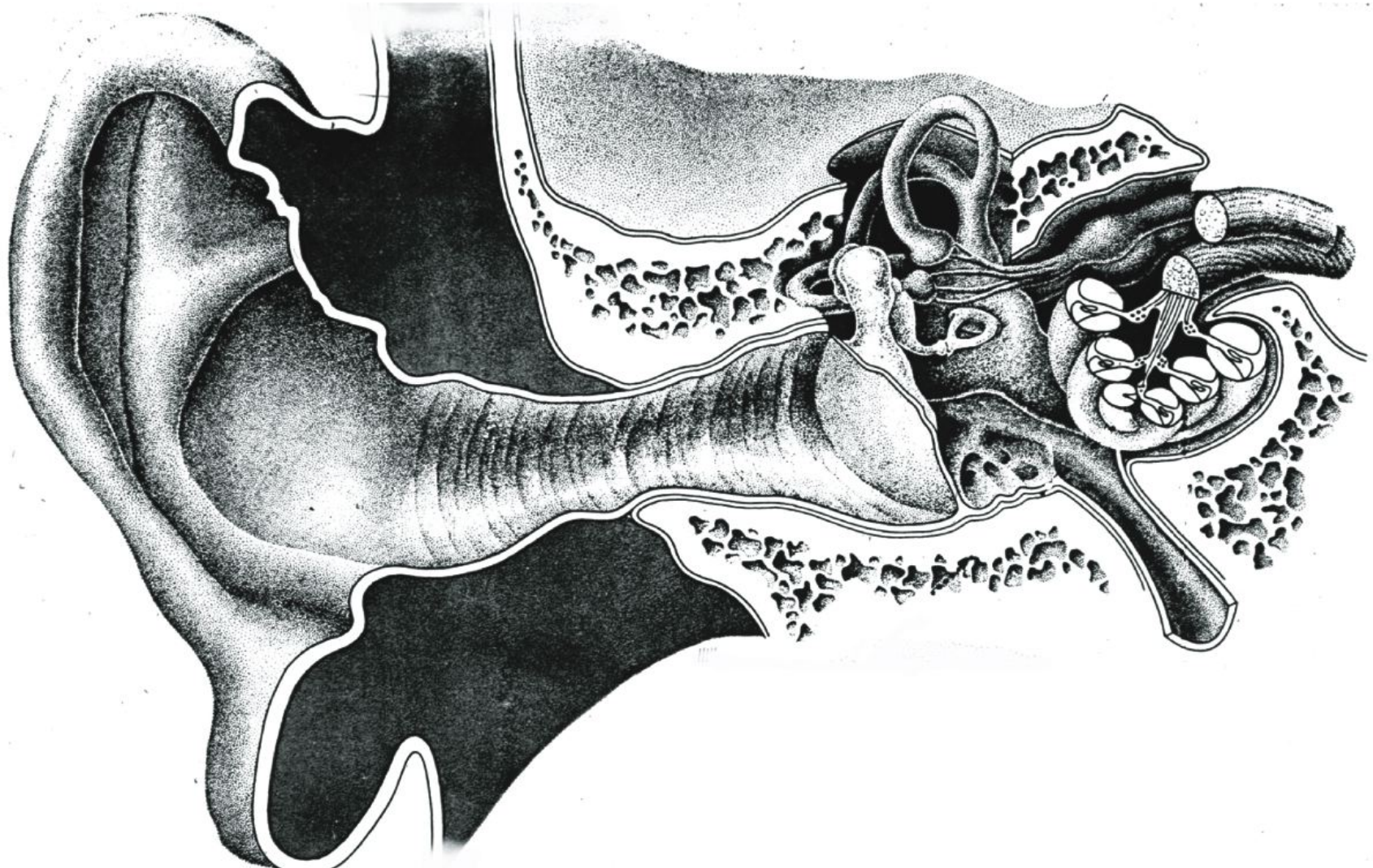




Dynamics of auditory hair cells

Christopher Bergevin (York University, Dept. of Physics & Astronomy)

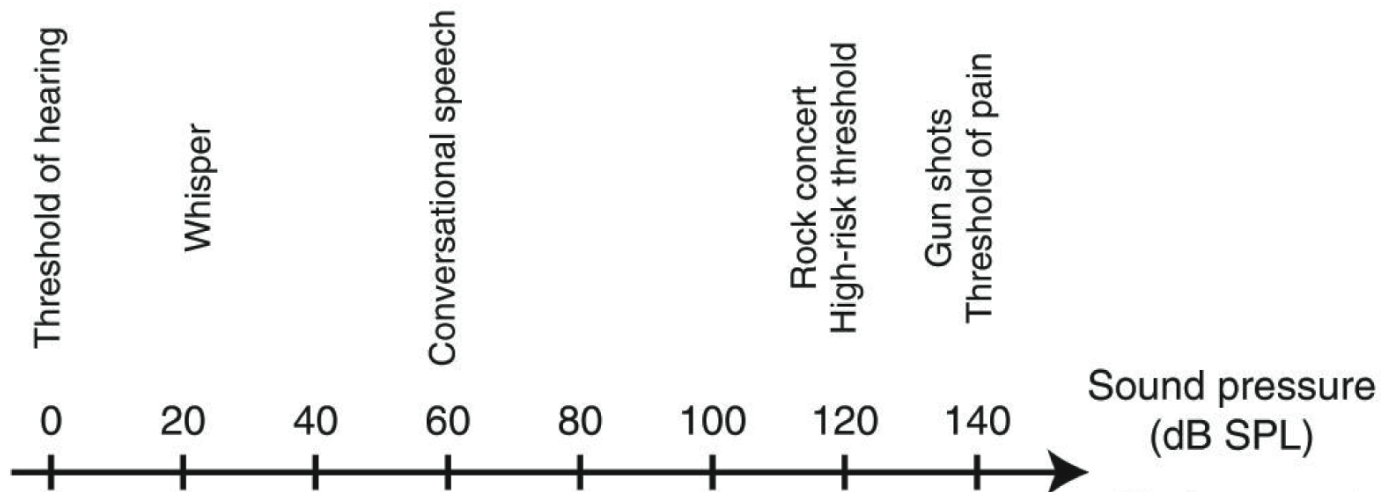
Cell Dynamics Workshop (2014)



