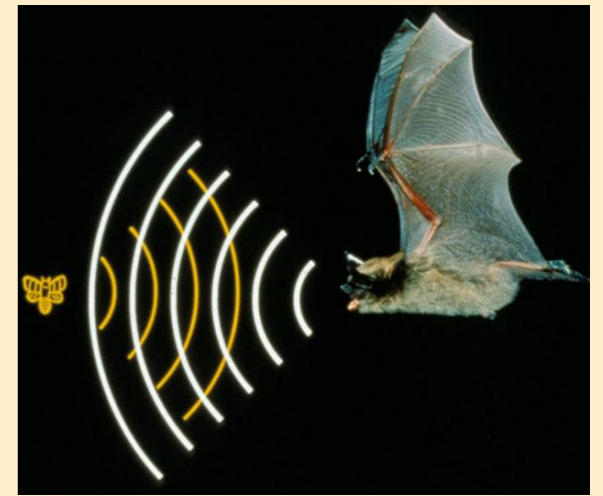


I. Acoustics & Echolocation | 01



Using *echoes* from the **sound** you produce to *locate* objects in your path

Why do animals (incl. humans) make sounds?

Birds (advertise)

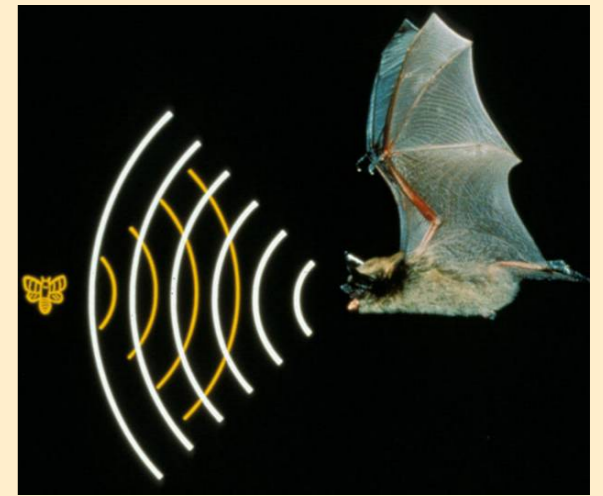


Bats : Navigate (avoid collision);
Feed (collision is required!)

(navigate)



I. Acoustics & Echolocation | 01



Animals which use echolocation include dolphins, porpoises, and toothed whales.

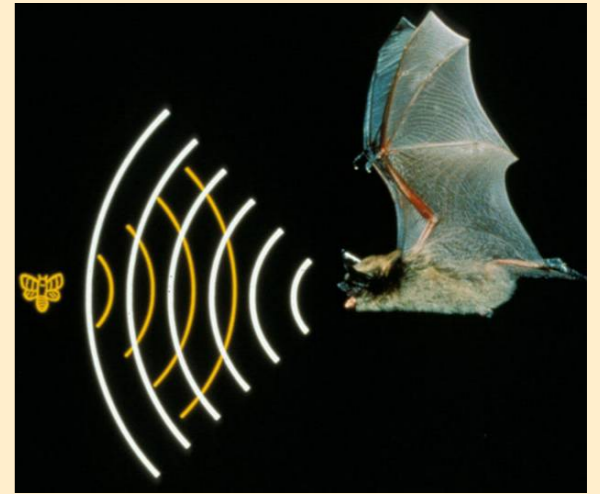
And some, but not all bats!

Old World Fruit Bats (Pteripodidae) don't use echolocation.

