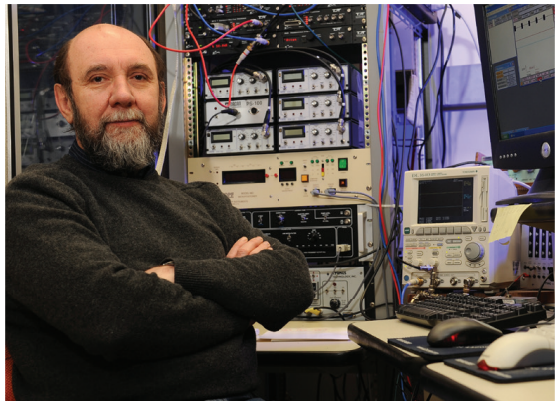
Northeast Ohio
MEDICAL UNIVERSITY

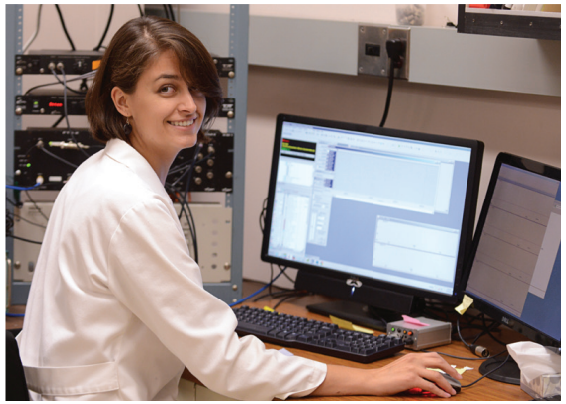
# The Neuroscience of Hearing and Its Disorders: Research at NEOMED

MERRI ROSEN, PH.D.
DIRECTOR, HEARING RESEARCH GROUP
DEPARTMENT OF ANATOMY AND NEUROBIOLOGY

https://www.neomed.edu/research/hearing/

HEARING RESEARCH
A NEOMED RESEARCH FOCUS AREA





# THE **HEARING RESEARCH** GROUP

Hearing disorders of many types begin in the inner ear, but they have long-term effects in the brain. The Hearing Research Group at NEOMED is interested in how the central nervous system functions in association with hearing and vocal communication, how it is affected by hearing disorders, and how interventions of the peripheral and central nervous systems may ameliorate hearing disorders.

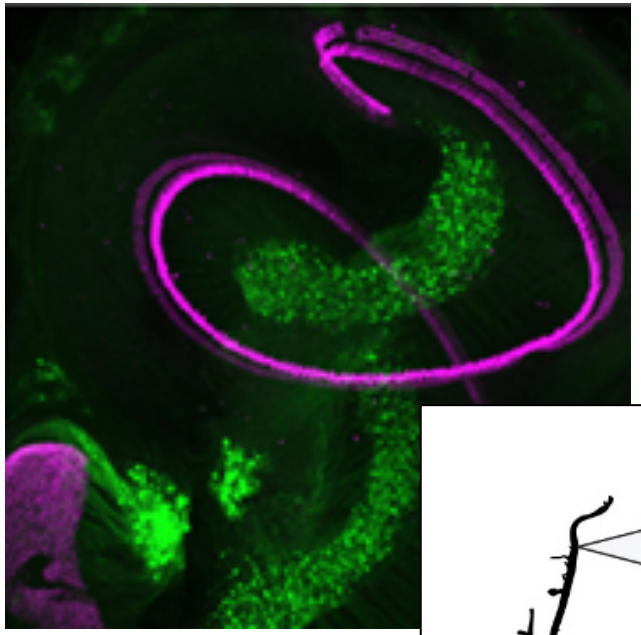
**HEARING RESEARCH**
A NEOMED RESEARCH FOCUS AREA

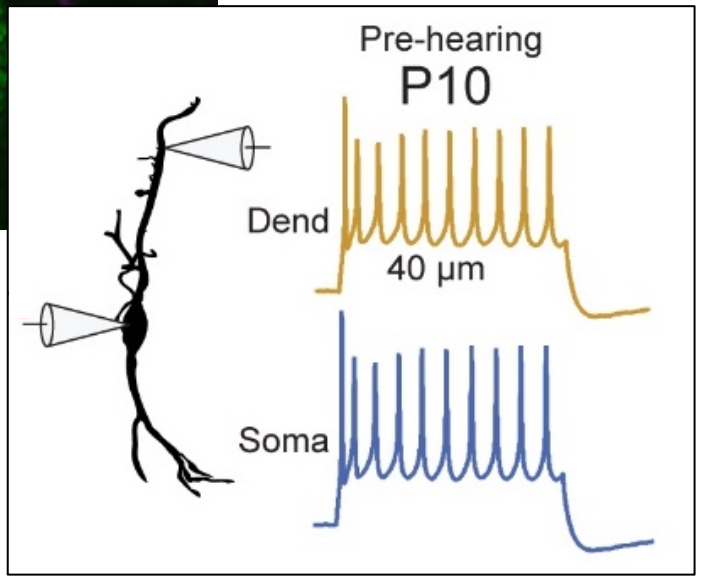
# Hearing Research Focus Group

- 10 labs with 12 faculty studying the auditory system, from the ear to the brain

- Research topics include:
  - Hearing loss (age-related, noise-induced, developmental)
  - Auditory processing disorder
  - Tinnitus
  - Emotional disorders
  - Much more!

- Wide variety of biomedical research techniques





# Hearing Research Focus Group

Rich training environment:

- Access to all faculty in the group – collaboration is the norm
- History of successful training. Over the past ~7 years:
  - 24 medical students
  - 11 graduate students
  - 7 postdoctoral trainees

