Hearing and the Brain:

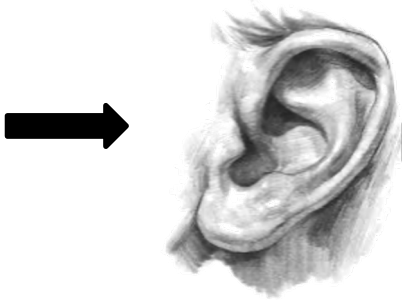
Making Sense of Sound and Hearing Loss

David K. Ryugo, PhD

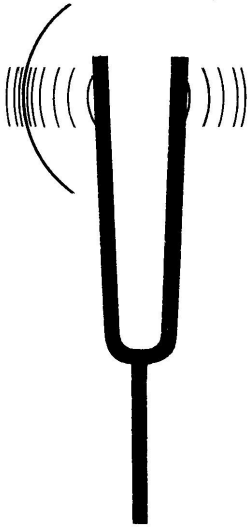
Garvan Institute of Medical Research
Sydney, NSW, Australia

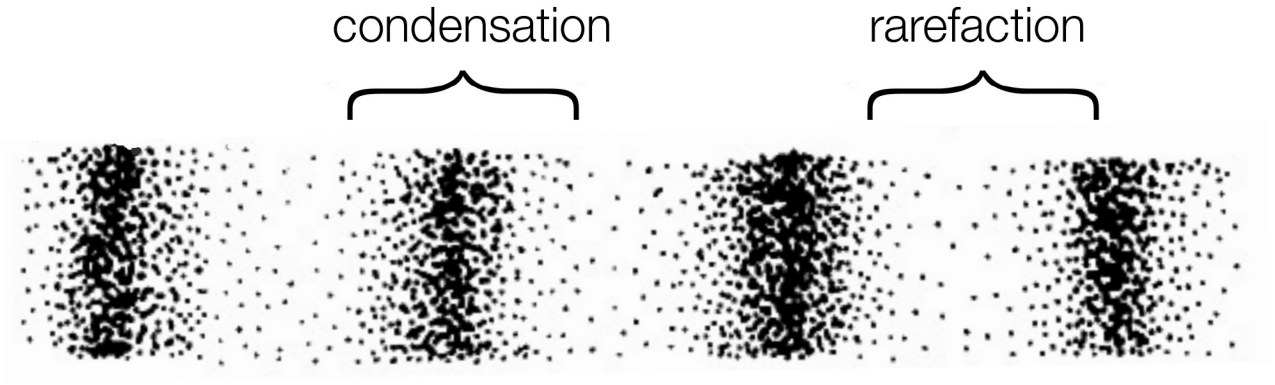
School of Medical Sciences
University of New South Wales
Sydney, NSW, Australia