Using *echoes* from the sound you produce to *locate* objects in your path



I. Acoustics & Echolocation | 01



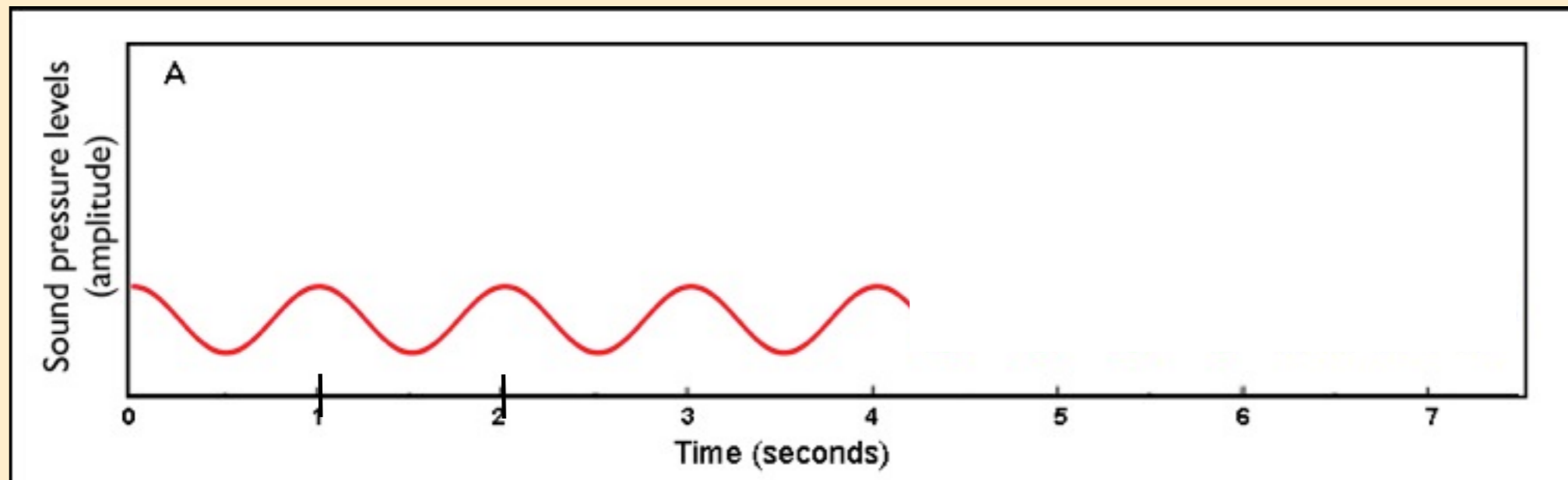
Using *echoes* from the *sound* you produce to *locate* objects in your path

Sound:

The propagation of pressure waves through a medium (e.g. air, water, soil)



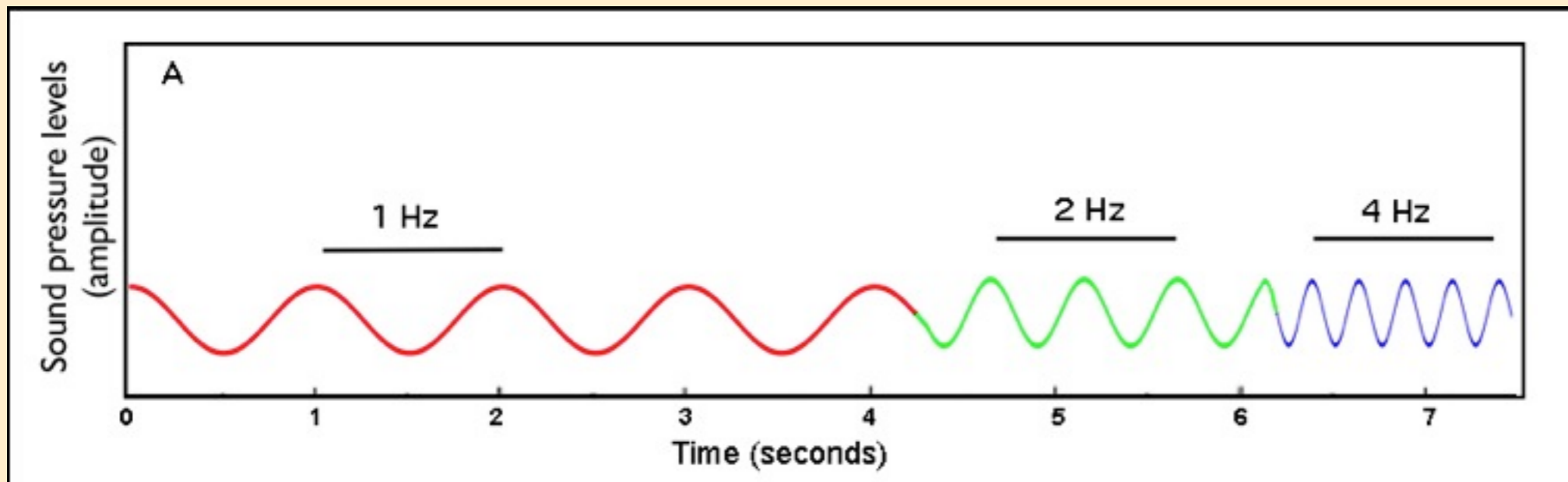
I. Acoustics 101 - what is a “sound” wave