# Hearing Research Focus Group

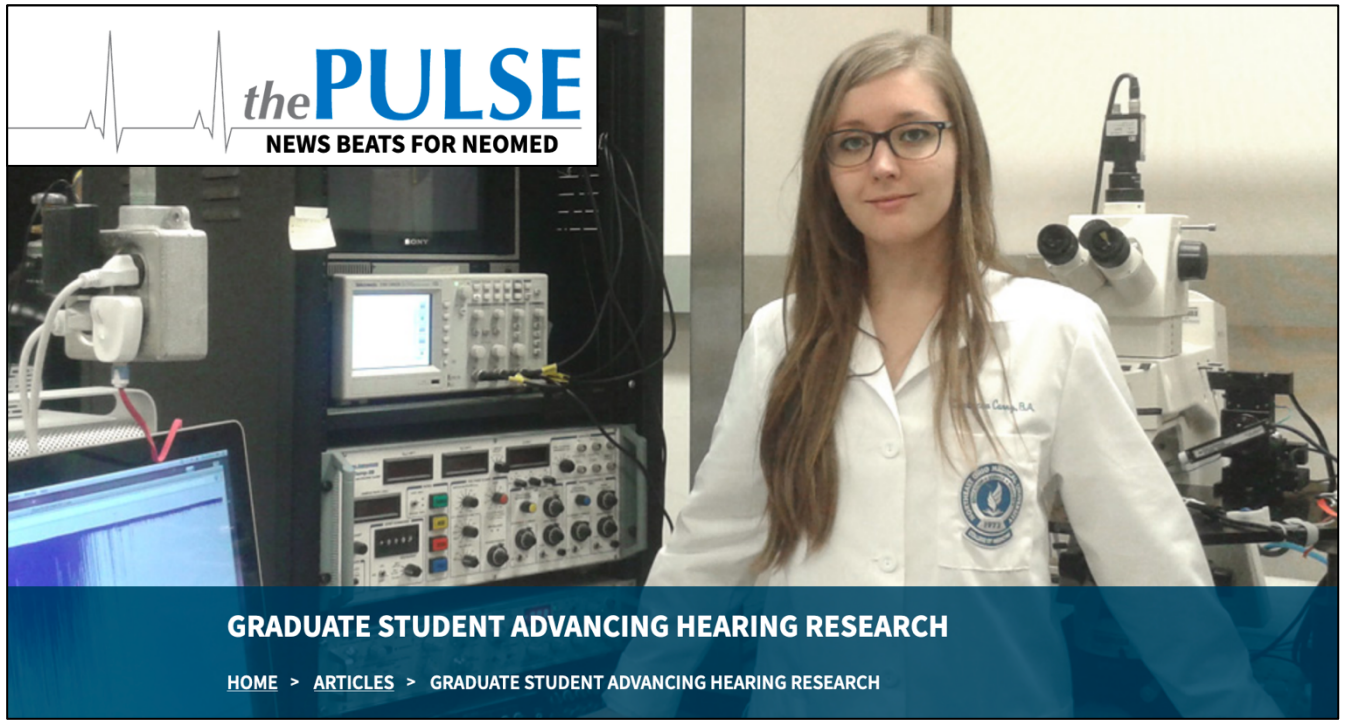

Rich training environment:

- Weekly journal clubs
- Seminars, with a chance to meet experts in the field
- Regular attendance at national and international conferences

# Hearing Research Focus Group

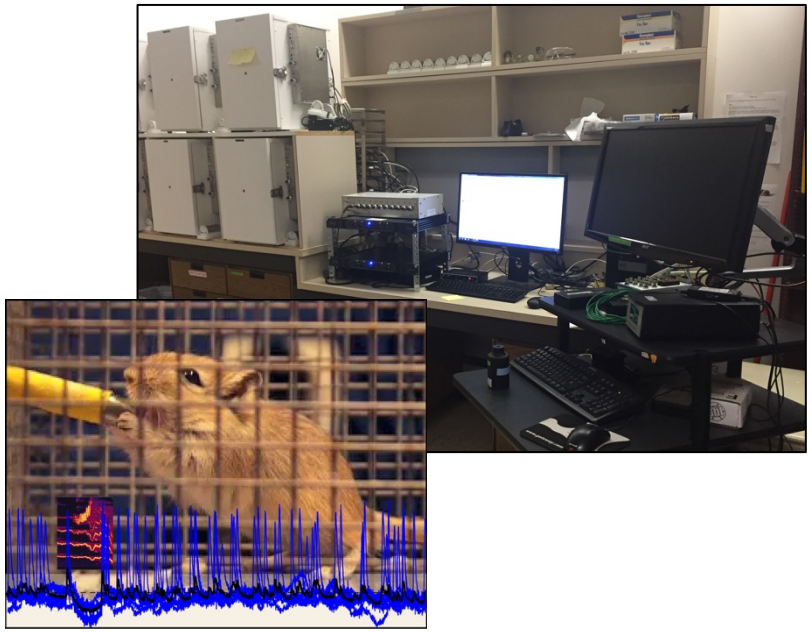
- Our labs receive funding through the National Institutes of Health (NIH)
  - Across 10 labs:
    6 R01s, 1 R41, 1 R21, 1 R15

- History of pre-doctoral NIH fellowships for PhD students
  - 4 since 2012

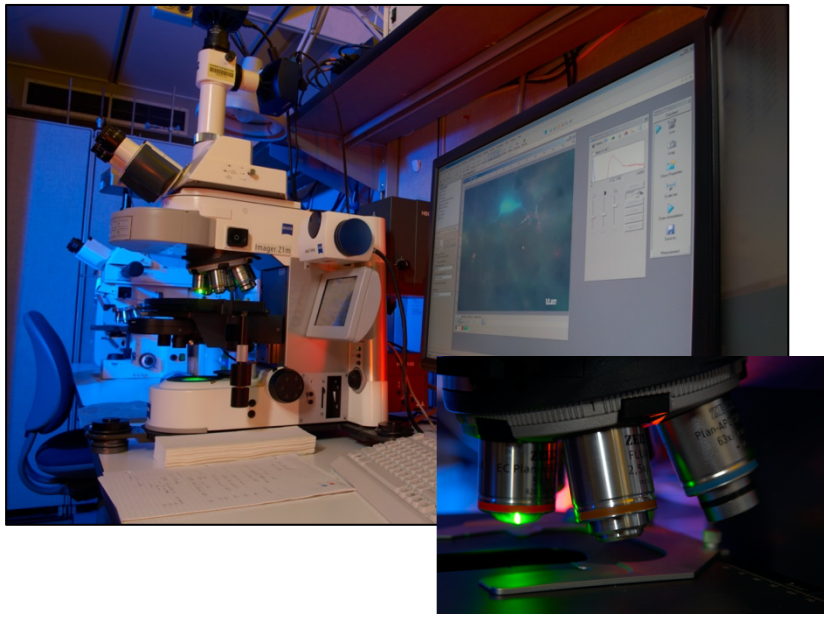


# Hearing Research Focus Group

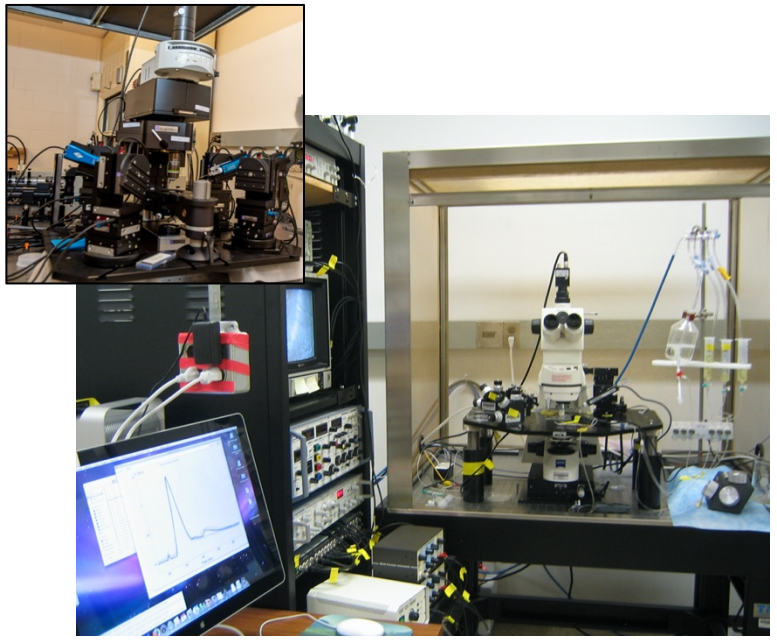
## Access to state-of-the-art techniques & resources