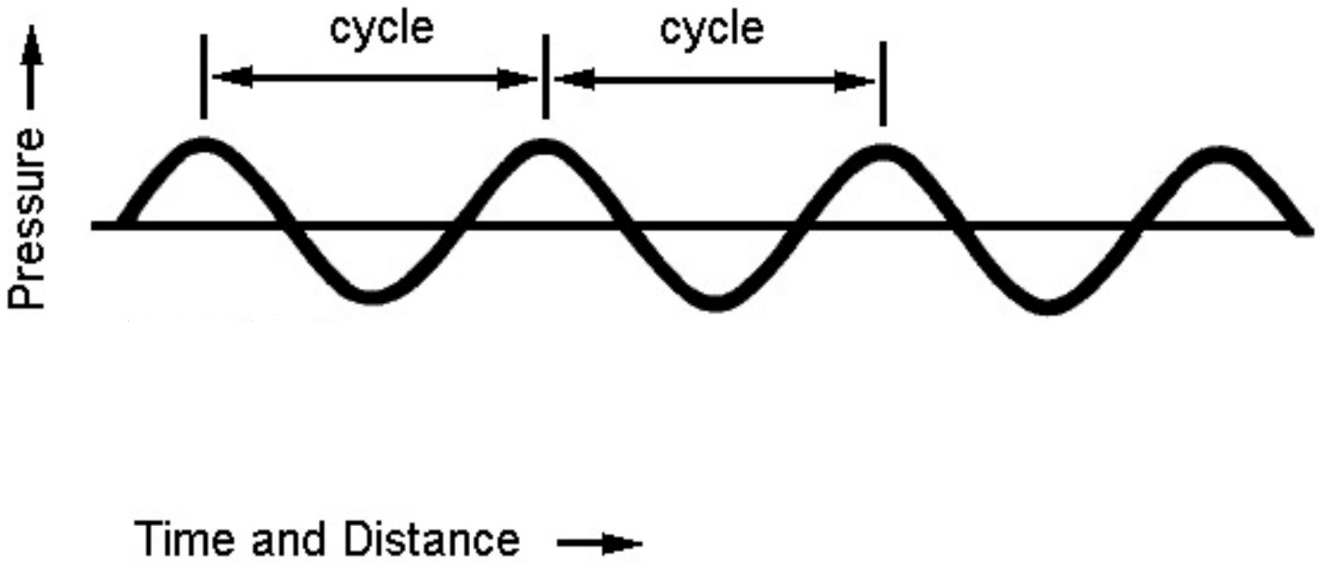
The Miracle of Hearing



Sound = Vibrations in air

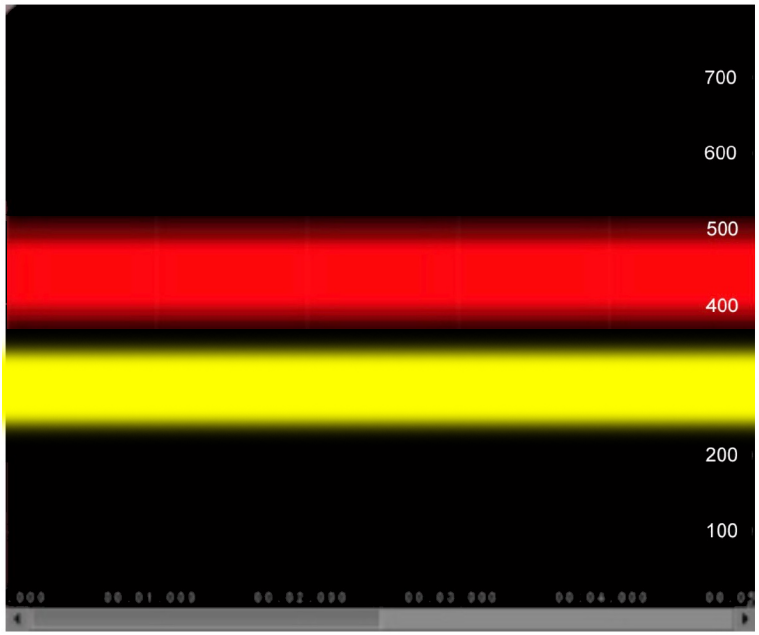






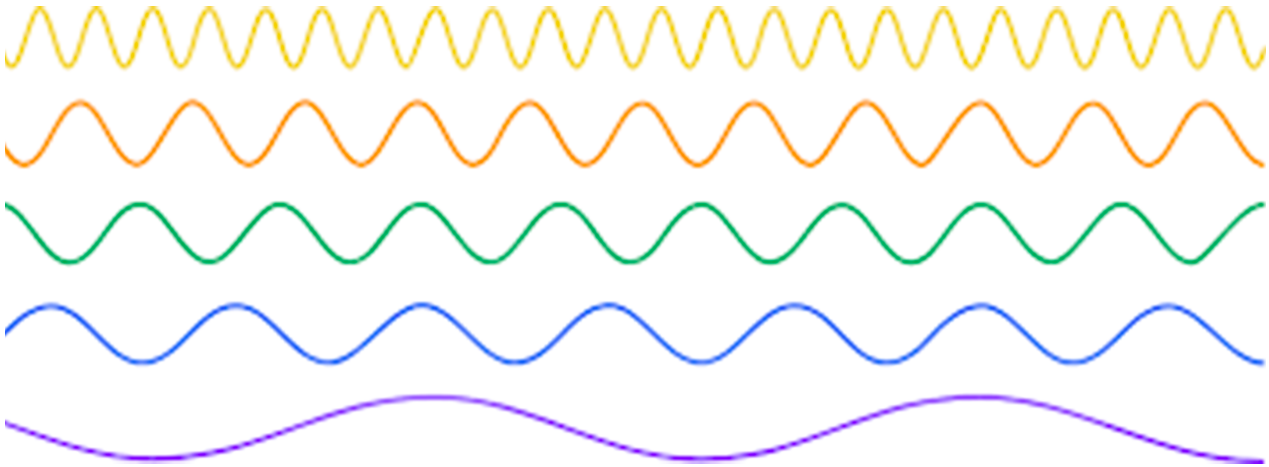
A

440 Hz = “A”



Middle C

Middle C



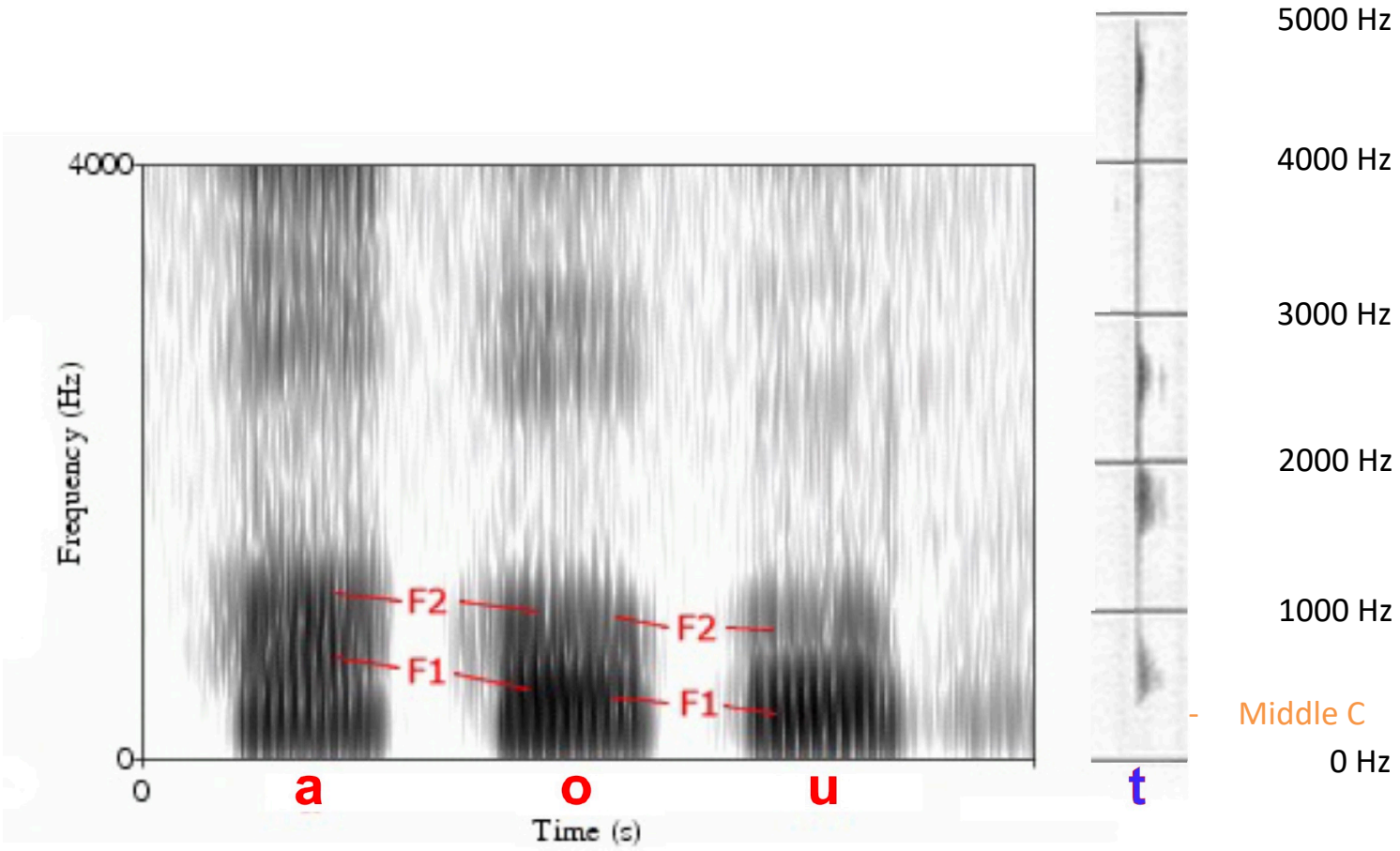
Time

High Frequency

Low Frequency

Sound is analyzed by its frequency composition, and this is shown by a spectrogram.

consonants = high frequencies



vowel sounds = low frequencies

Frequency and Conversational Speech

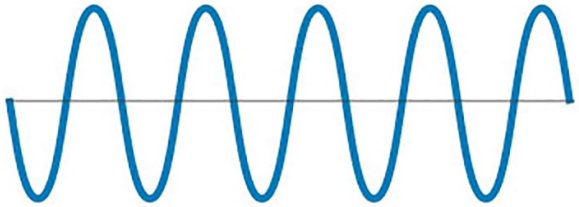