A. Greene

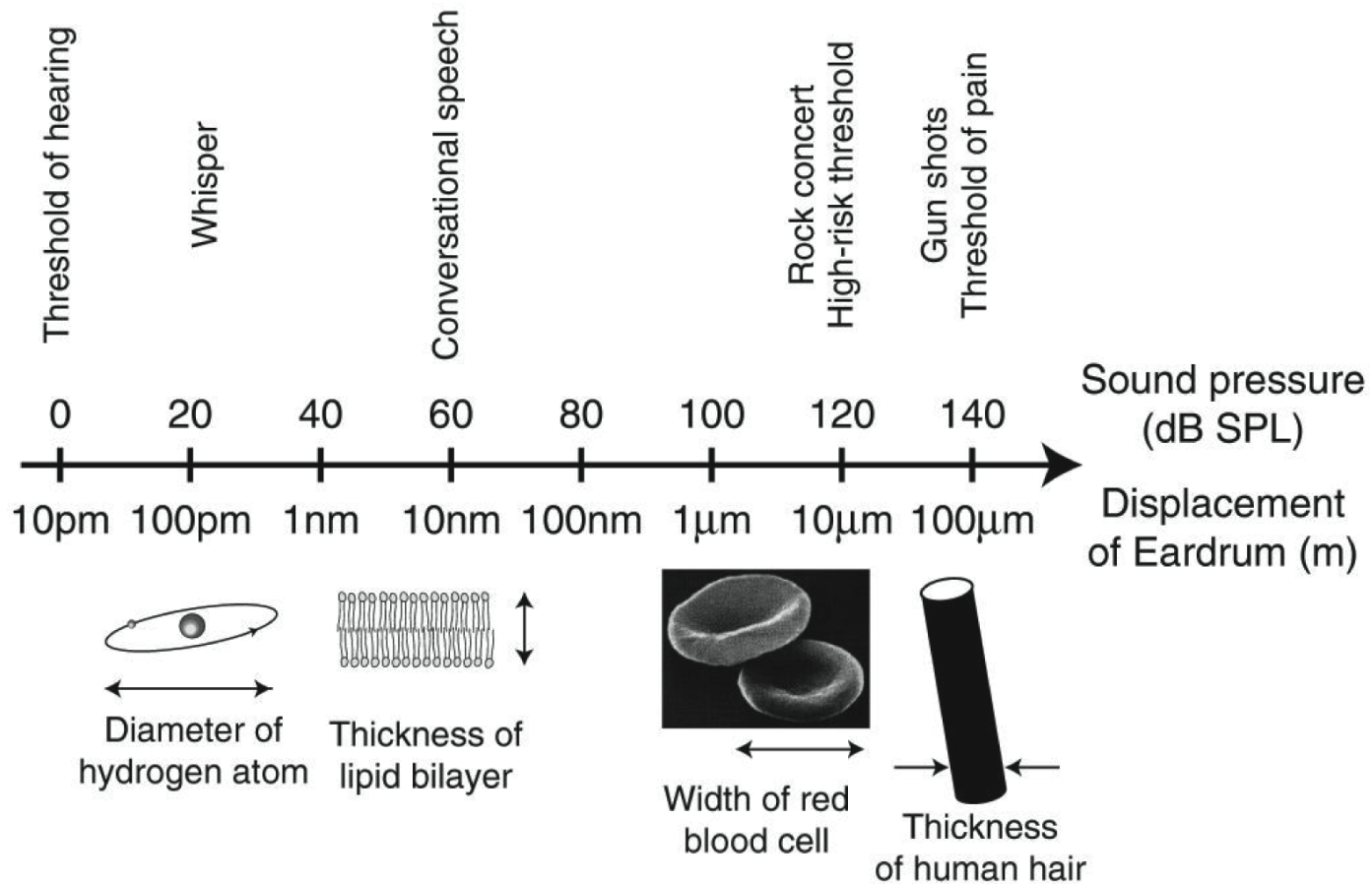
Dynamic Range

Humans hear over a pressure range of 120 dB [that's a factor of a *million*]



Dynamic Range

Humans hear over a pressure range of 120 dB [that's a factor of a *million*]





→ Ear actually **EMITS** sound!

otoacoustic emissions – OAEs

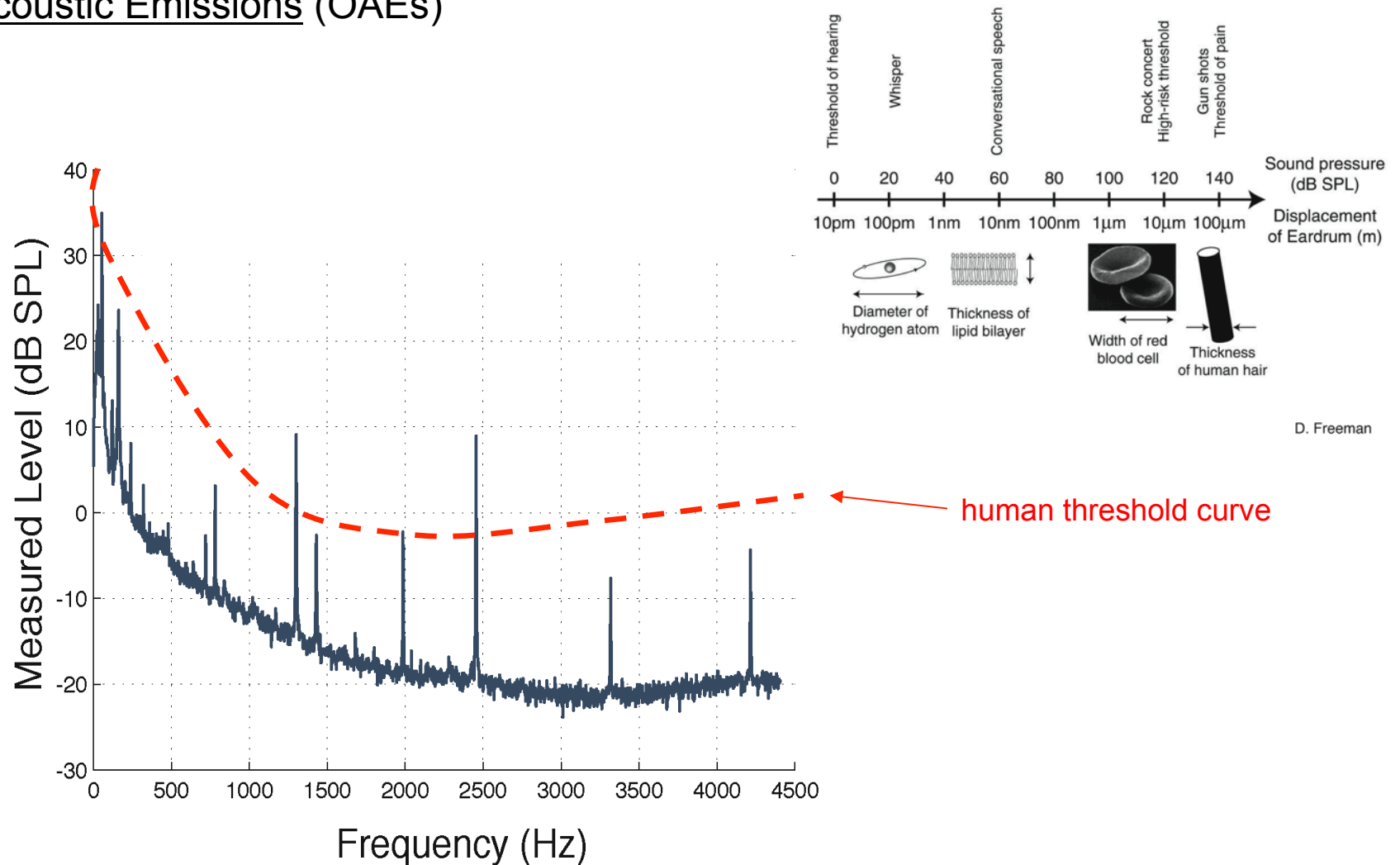


→ OAEs used for newborn hearing screening (only healthy ears emit)