- Behavioral assessments: operant conditioning, acoustic startle responses, vocal communication



- Imaging and microscopy: optogenetics, transmission electron microscopy, multiphoton imaging



- Neurophysiological recording: brain slice recording, *in vivo* recording in behaving animals, voltage-sensitive measurement

# NEOMED

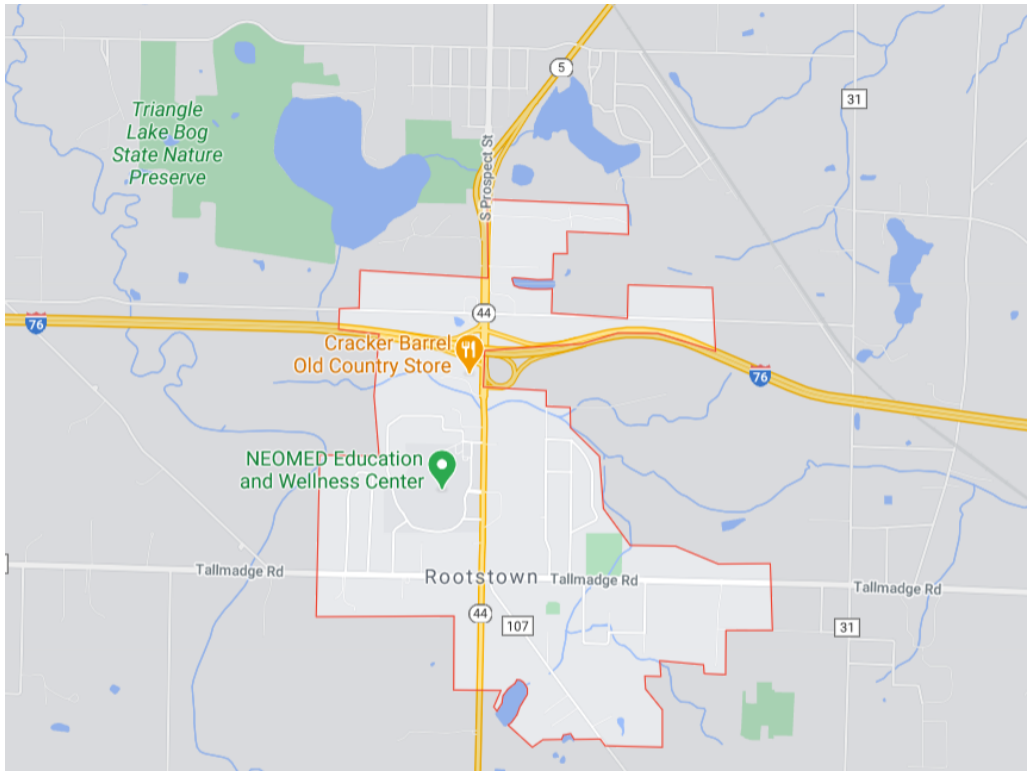
Founded in 1973

3 Colleges: Medicine, Pharmacy, Graduate Studies

"*NEOMED harnesses diversity, innovation and collaboration to create transformative leaders and improve health through education, discovery and service*."

# NEOMED

- Located in Rootstown, OH
- Rural area; on-campus living, dining, and fitness center are available
- Graduate students, pharmacy students, medical students, postdoctoral fellows

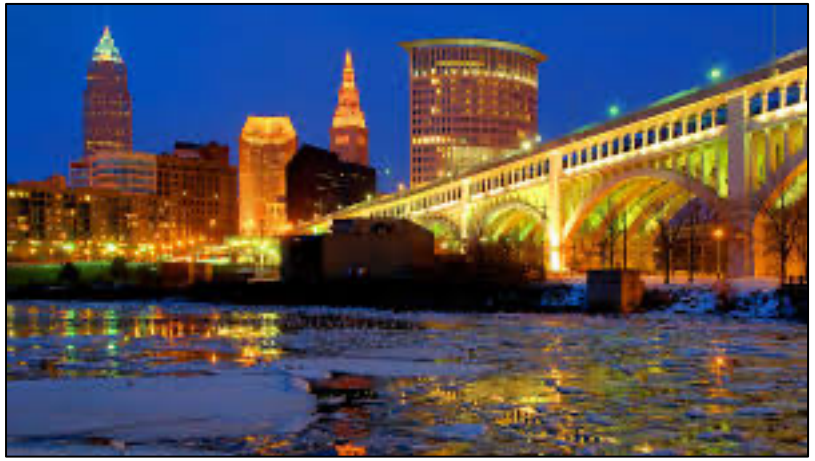



# Just down the road from Kent, OH

- Home to Kent State University
- Shopping, dining, music, events, outdoor recreation


# Also near…

- Akron, OH (~20 minutes)
- Cuyahoga Valley National Park (~30 minutes)
- Cleveland, OH (~50 minutes)



BRAIN HEALTH RESEARCH INSTITUTE
at Kent State University

# Brain Health Research Institute

The HRG is part of a consortium of neuroscience research based at Kent State University

- Seminars on a broad range of topics in neuroscience
- Connections with scientists with expertise beyond the auditory system
- Career training opportunities

https://www.kent.edu/brainhealth

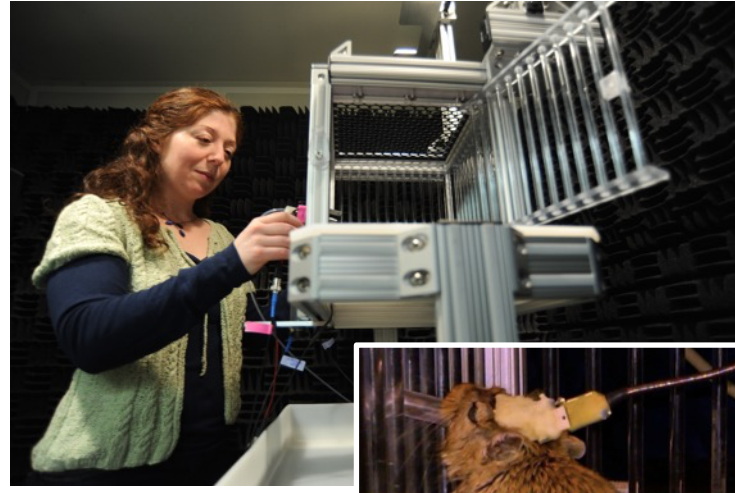
Northeast Ohio MEDICAL UNIVERSITY

HEARING RESEARCH
A NEOMED RESEARCH FOCUS AREA

# Our researchers:

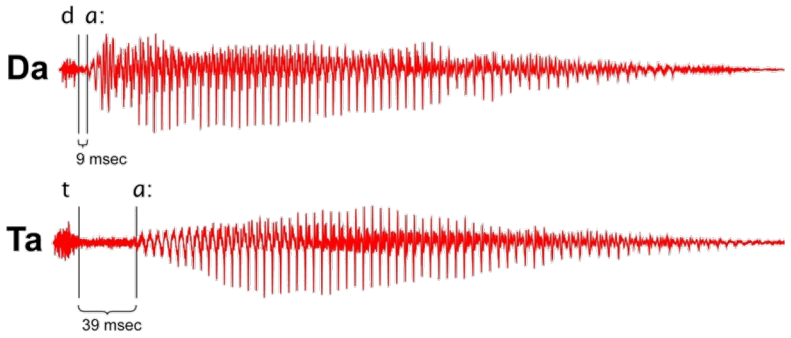
- Dr. Merri Rosen
- Dr. Jianxin Bao
- Dr. Alex Galazyuk
- Dr. Julia Huyck
- Dr. Yong Lu
- Dr. Jeffrey Mellott
- Dr. Bruna Mussoi
- Dr. Brett Schofield
- Dr. Jeffrey Wenstrup
- Dr. Bradley Winters
- Dr. Sharad Shanbhag
- Dr. Nichole Beebe