Frequency = # of cycles of pressure change

Hertz (Hz) = 1 cycle per second

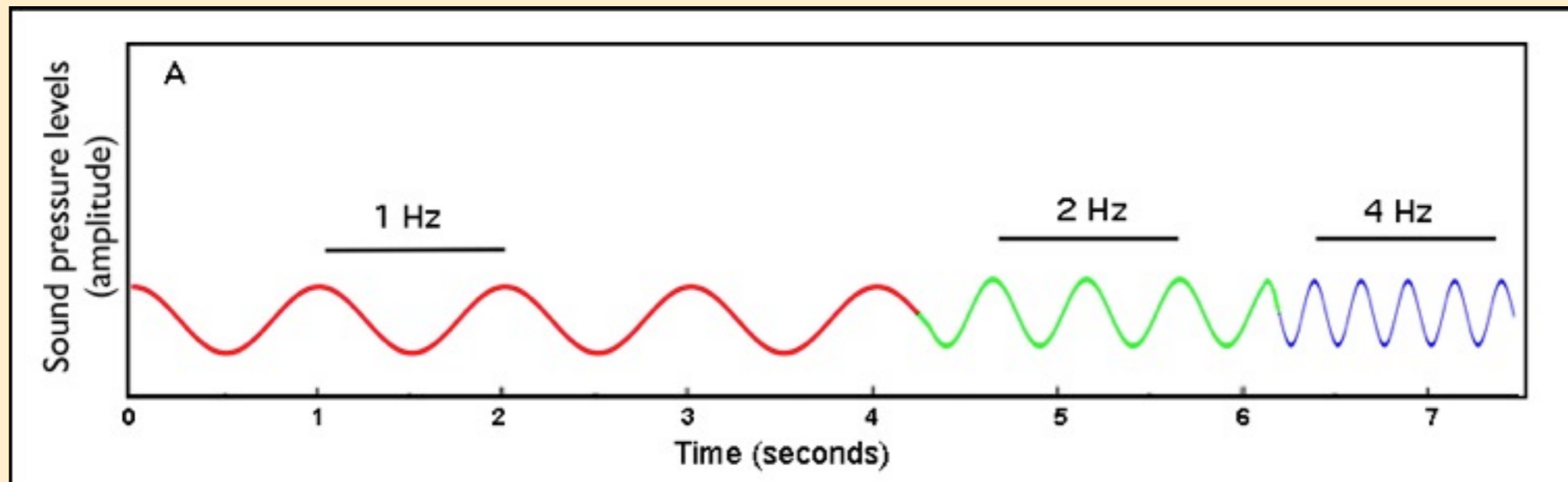
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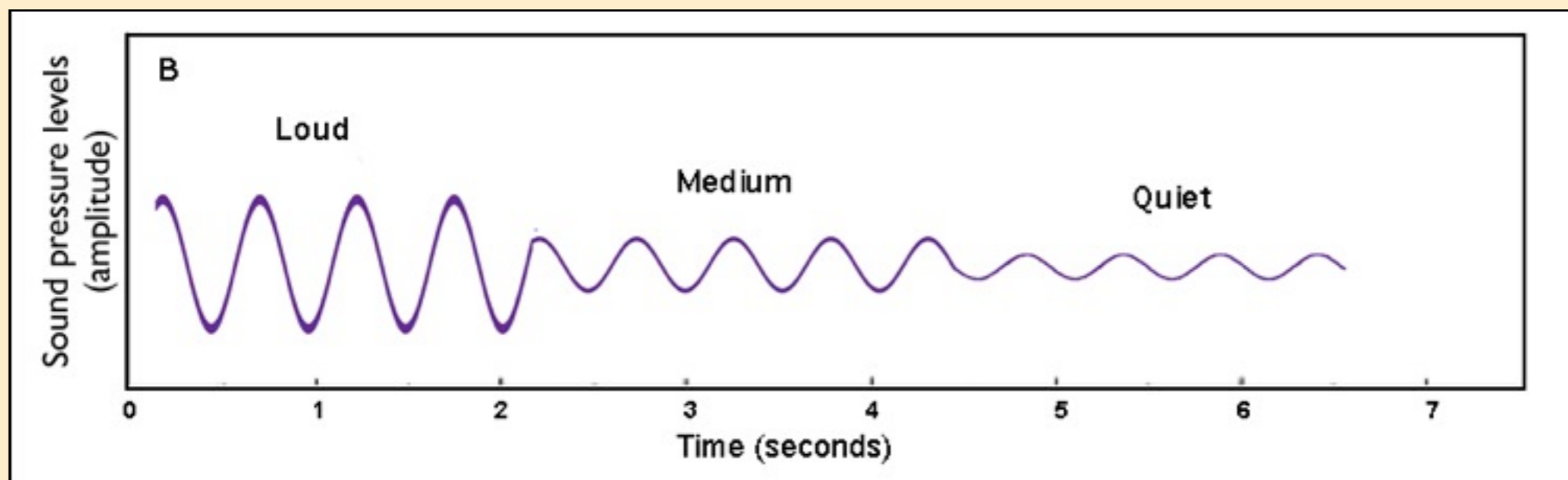
I. Acoustics 101 - what is a “sound” wave