Meniere's Hearing Loss

Most Speech, esp Vowels

Treble: consonants, the "ssss" sounds

Sound has Energy or Loudness

High Volume
(more air pressure)



Low Volume
(less air pressure)

Softest sound heard	0 dB
Whisper in library	30 dB
Normal conversation	60-70 dB
Telephone dial tone	80 dB
Sydney train arriving at station	90 dB
iPod, 80% maximum loudness	95 dB
Power mower	100 dB
Chain saw, motorcycle	110 dB
Pain begins	120 dB

} Danger

Sound has important timing features

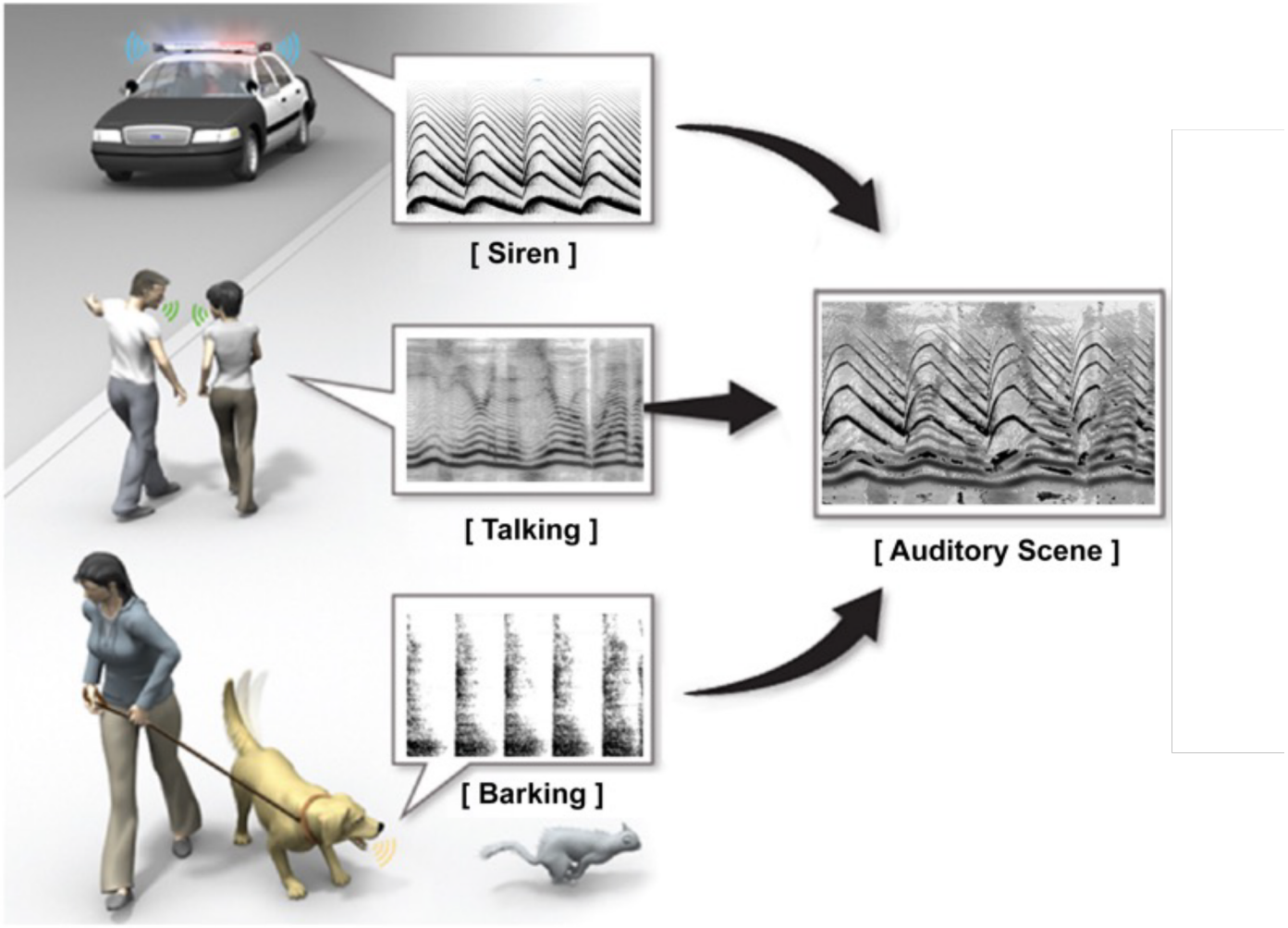
(onset, offset, duration, change)