# Dr. Merri Rosen's Laboratory:
## Development of neural underpinnings of auditory perception



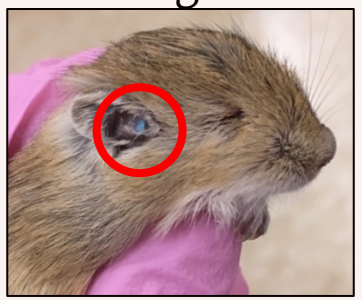
mrosen@
neomed.edu

- Kids with **hearing loss** are at risk for later problems with speech perception.
- **Early life stress** increases the risk of long-term language deficits.
- RESEARCH GOAL: to understand the specific **perceptual** deficits, and the **neural changes** that cause these problems.
- This will allow us to design optimal **remediation** strategies.

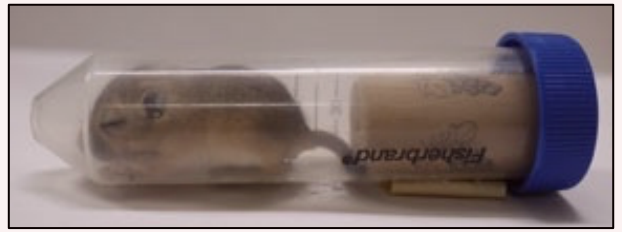



**Developmental manipulations:**

*Hearing loss*



*Early-life stress*

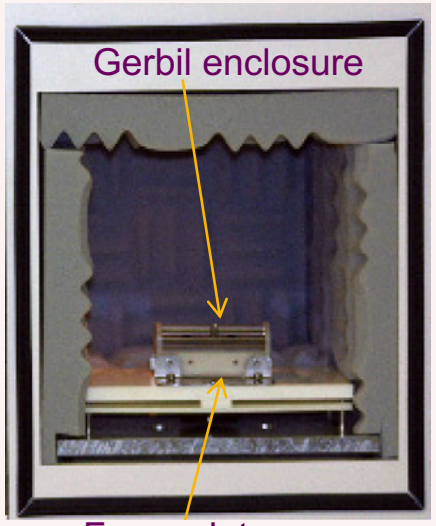


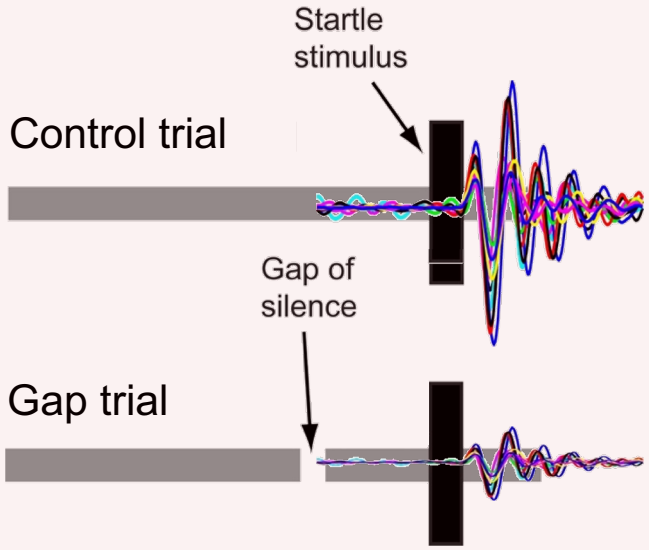
# Measuring perception and neural activity

mrosen@
neomed.edu

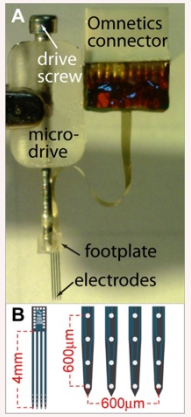
## Auditory perception:
*Operant conditioning*

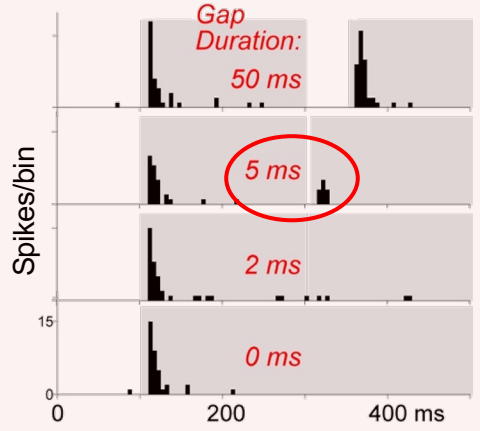
## Auditory perception:
*Attenuation of acoustic startle*



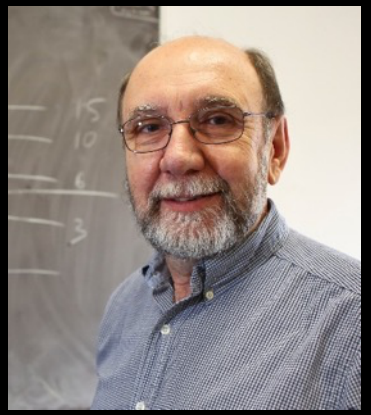

## Neural recordings:
*Awake or anesthetized, behaving or passive*



# Dr. Alex Galazyuk's Laboratory:

## Tinnitus, Age-Related Hearing



agalaz@neomed.edu

## Tinnitus

Brain mechanisms and treatment

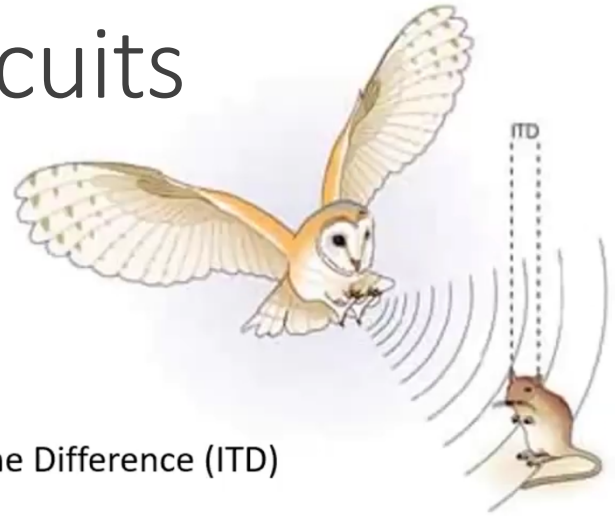
## Aging in bats?