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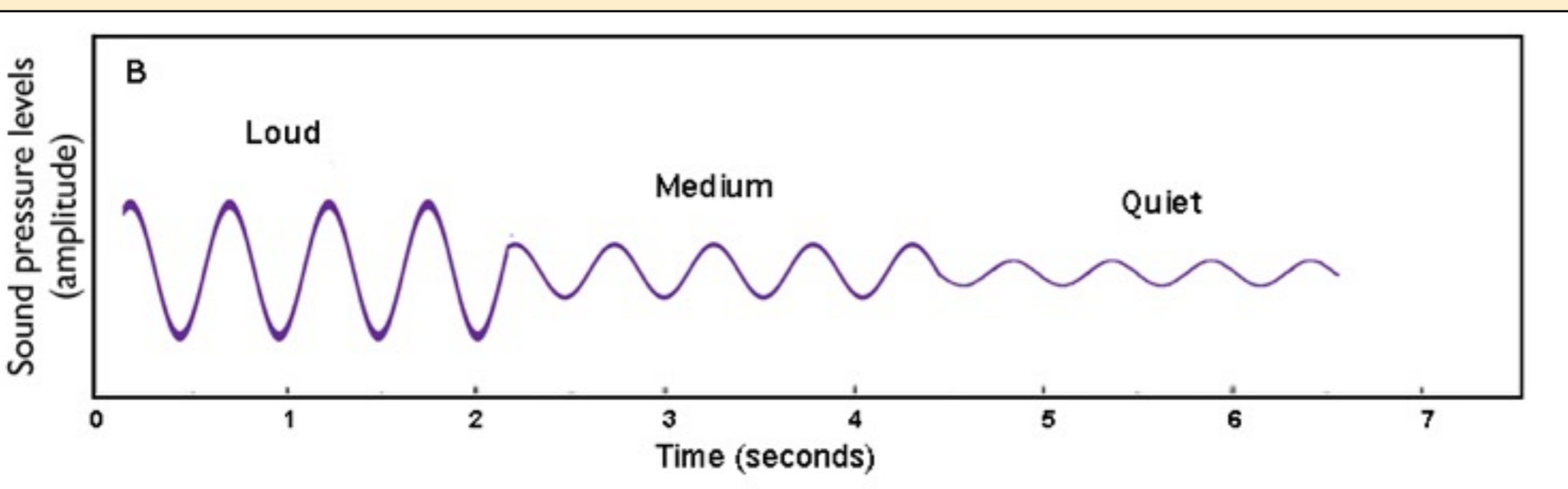
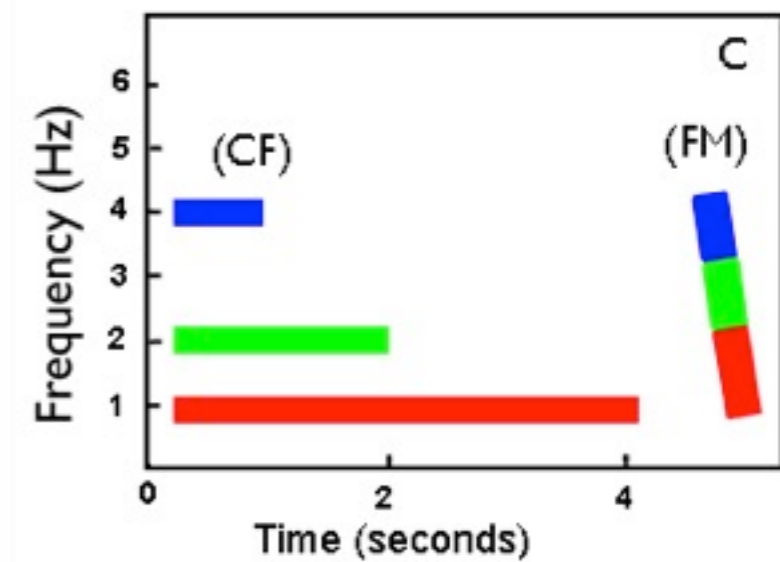