Rhythm: dot dot dot dash dash dash dot dot dot

Melody: 

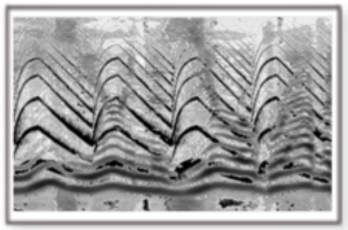
Prosody: “Inventory” **In**’ ven tor ee versus In **vent**’ tor ee

Sound in the real world



Sound in the real world

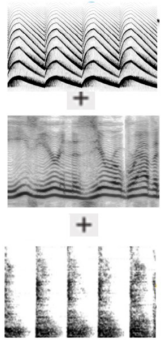
Delivered to the Brain



[Auditory Scene]

Processed by the Brain

Perception



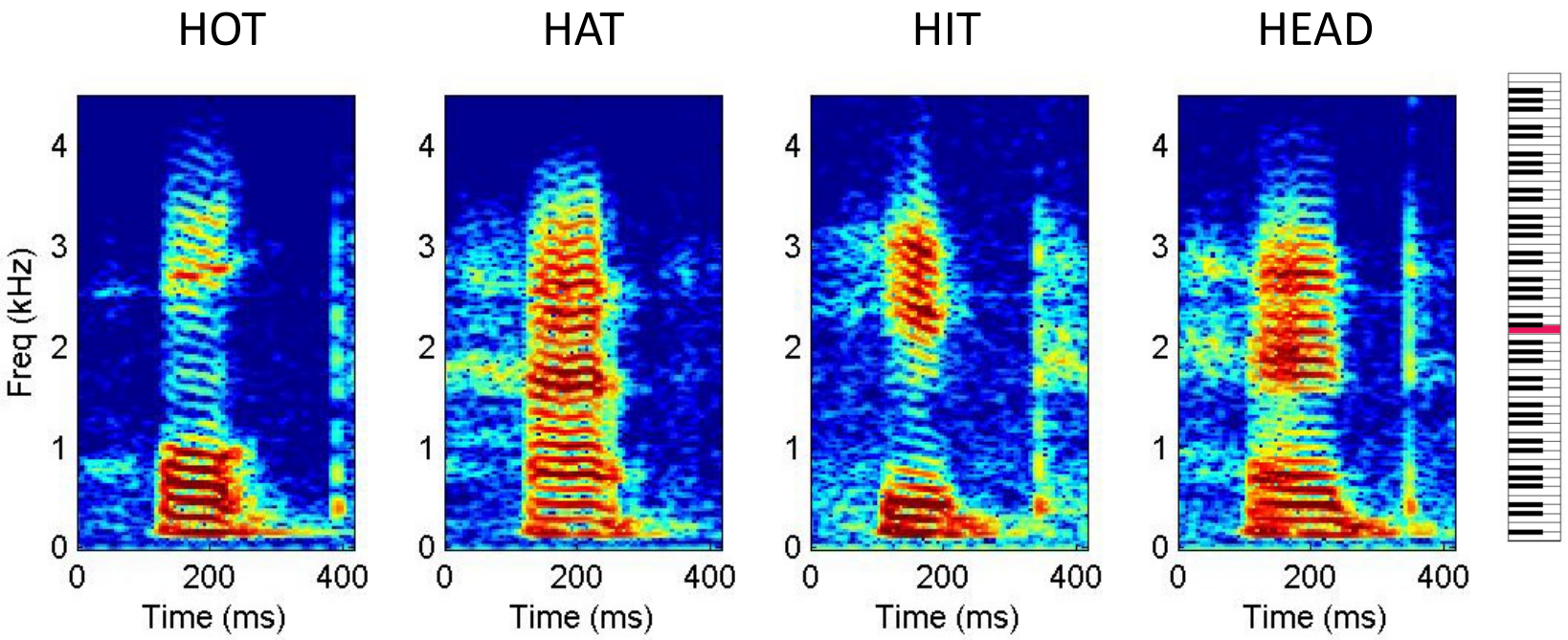
[Siren]