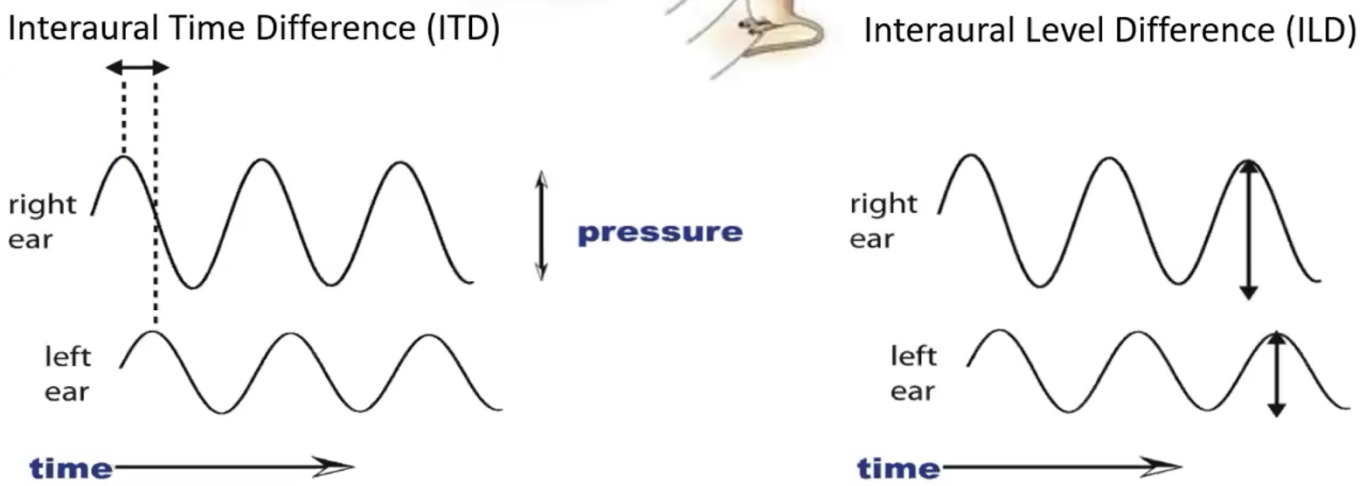
Bats live very long lives with minimal signs of aging!!!