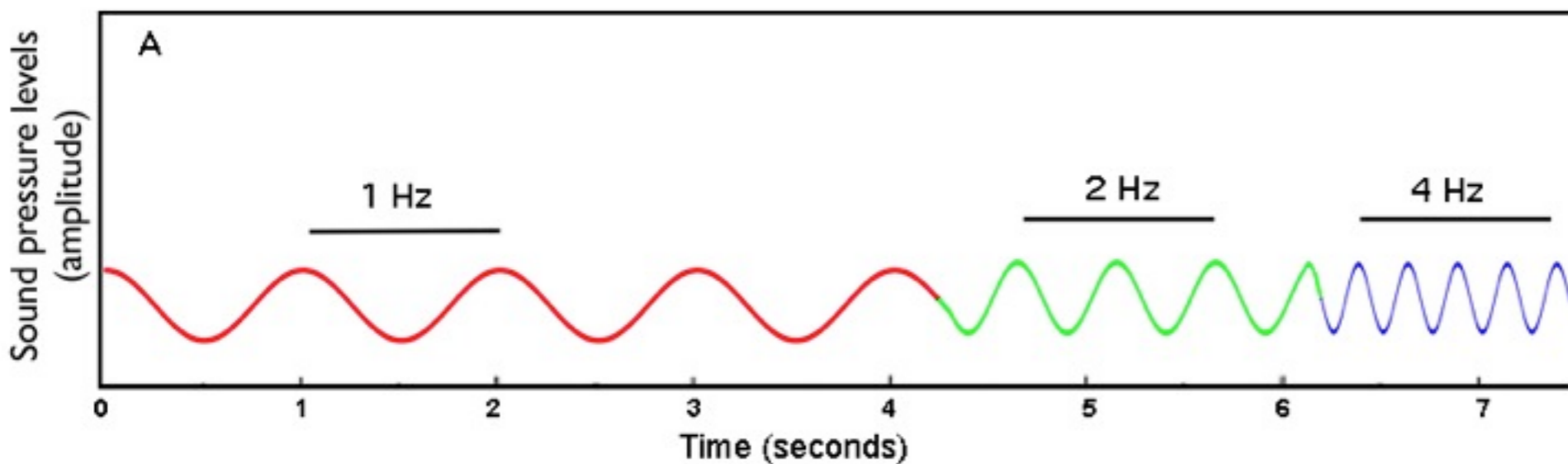
Amplitude = height of wave / intensity / decibels (dB)