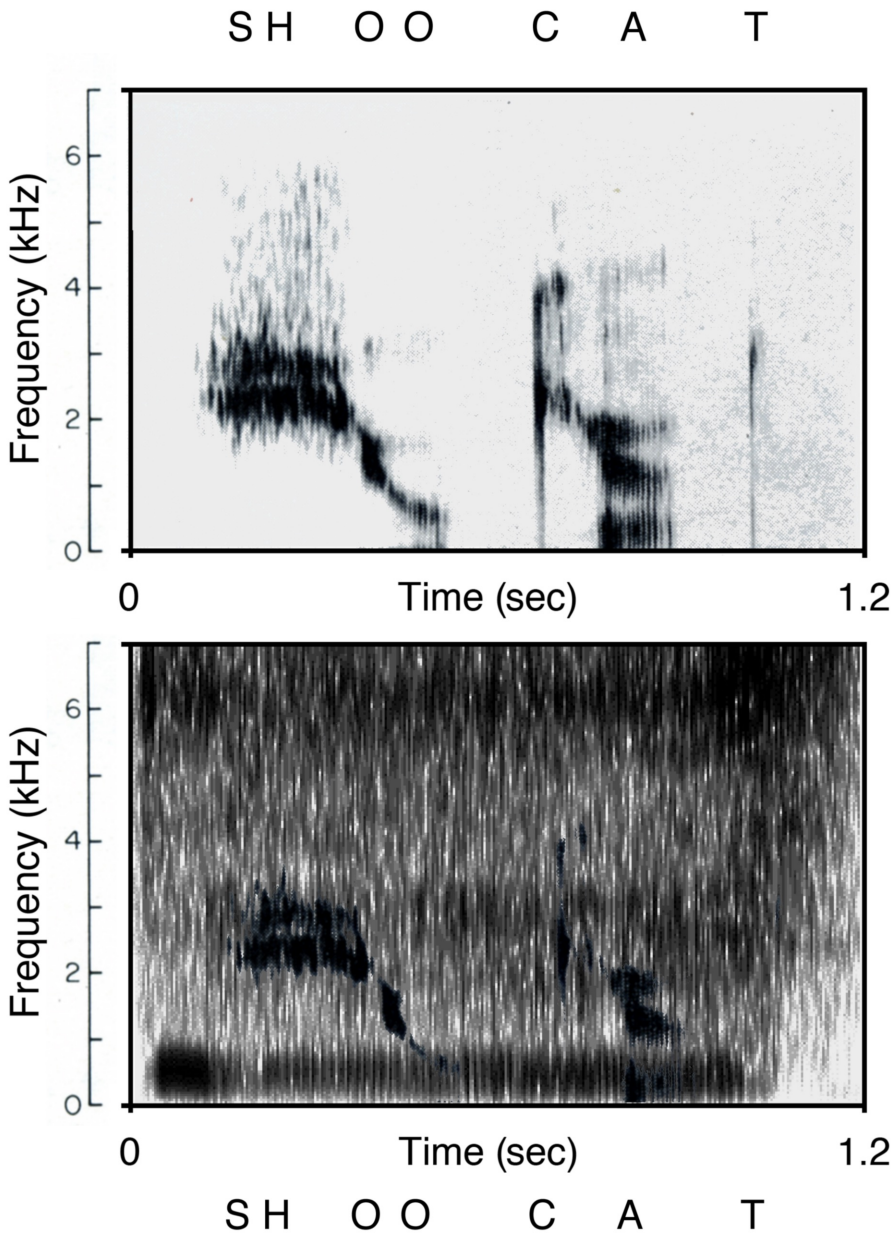
[Talking]

[Barking]

Spectrogram of Common Words

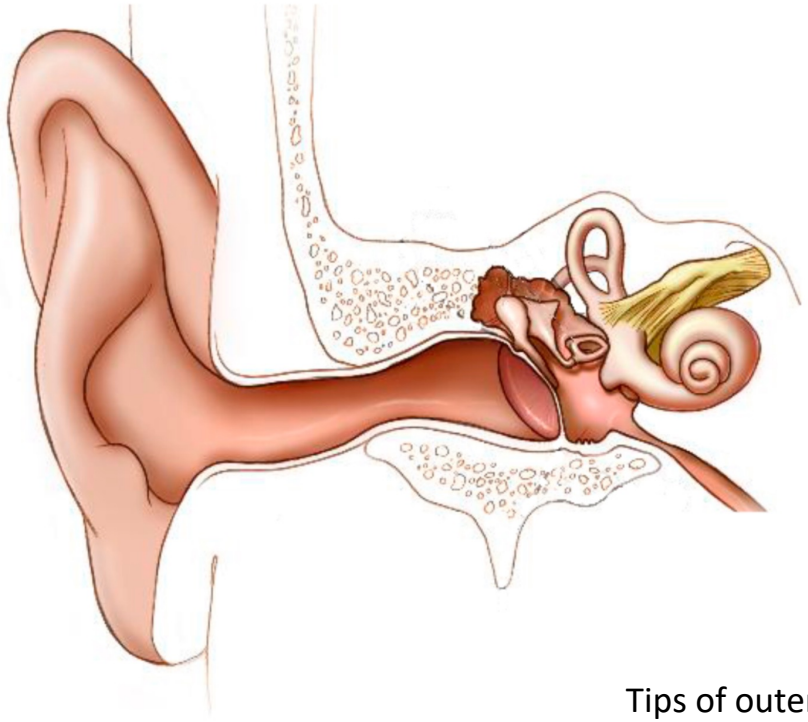
Different Sounds are made of different frequency combinations