→ Much faster/easier than evoked electrical potentials

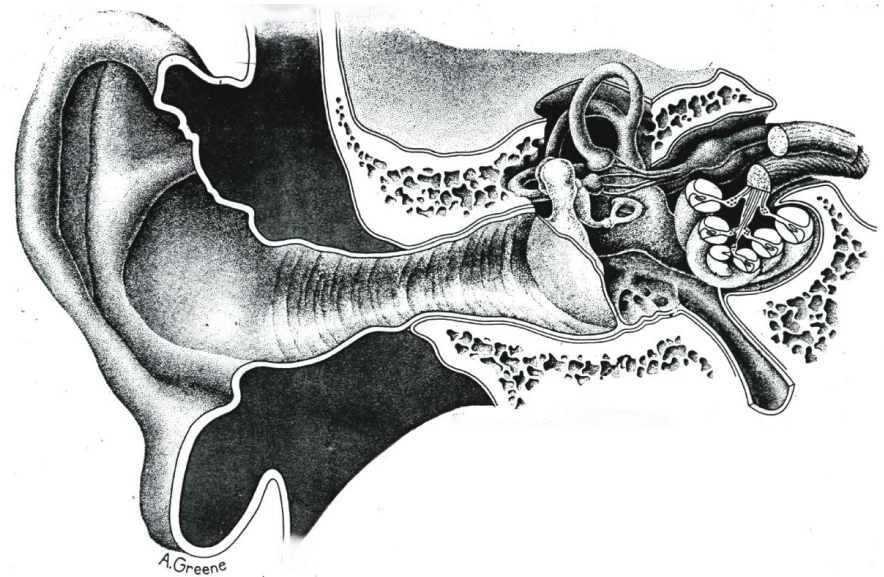


Otoacoustic Emissions (OAEs)

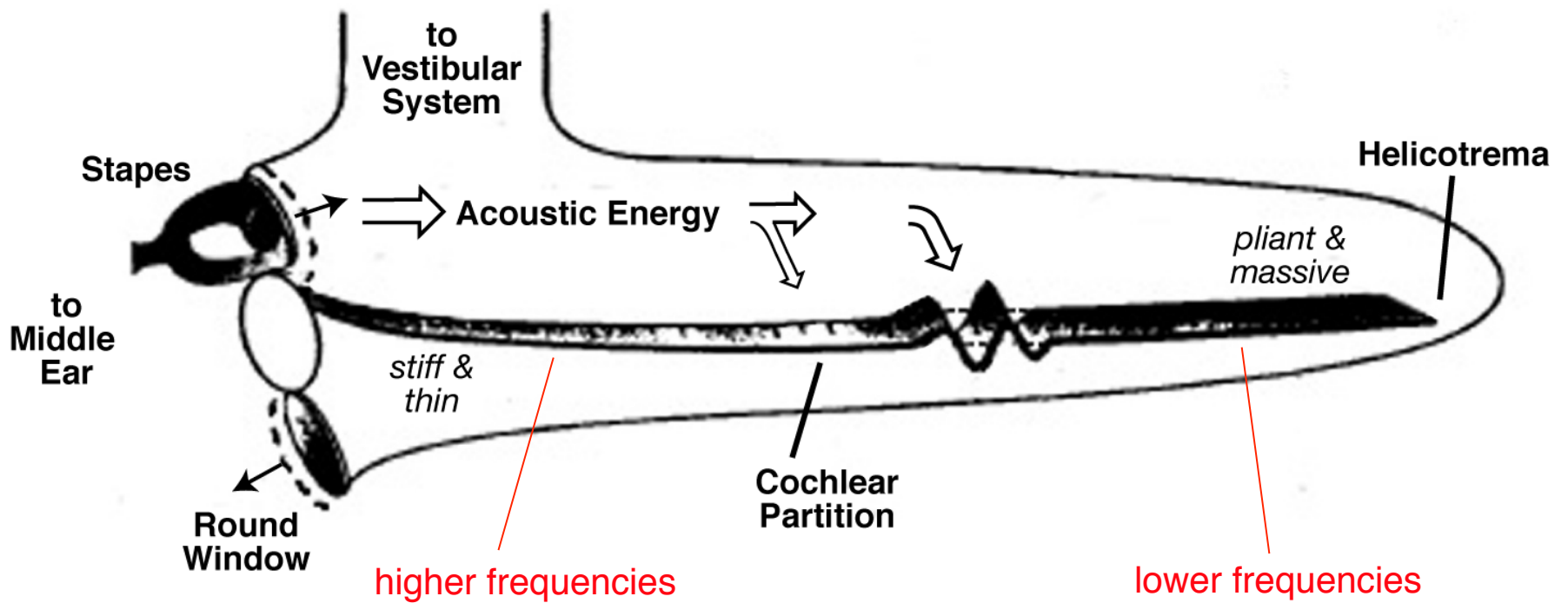


- OAEs apparently a byproduct of the *amplification* mechanism
- Provide means to non-invasively probe inner ear (e.g., hair cell dynamics)

