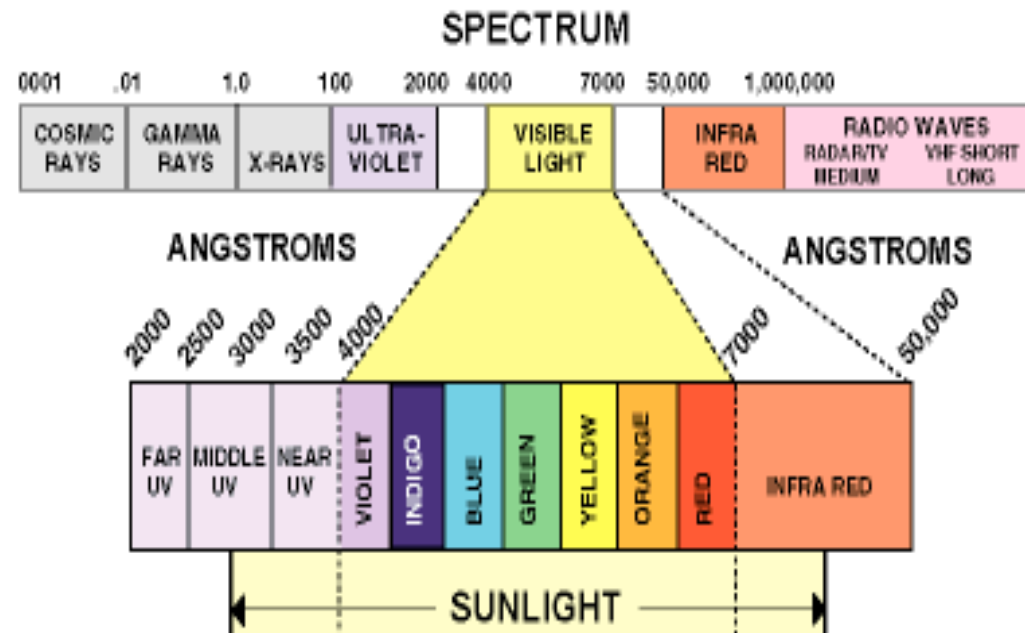
- Visual filtering
  - What is color?
    - Electromagnetic spectrum
      - range of wavelengths of light (radiant energy)



- How is color perceived?
  - reflection of photons off surfaces

WHITE = all wavelengths reflected and perceived

BLACK = no wavelengths reflected or perceived

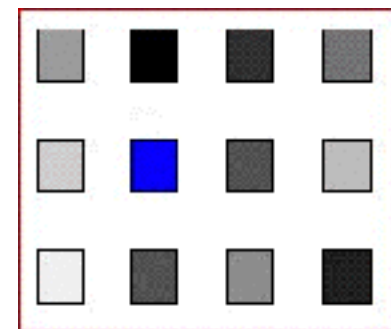


# Sensory specialization

- Animal color vision
  - Can animals see color?
    - trained honeybees to scented sugar water on colored squares
  - What colors do they see?
    - Bees do not see red!

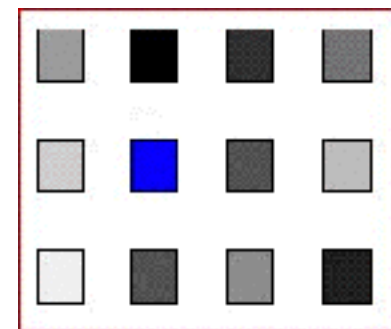
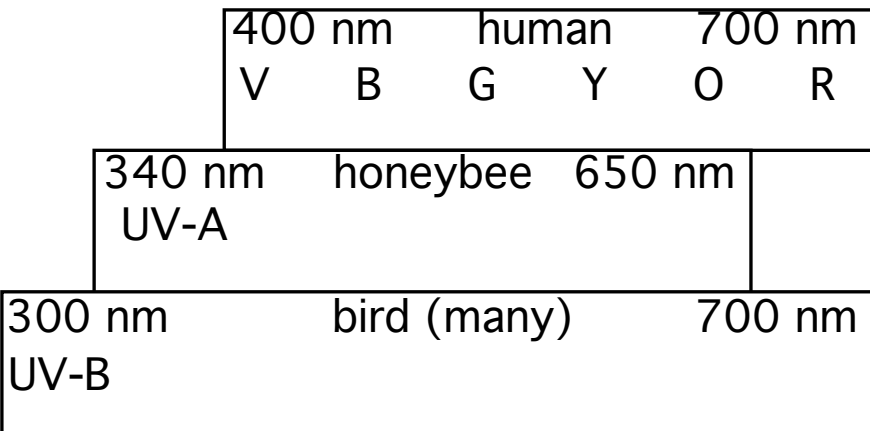
400 nm	human	700 nm
V	B G Y O	R

340 nm	honeybee	650 nm
UV-A		



# Sensory specialization

- Animal color vision
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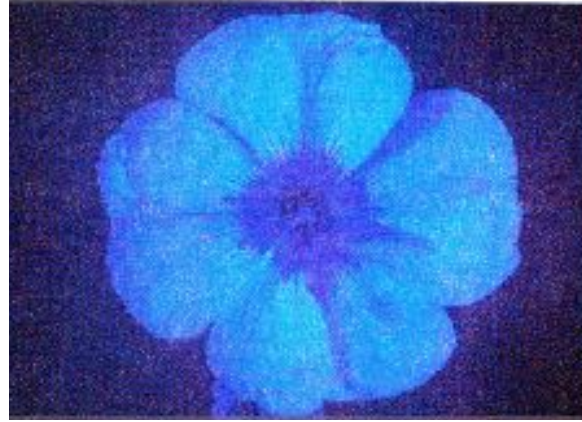


# Sensory specialization

- European kestrels
  - Track mice by UV urine trails!
- Bee vision



What humans see



What bees see



# Sensory specialization

- Animal color vision
  - Humans do not see UV, bees do not see red
  - Can other insects see red? Yes: Butterflies
  - Can other organisms see UV and red? Yes: Birds
    - Bluethroat example = female mate-choice based on UV signal on male



Bluethroat