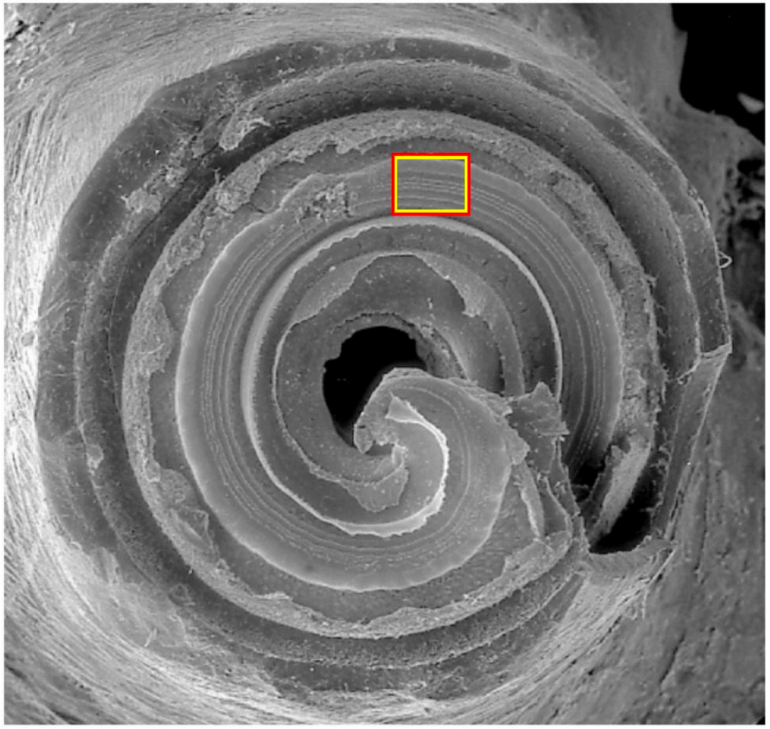




Spoken in quiet

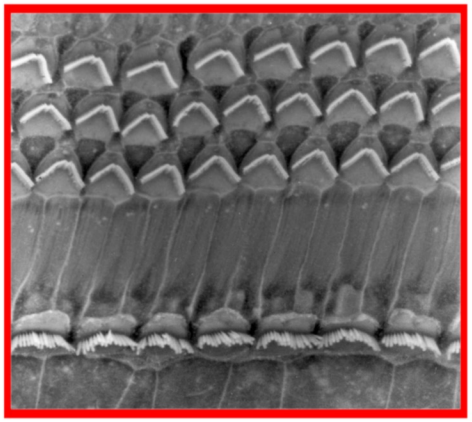
Spoken in noise

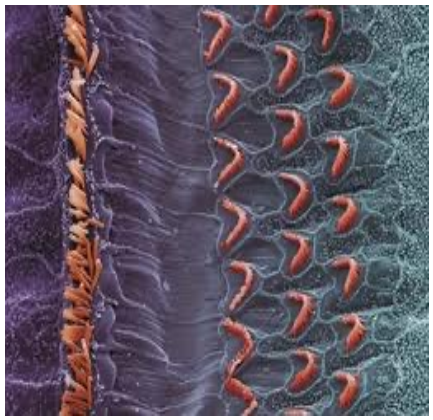


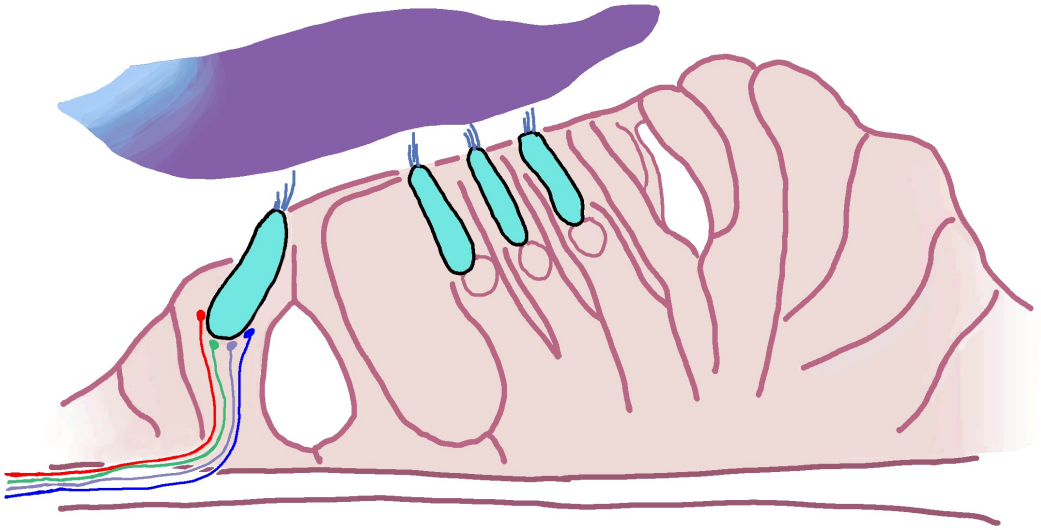


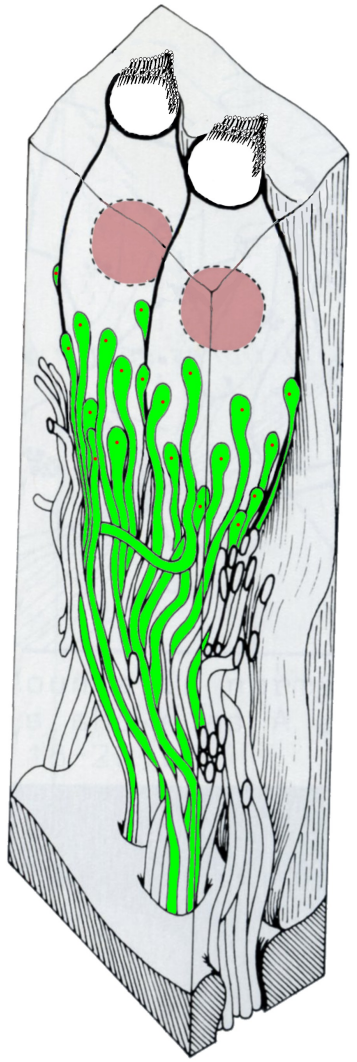
Tips of outer hair cells

Tips of inner hair cells

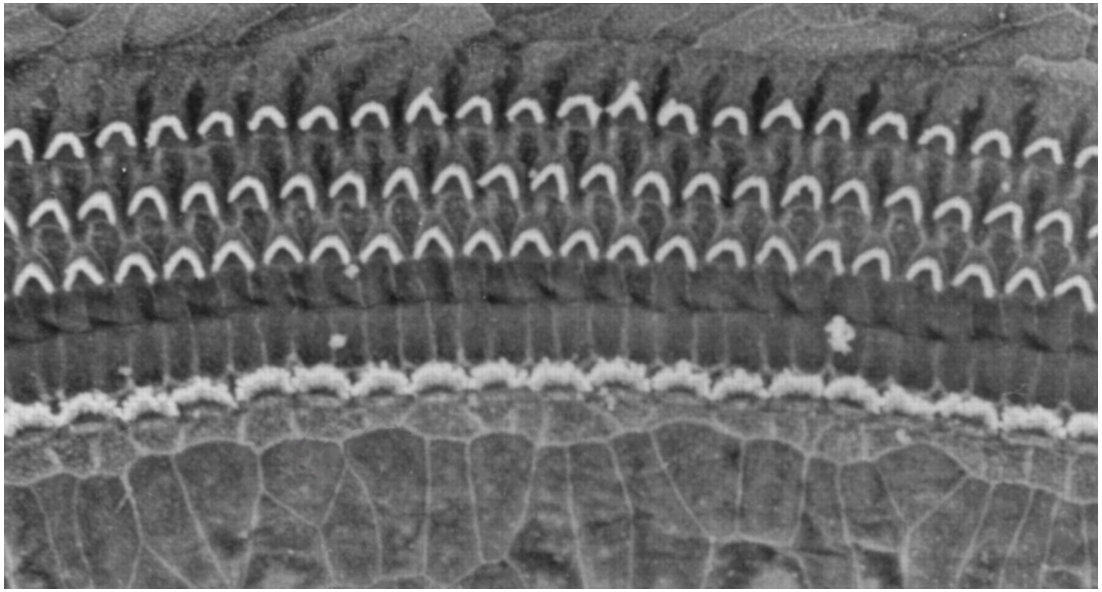




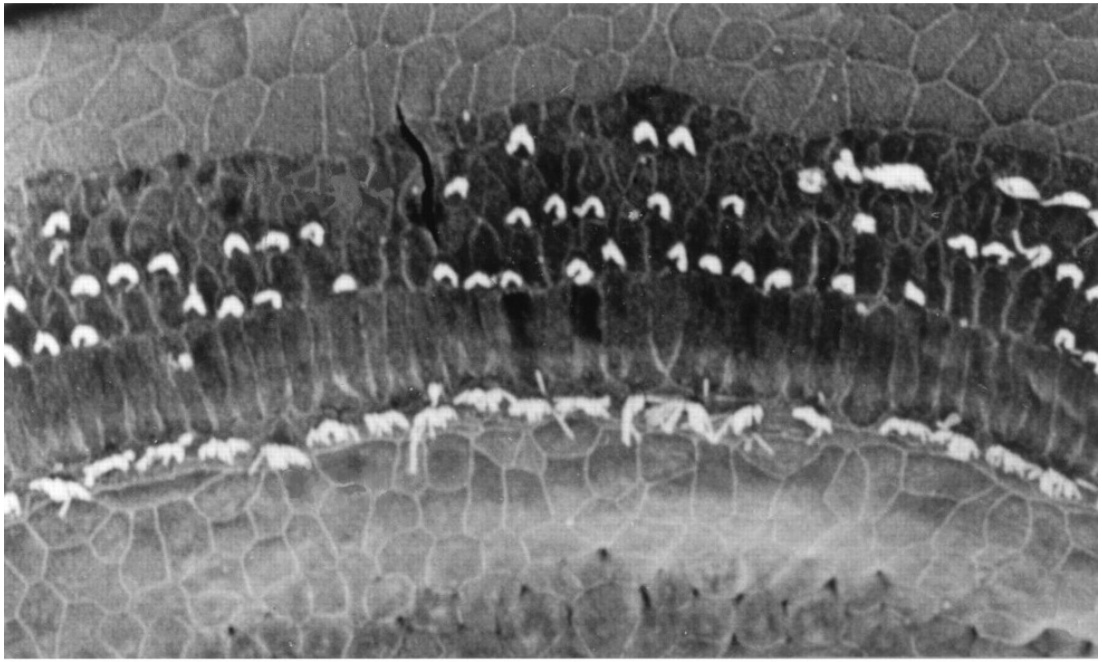




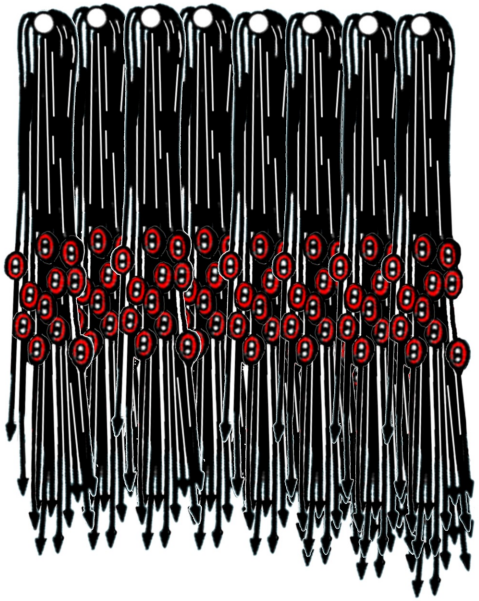
Normal Sensory Cells



Damaged Sensory Cells



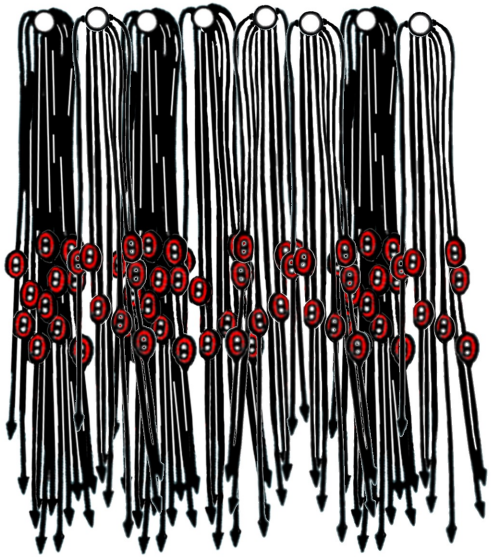
Normal

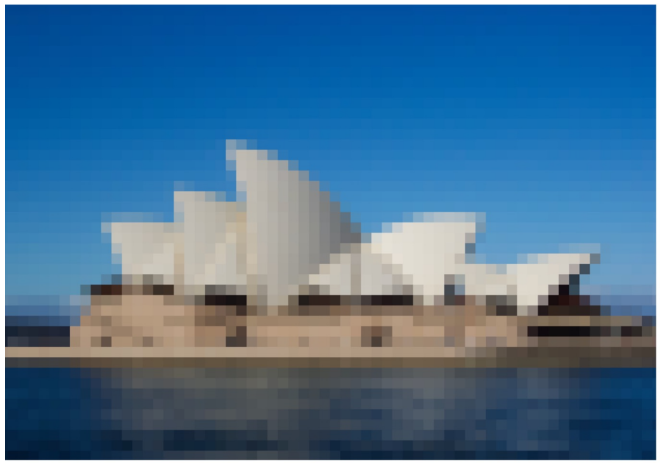


IHCs