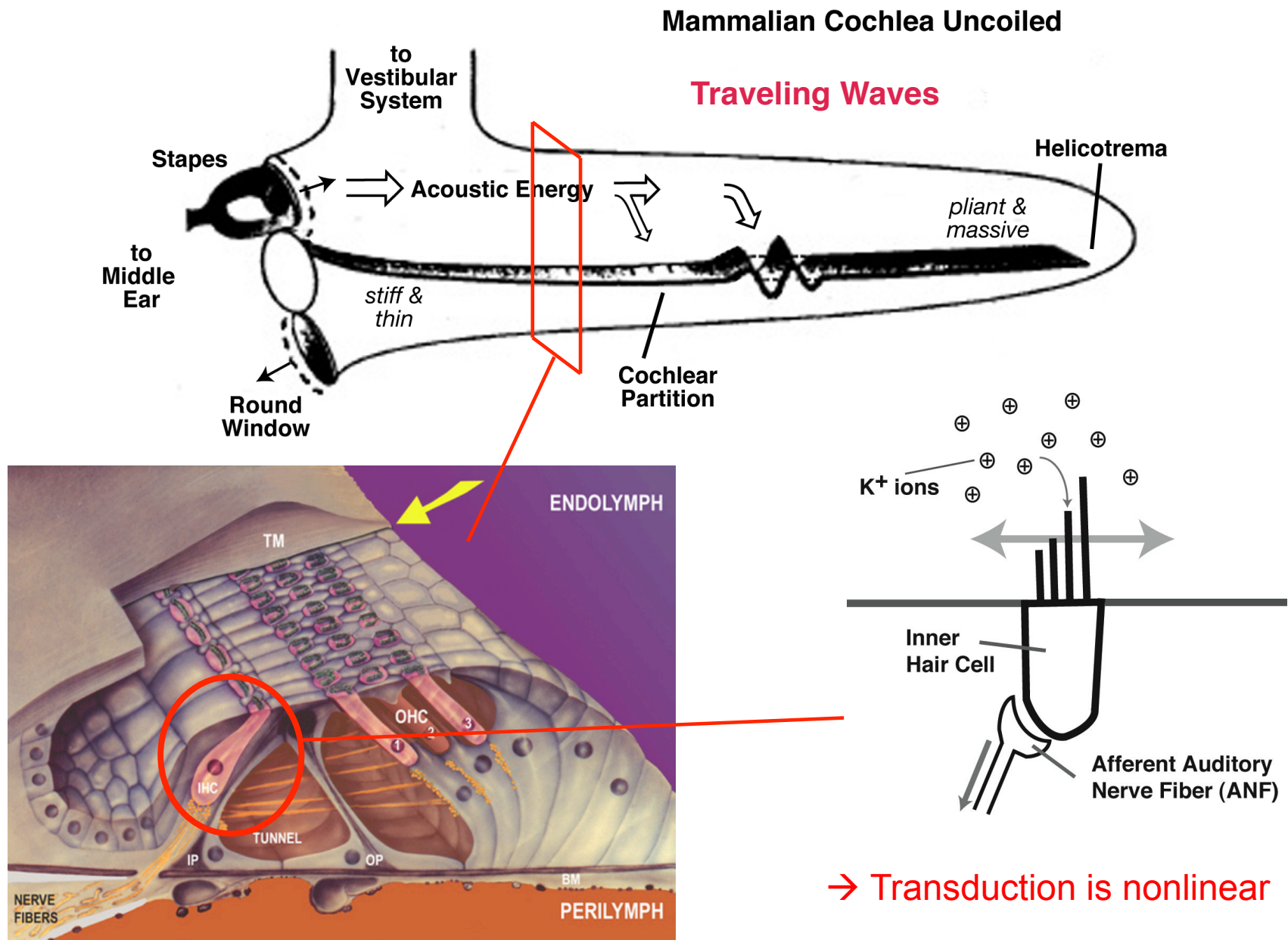
Ear is a Fourier analyzer (*Tonotopicity*)



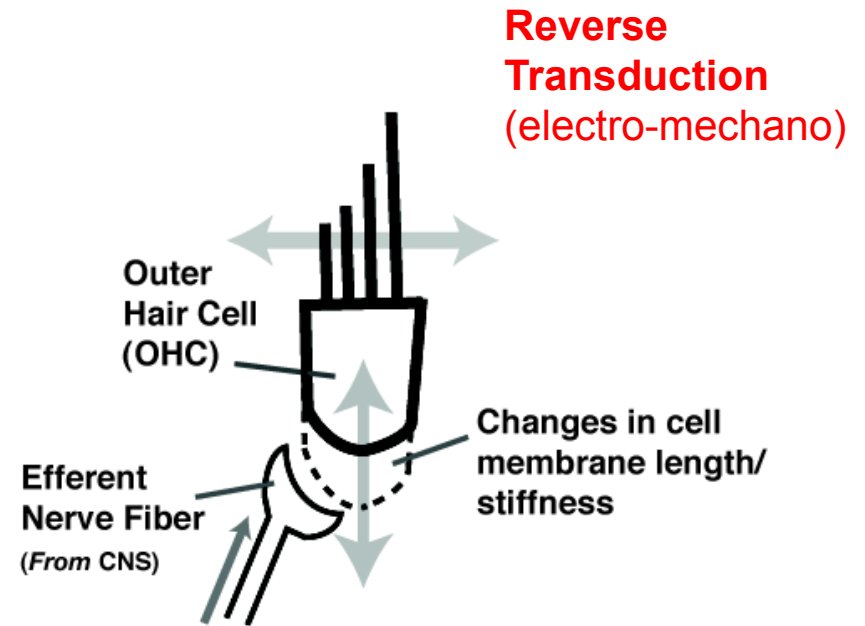
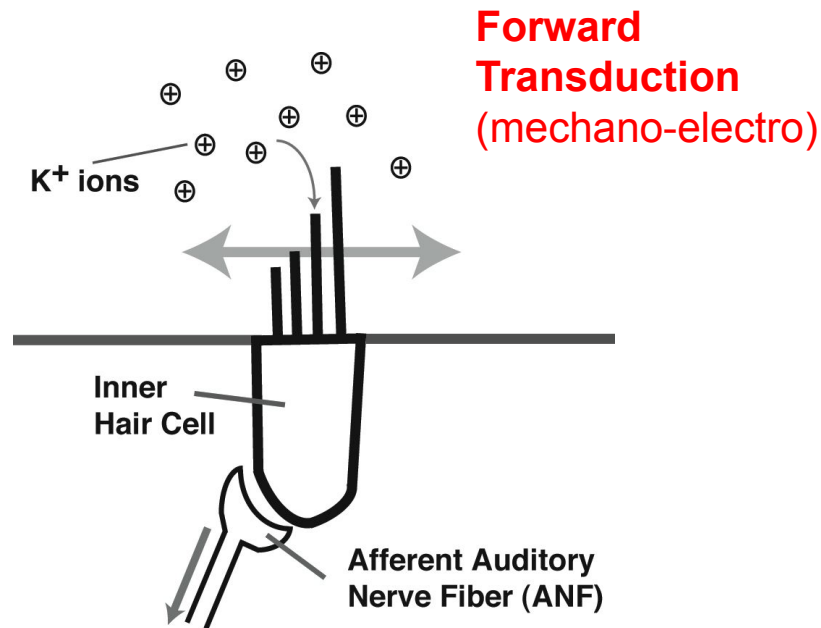
Basilar membrane
(BM)



Hair cell = 'Mechano-electro' transducer

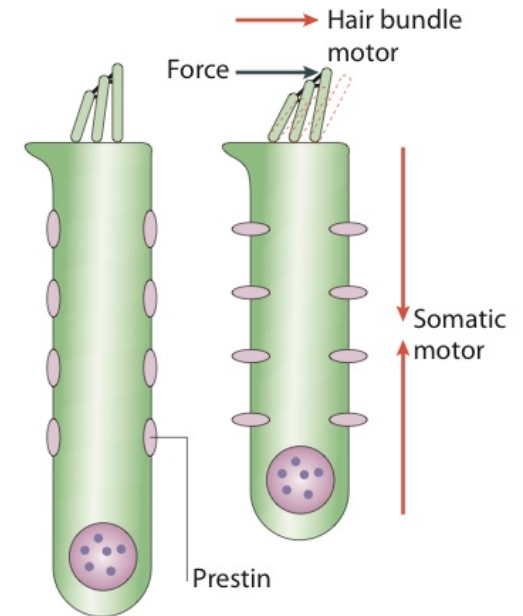


Hair cell = amplifier?