# Dr. Bradley Winters' Laboratory:

## Cellular properties underlying sound localization circuits

bwinters@neomed.edu

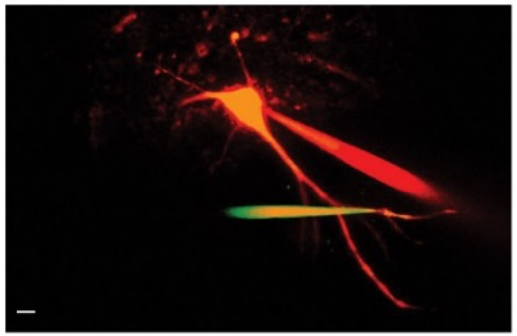


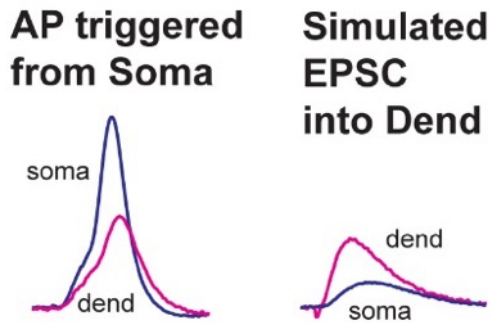




Grothe, 2003

# Dr. Bradley Winters' Laboratory:
## Cellular properties underlying sound localization circuits

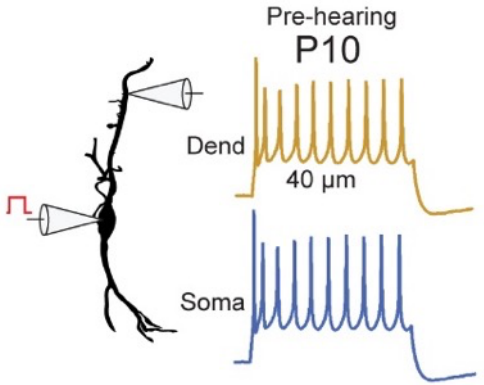
bwinters@neomed.edu

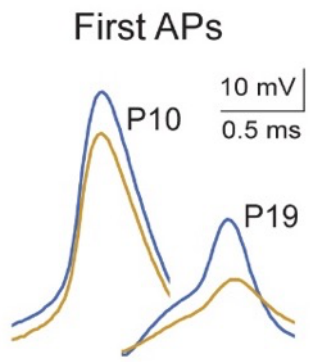


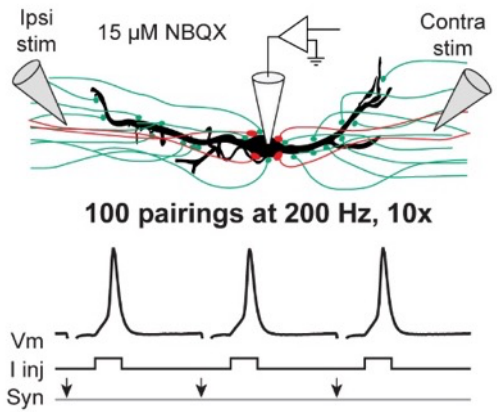


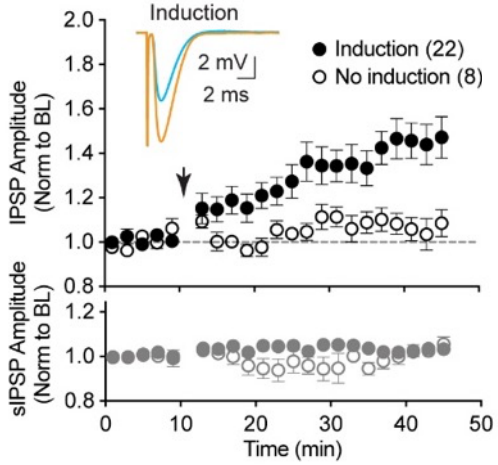






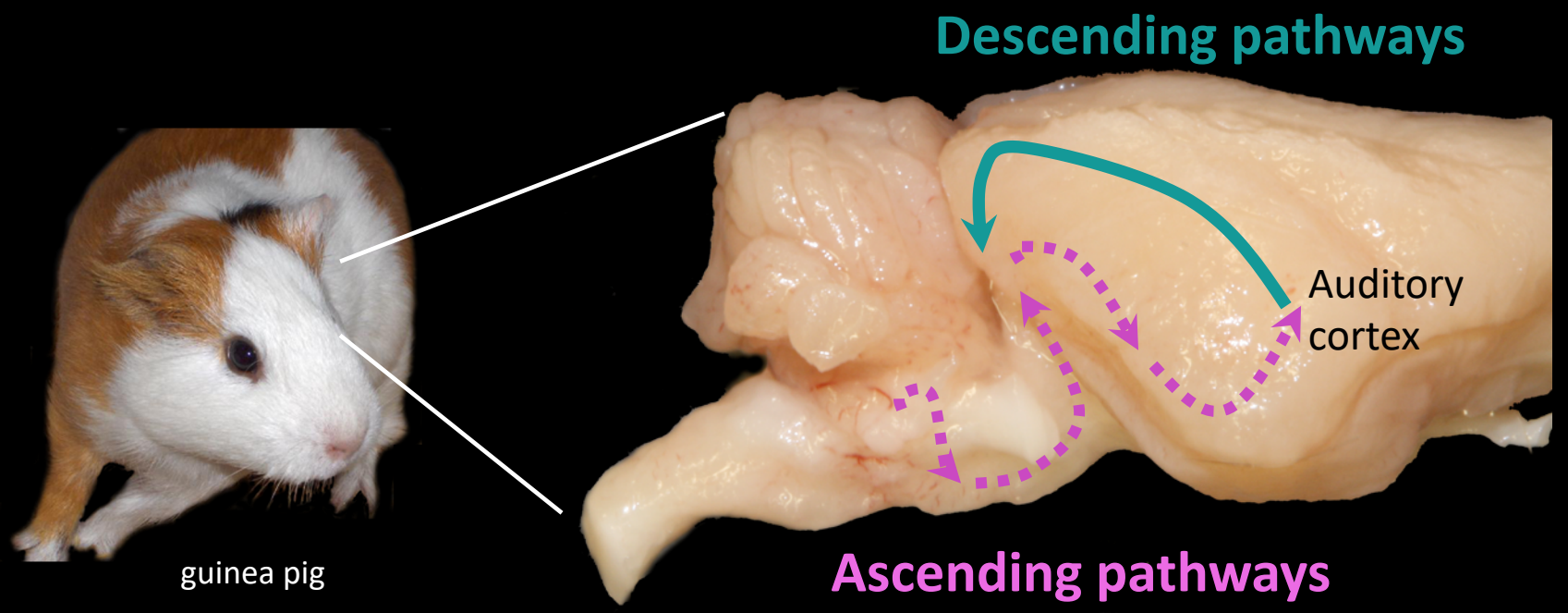



# Dr. Brett Schofield's Laboratory:
## Identifying brain circuits for the sense of hearing

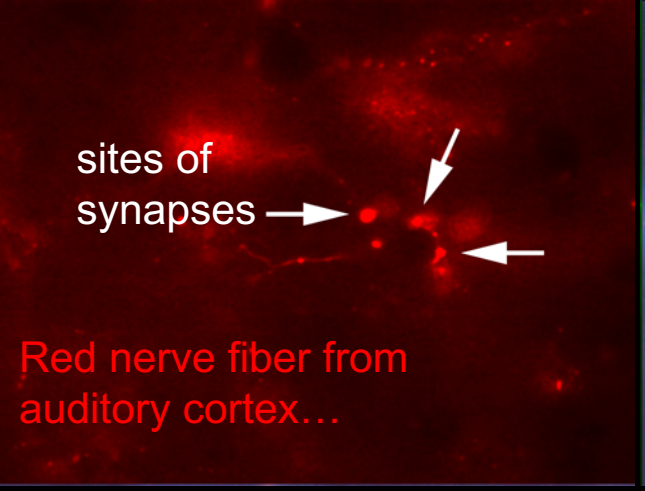
bschofie@neomed.edu



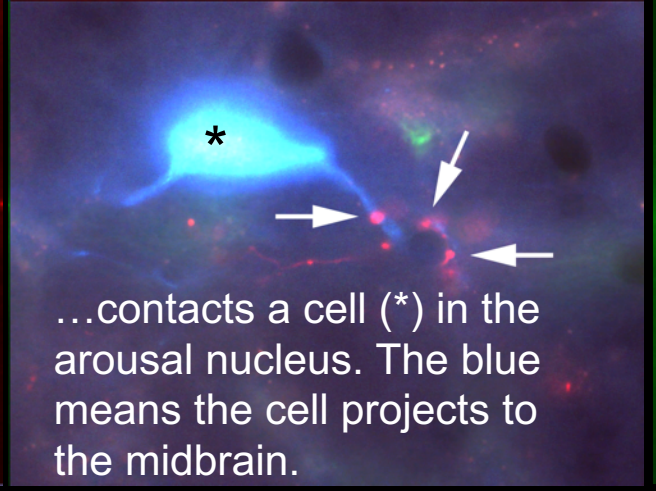

guinea pig

Ascending pathways carry information to the "top" – auditory cortex – for perception.

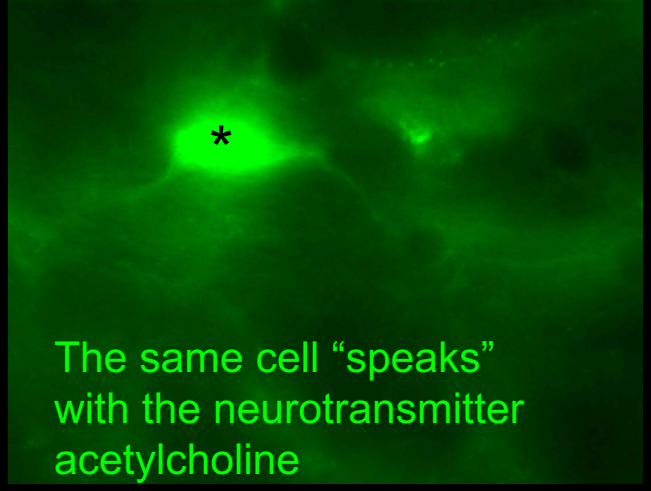
Our focus: how do descending pathways allow auditory cortex to control what we hear?