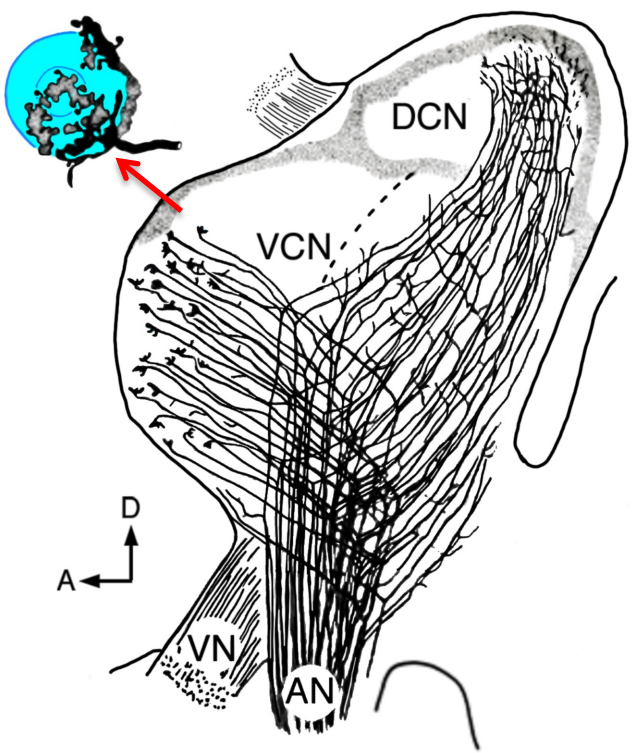
Auditory Nerve

Hearing Loss

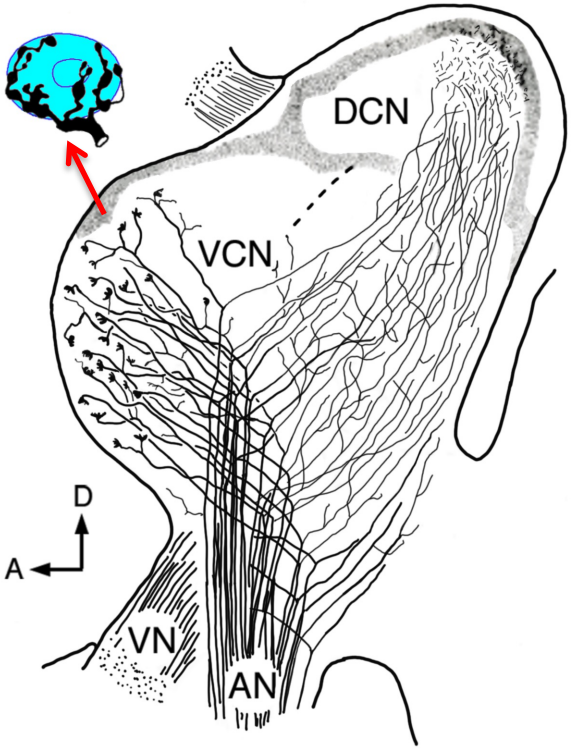




Changes in Auditory Nerve Input after Hearing Loss



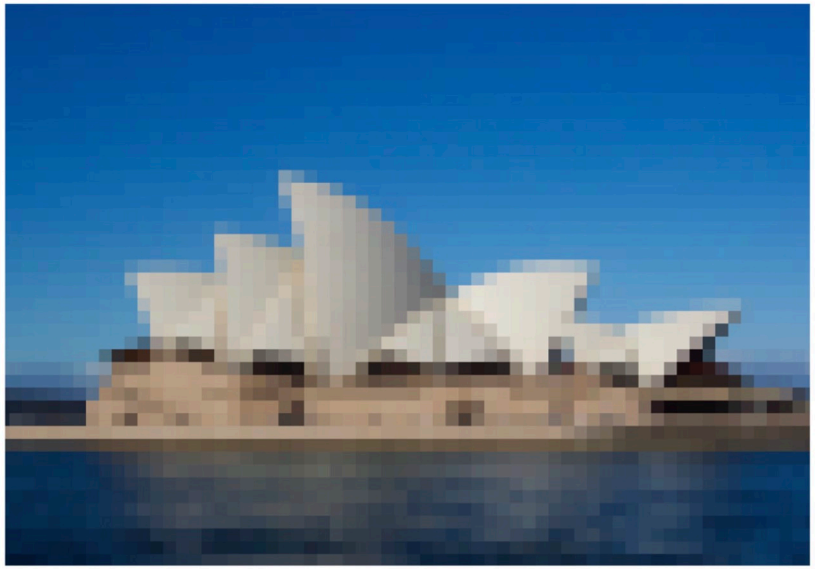
Normal Hearing



Hearing Loss

Normal

Pixelated



Loss of sharpness
Loss of detail

Summary

Three Components of Sound

- Frequency
  Different sounds are composed of different combinations of frequencies
- Loudness
  Sound pressure varies from very low to extremely high
  Sound exposure is cumulative like radiation – too much is harmful
- Timing
  Sound has onset, offset, duration, rhythm

Symptoms of Hearing loss

(caused by brain changes)

- Difficulty understanding speech in noise
- Appearance of phantom sounds (tinnitus)
- Distortions of loudness (hyperacusis)

“Use it or Lose it”

If you think you have hearing loss, go to your audiologist and have your hearing tested. If you have hearing loss and don’t attend to it, the loss will get worse and you risk social isolation and cognitive loss.

Hearing Research Laboratory—Garvan Institute

Bella Williams

Kiera Grierson

Tan Pongstaporn

David Ryugo

Anastasia Filimontseva