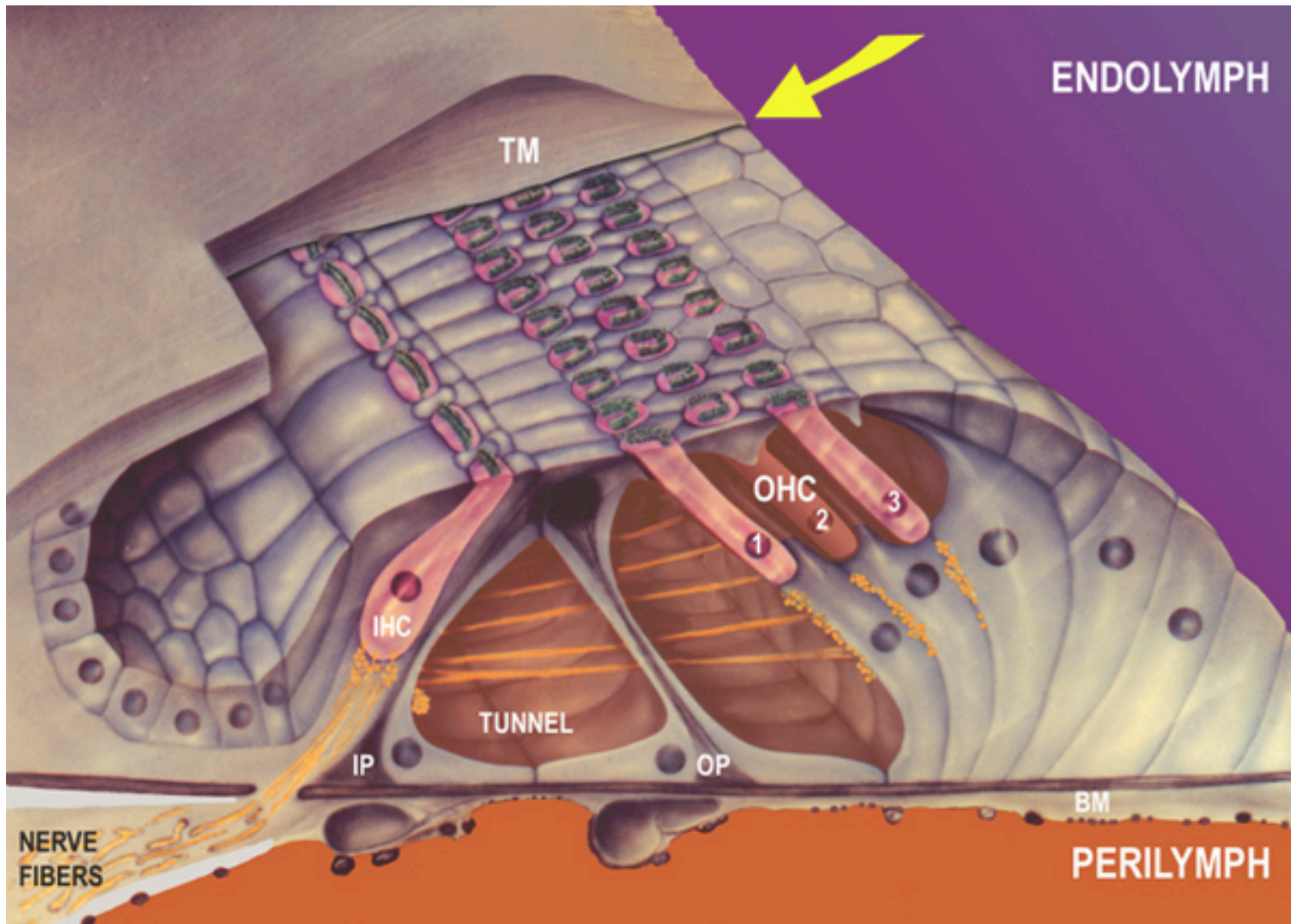


→ Hair cells also amplify (forming basis for OAEs)

→ Motility mechanism for reverse transduction still not well understood



Cochlear micromechanics are poorly understood



Comparative Approach



- Wide variation in morphology/physiology
- Relatively 'simpler' ears
- Extensive neurophysiology, behavioral measures
- OAEs fairly universal