Red nerve fiber from auditory cortex…

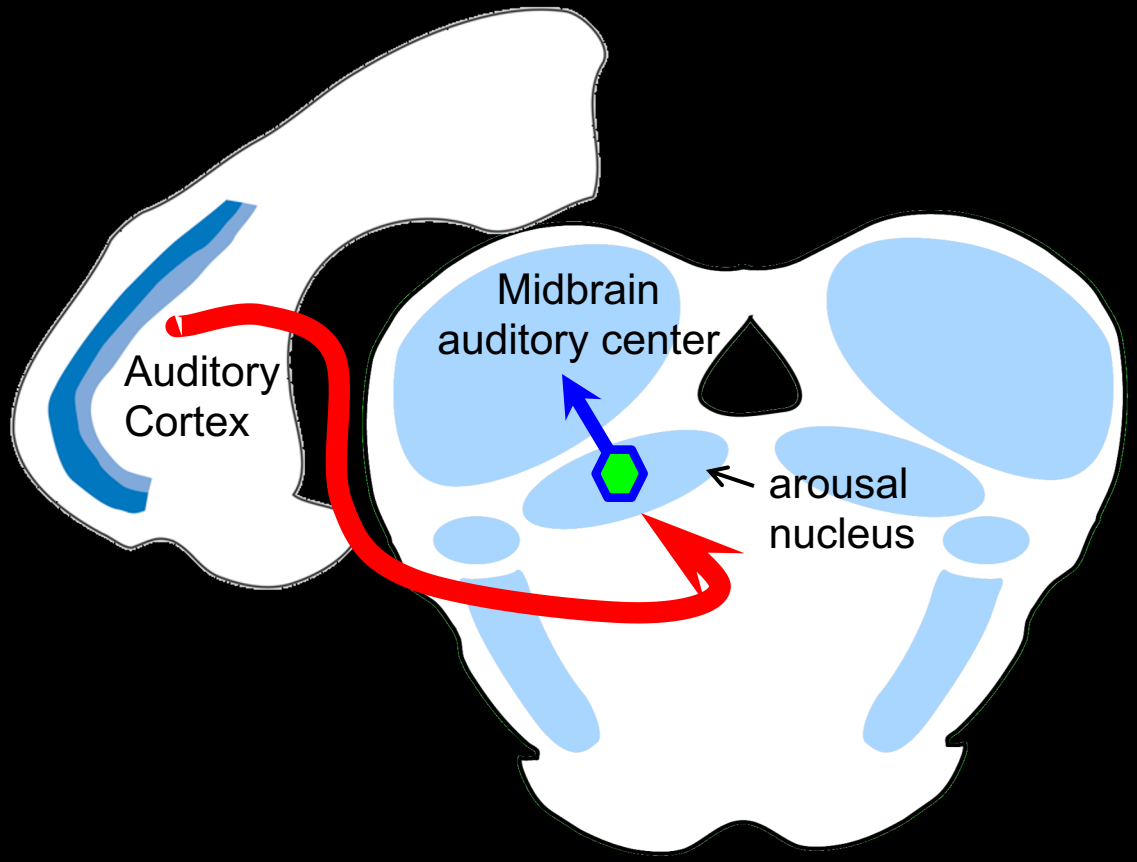



…contacts a cell (*) in the arousal nucleus. The blue means the cell projects to the midbrain.




The same cell “speaks” with the neurotransmitter acetylcholine

bschofie@neomed.edu




Schofield lab

# Dr. Bruna Mussoi's Laboratory: Hearing and Aging Lab

bmussoi@kent.edu

Premise: Older adults have more difficulty understanding speech in background noise, even without hearing loss.

Goals:

- To understand factors that contribute to difficulty with speech understanding in noise
- To explore factors that may counteract age-related difficulty with speech in noise

Methods:

- Behavioral and auditory electrophysiology testing
- Participants: human listeners with normal hearing or hearing loss; cochlear implant users

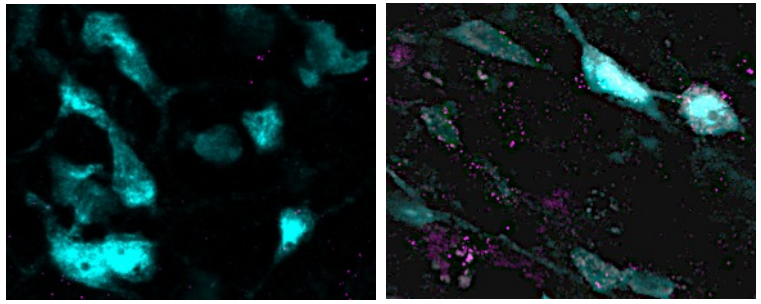
# Dr. Jeffrey Mellott's Laboratory:

## Neurotransmitter Changes in the Auditory System during Age-Related Hearing Loss

jmellott@neomed.edu

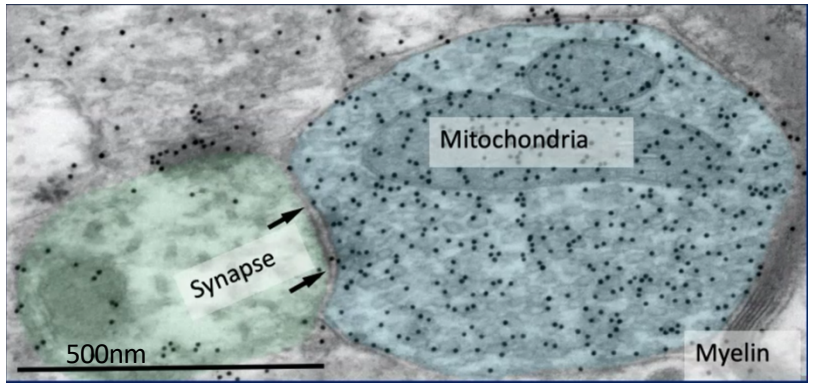
We use fluorescent immunohistochemistry…

**3 mo** **21 mo**



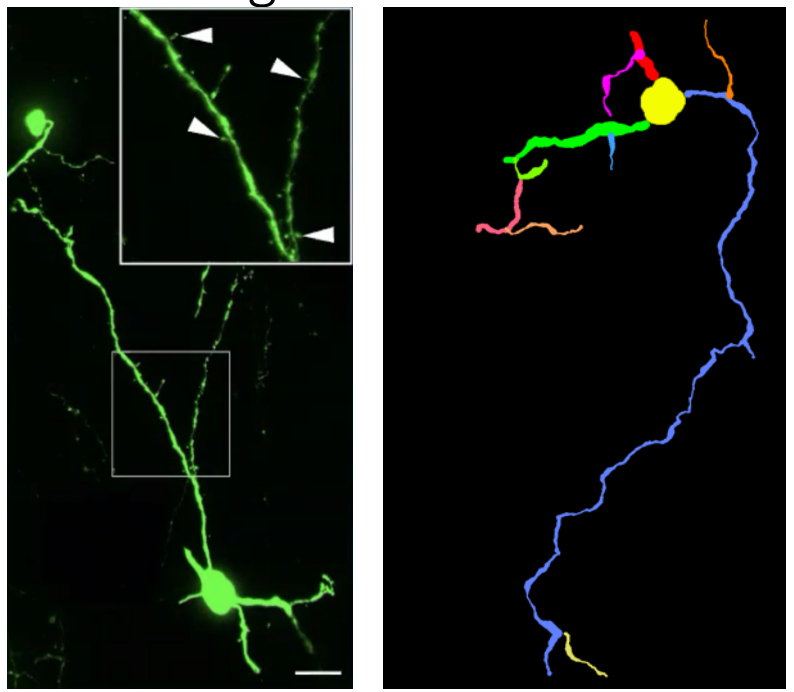
…to visualize changes in specific receptor subunits (magenta) that compensate for loss of neurotransmitters

Immuno electron microscopy…




…to visualize GABAergic synapses

Tract-tracing and reconstruction…

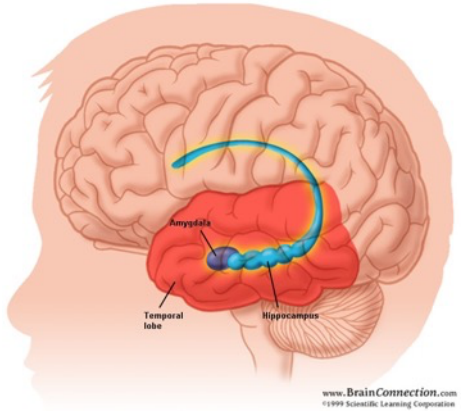


…to visualize changes in GABAergic input with age

# Dr. Jeffrey Wenstrup's Laboratory:
## Acoustic Communication and Emotions

jjw@neomed.edu

**The Rationale:**
The amygdala orchestrates emotional responses to sounds, e.g. speech




**Our Goal:**
- To understand how the amygdala contributes to acoustic communication
- To develop an understanding of brain mechanisms in psychological disorders that contribute to an altered emotional response to speech