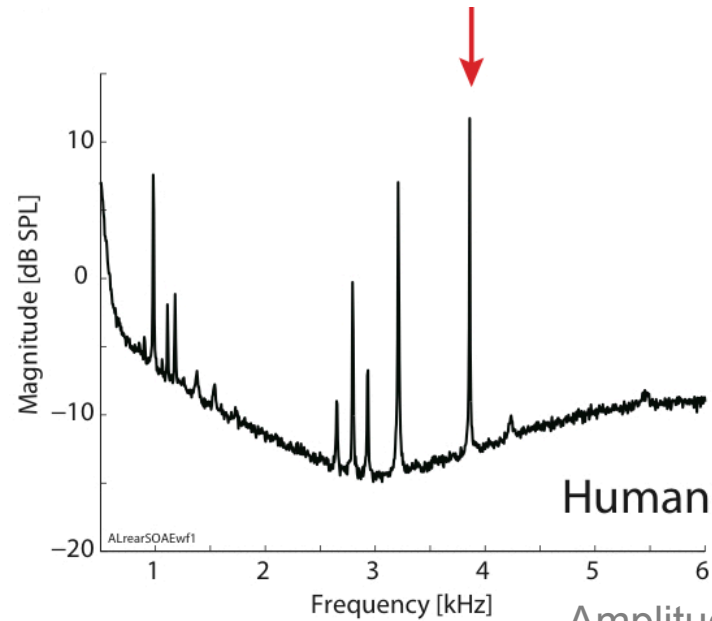


Anolis carolinensis

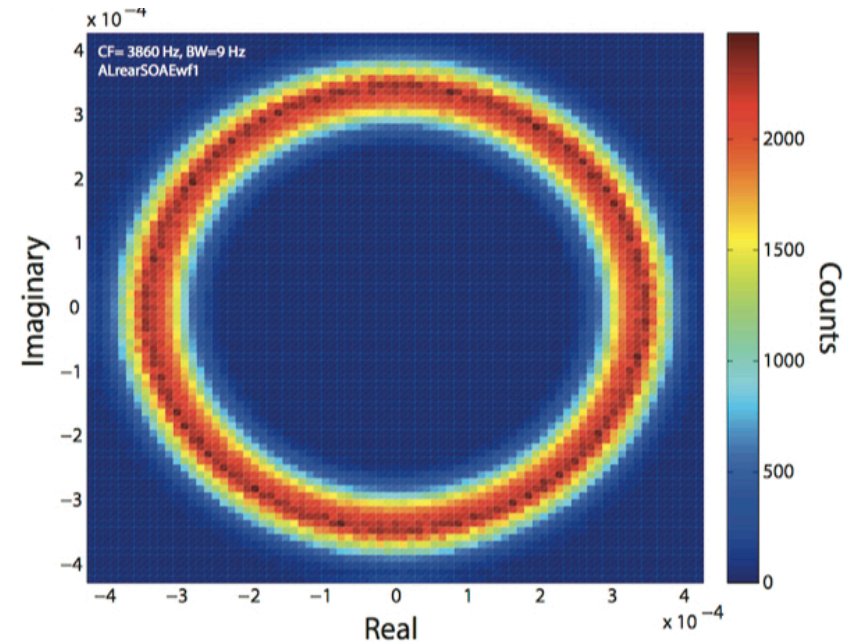


Statistics

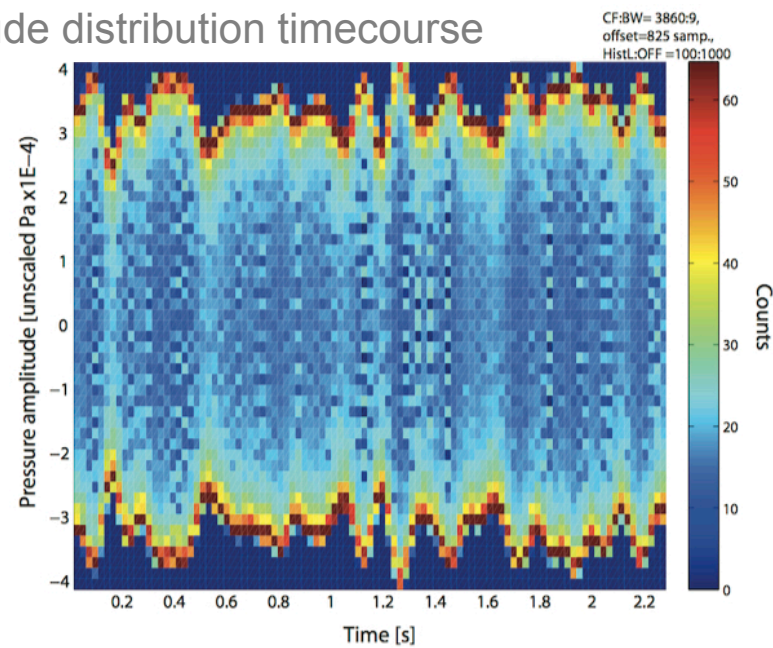
Fourier transform (spectral averaging)



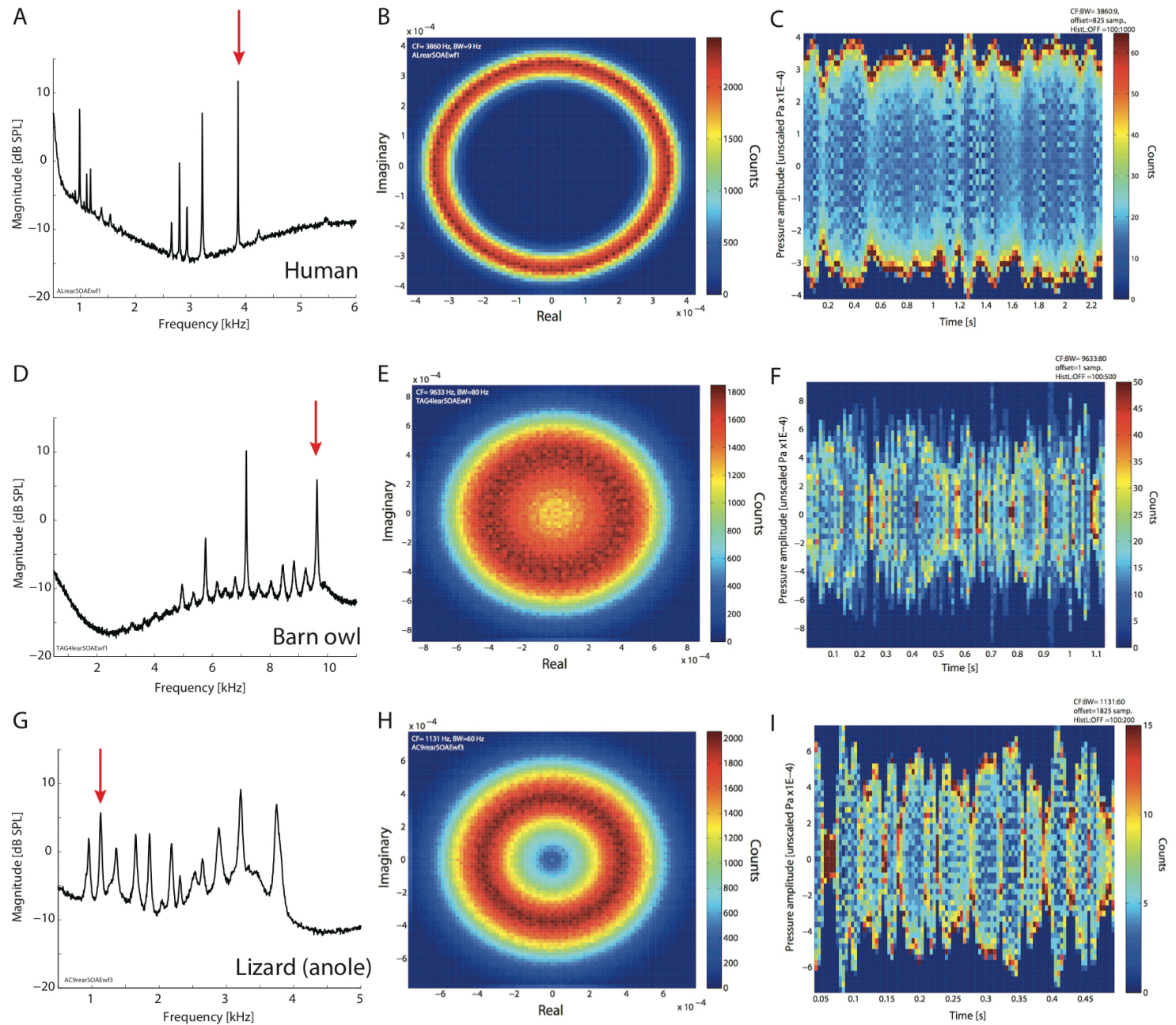
Analytic signal distribution (filtered peak)



Amplitude distribution timecourse

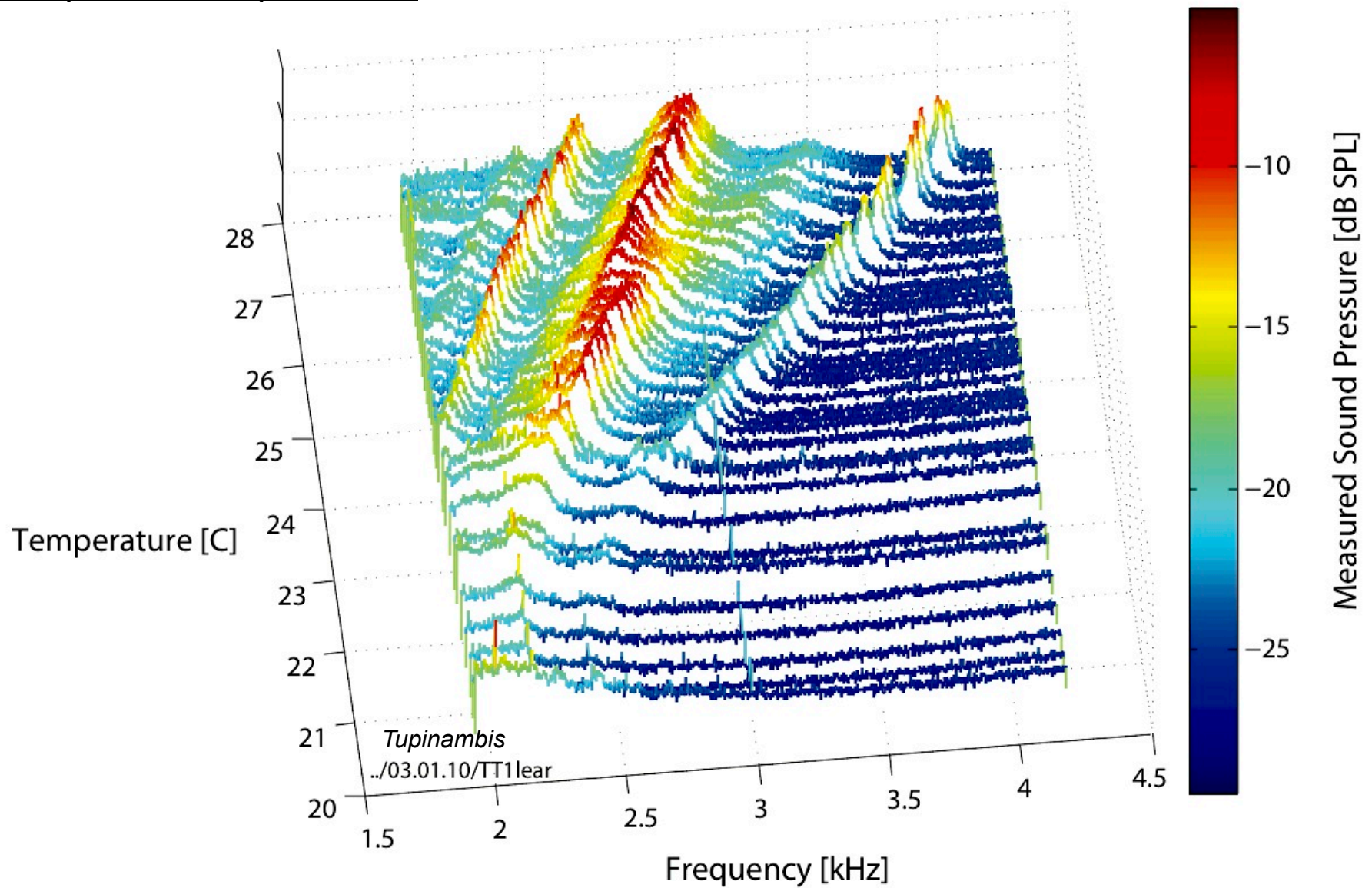


Statistics



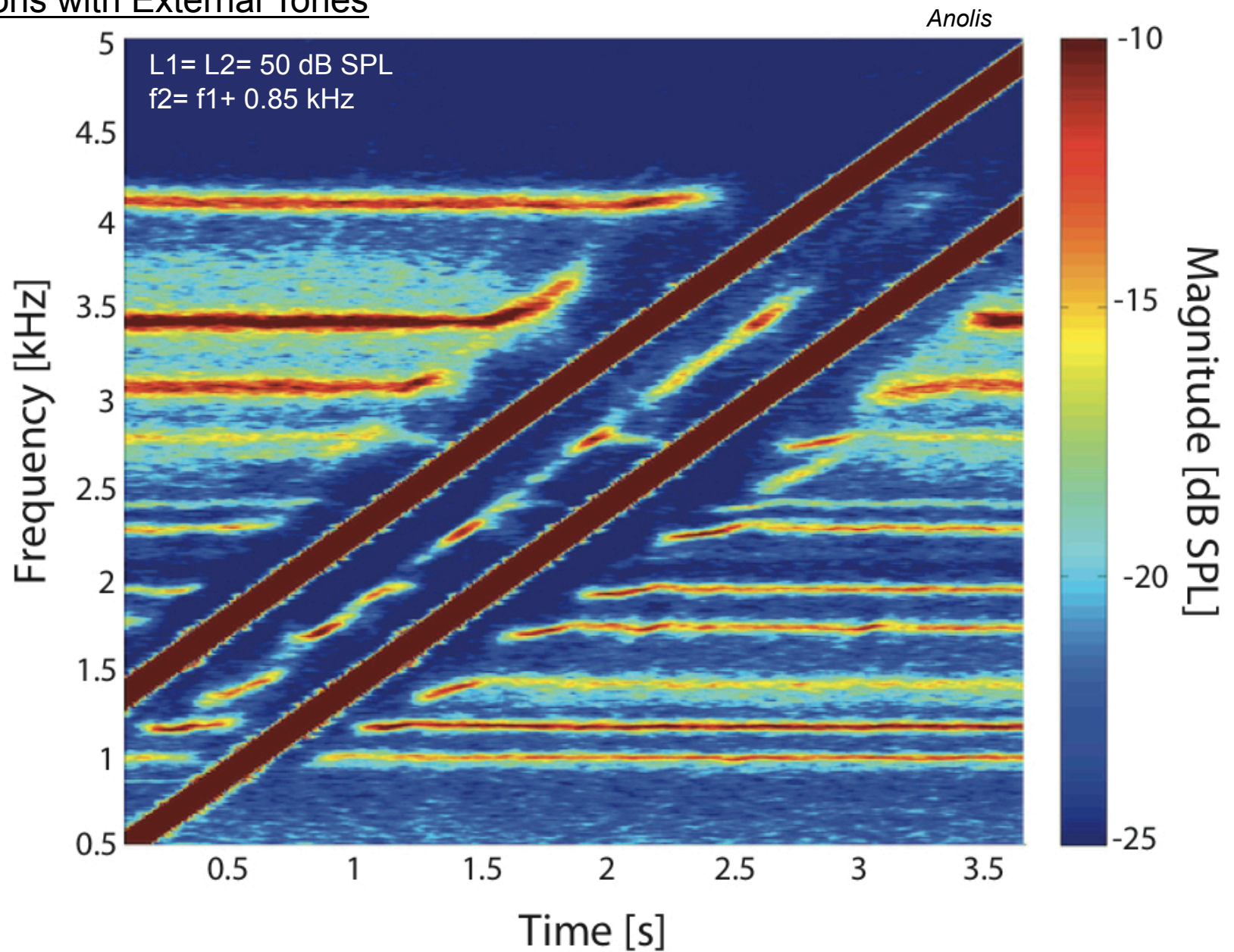
→ (Noisy) Self-sustained oscillators, suggestive of an 'active' mechanism