**Our approach:**
Describe the acoustic features of social vocalizations
Relate the acoustics to internal state and behavioral contexts
Examine how amygdalar neurons respond to these signals across contexts

Big Brown Bat (*Eptesicus fuscus*)

CBA-CaJ Mouse

# Dr. Jianxin Bao's Laboratory:
## Hearing Loss and Tinnitus

jbao@neomed.edu

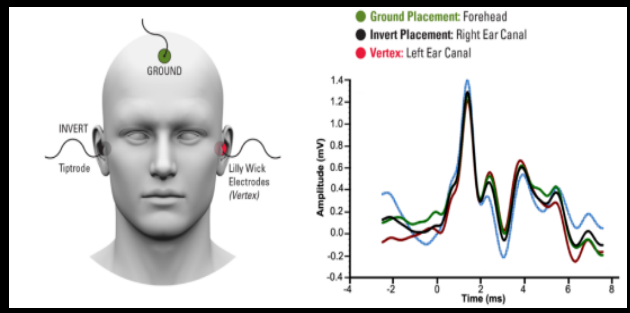
**Translational Research**

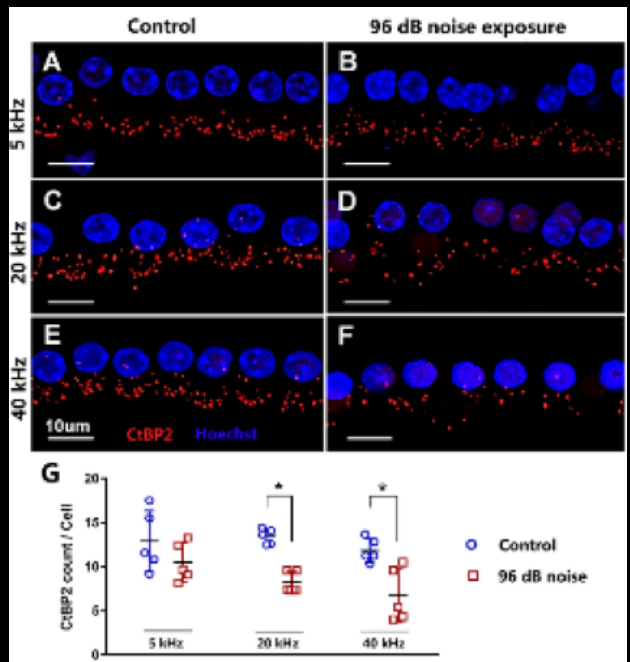
- **Tinnitus**
  - Novel tinnitus detection methods
  - Molecular markers
- **Hearing loss**
  - Functional assessments
  - Molecular markers

**Clinical Research**

- **Hearing loss**
  - Hidden hearing loss
  - Pharmacogenetics of Presbycusis

Auditory Brainstem Response

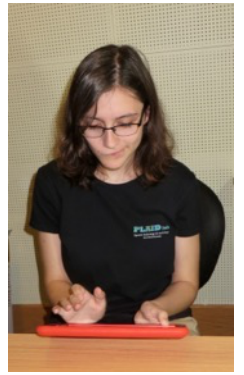


# Dr. Julia Huyck's Laboratory:
## Perception, Learning, and Individual Differences (PLAID)

jhuyck@kent.edu

- Located at Kent State University (Speech Pathology and Audiology)
- Examine how adolescents and young adults perceive, and learn to perceive, speech and other sounds.
- Perform cognitive testing to better understand how cognition affects auditory processing

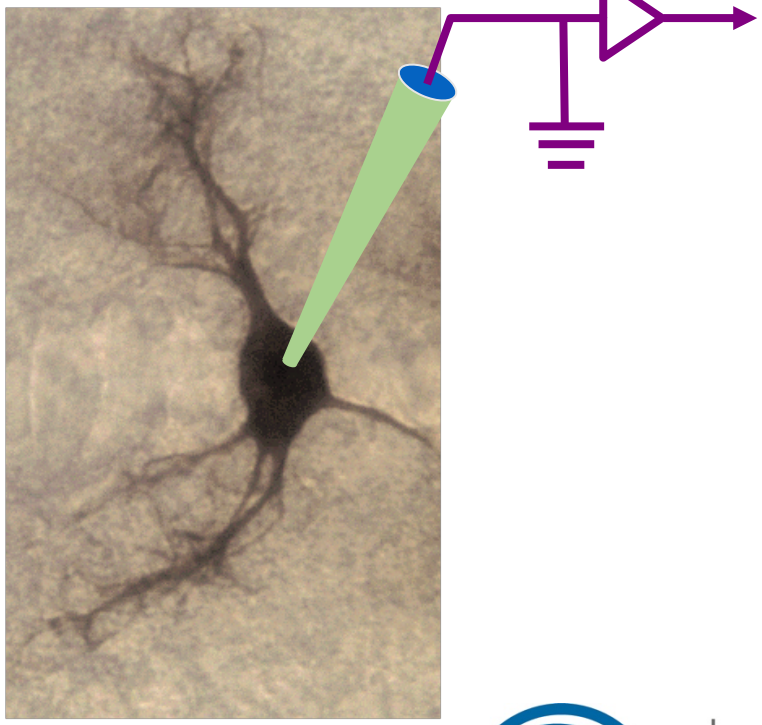


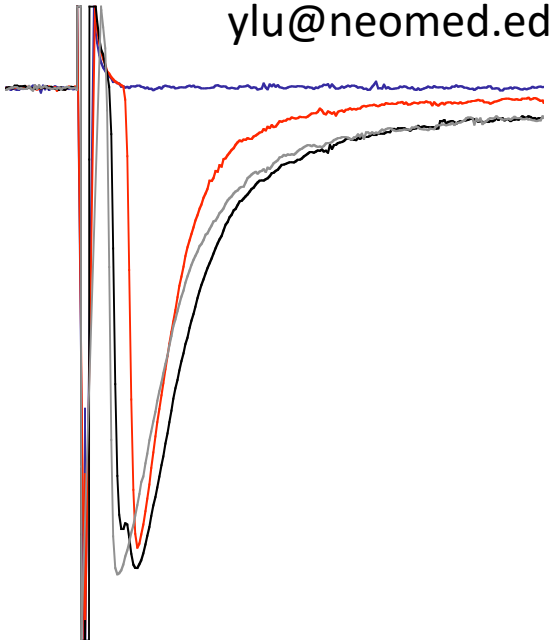
# Dr. Yong Lu's Laboratory:
## Cellular Mechanisms of Auditory Processing

ylu@neomed.edu

Research Interests:
- Cellular mechanisms of sound localization
- Development of auditory circuits
- Plasticity of auditory neurons in brain diseases

Research Methods:
- in vitro electrophysiology
- optical imaging
- immunohistochemistry





# Opportunities for Neuroscience-Related Hearing Research at NEOMED

**Email any of us** (addresses on each of our slides)
to learn more about our research opportunities

## Hearing Research Group

https://www.neomed.edu/research/hearing/

Follow us on Twitter (**@NEOMEDHearing**) or
FaceBook (**Northeast Ohio Medical University Hearing Research**)