Temperature Dependence



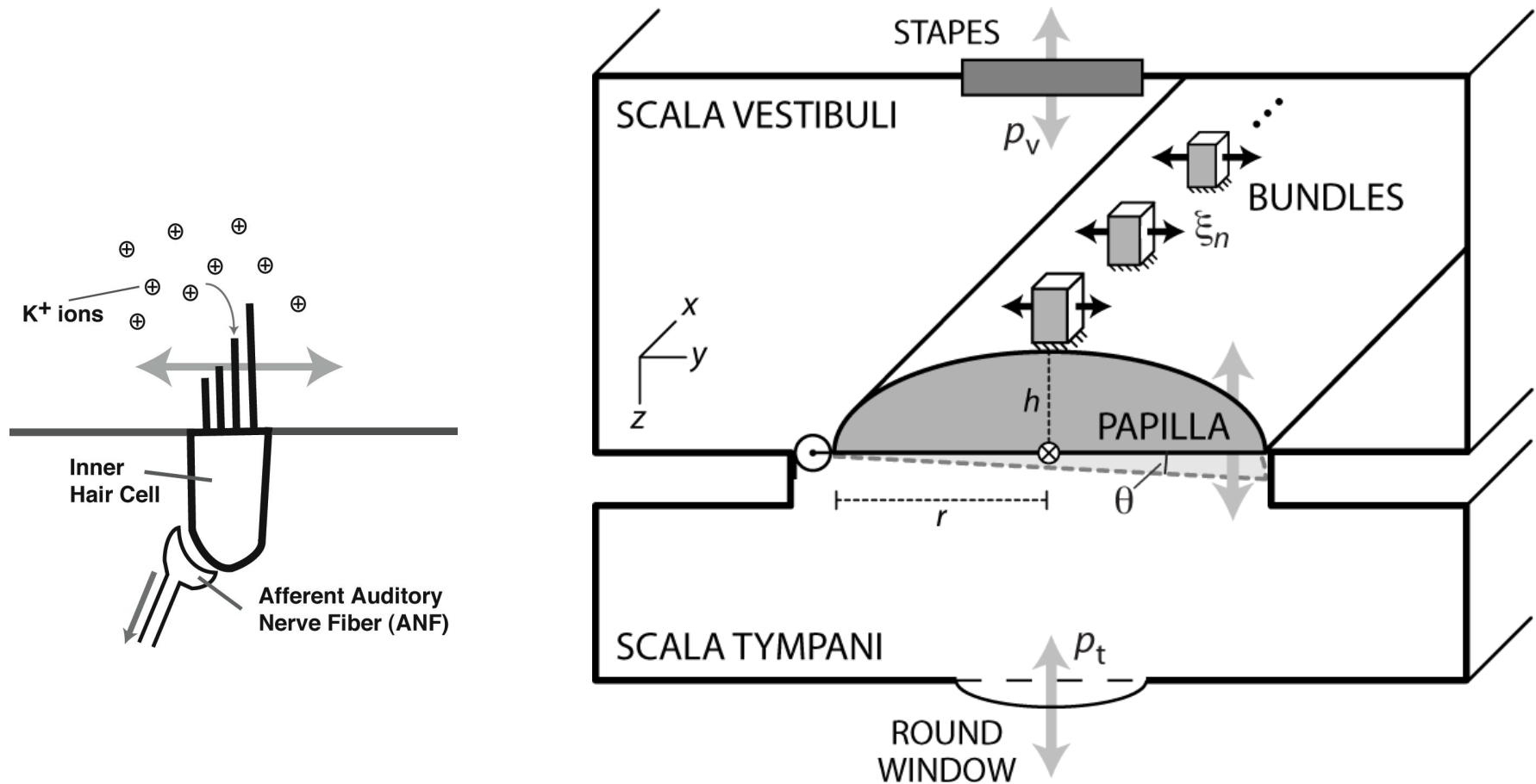
→ SOAEs metabolically-dependent (e.g., upward frequency shift w/ temperature)

Interactions with External Tones



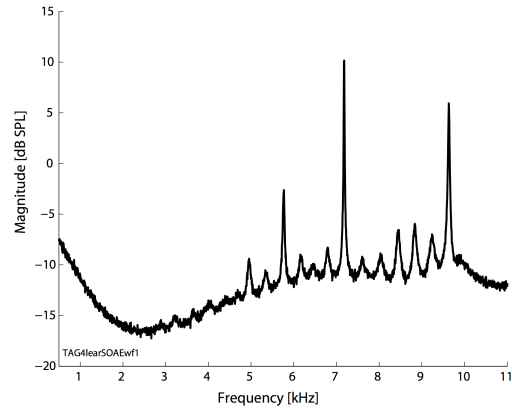
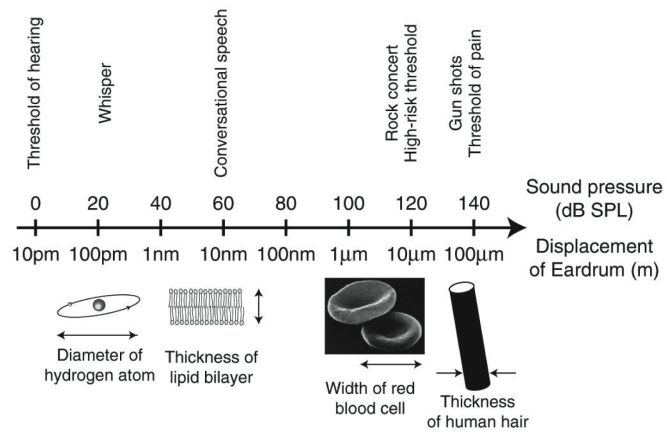
→ Complex interactions (nonlinear dynamics)

Model – Coupled (Non)Linear Oscillators



- Lizard (inner) ear as collection of coupled oscillators
- Nonlinearity: Limit-cycle oscillators
- Parameters primarily determined by neurophysiology
- Model predictions match data well

Summary



D. Freeman