I. Acoustics | 0 |

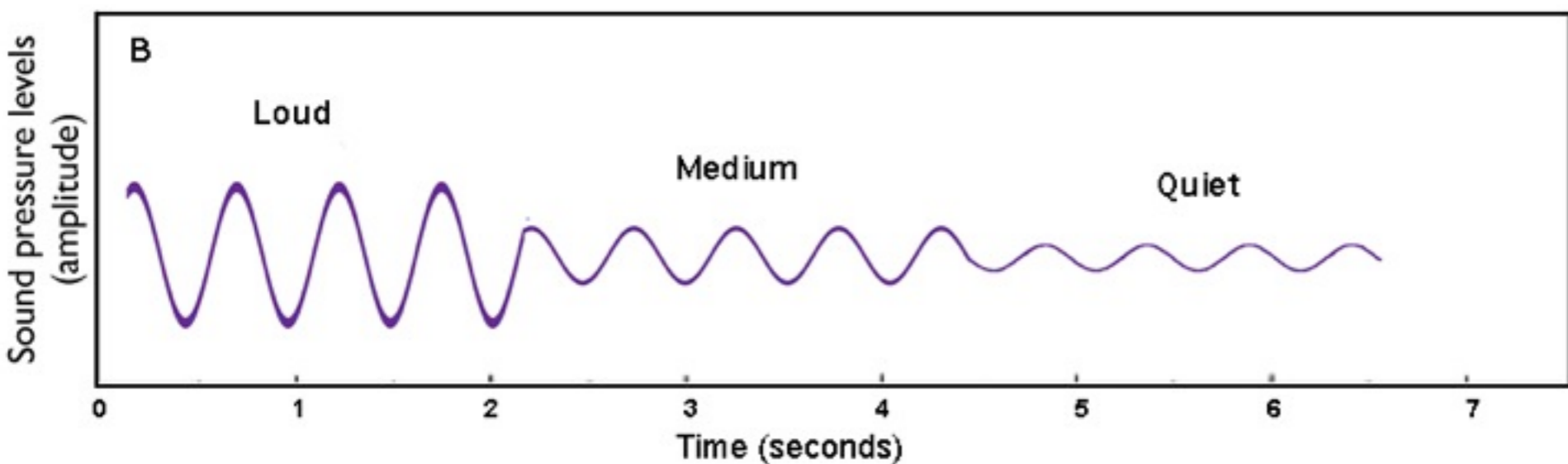
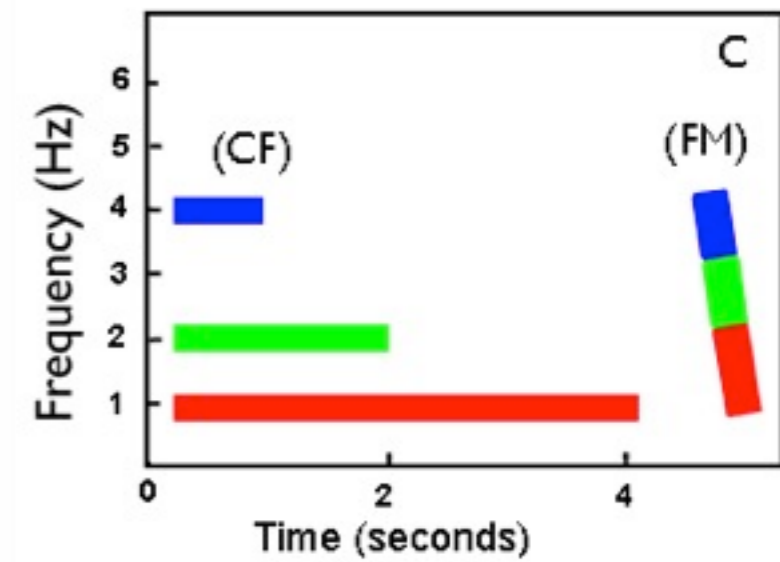
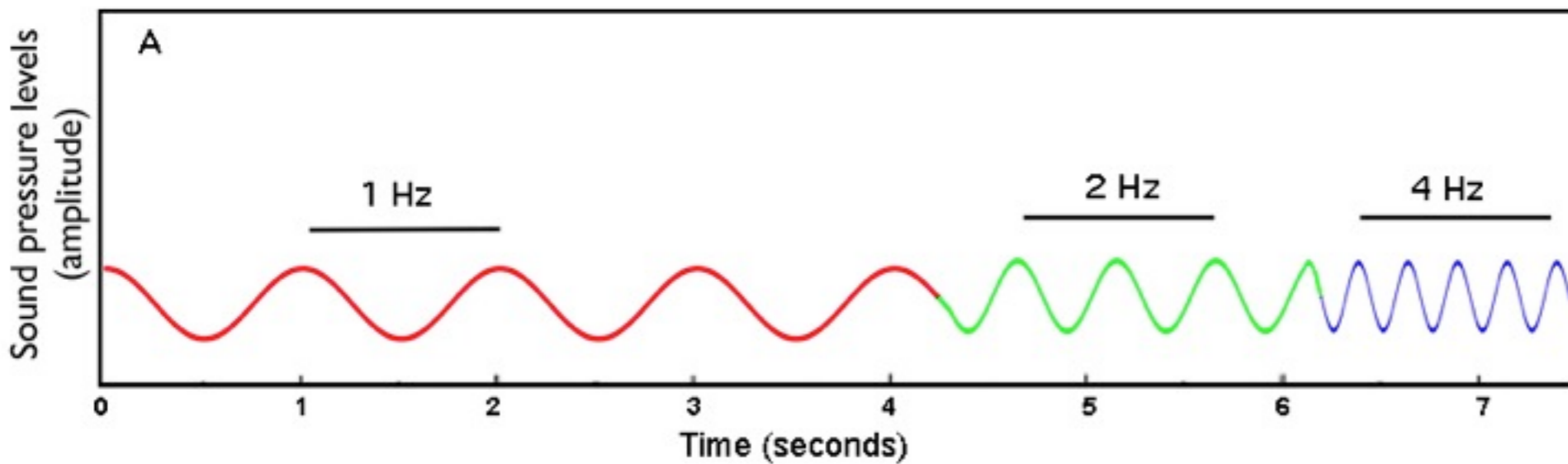
• Constant Frequency (CF)
(Narrowband)

• Frequency Modulated (FM)
(Broadband)



I. Acoustics | 0 |

- Constant Frequency (CF)
(Narrowband)
- Frequency Modulated (FM)
(Broadband)

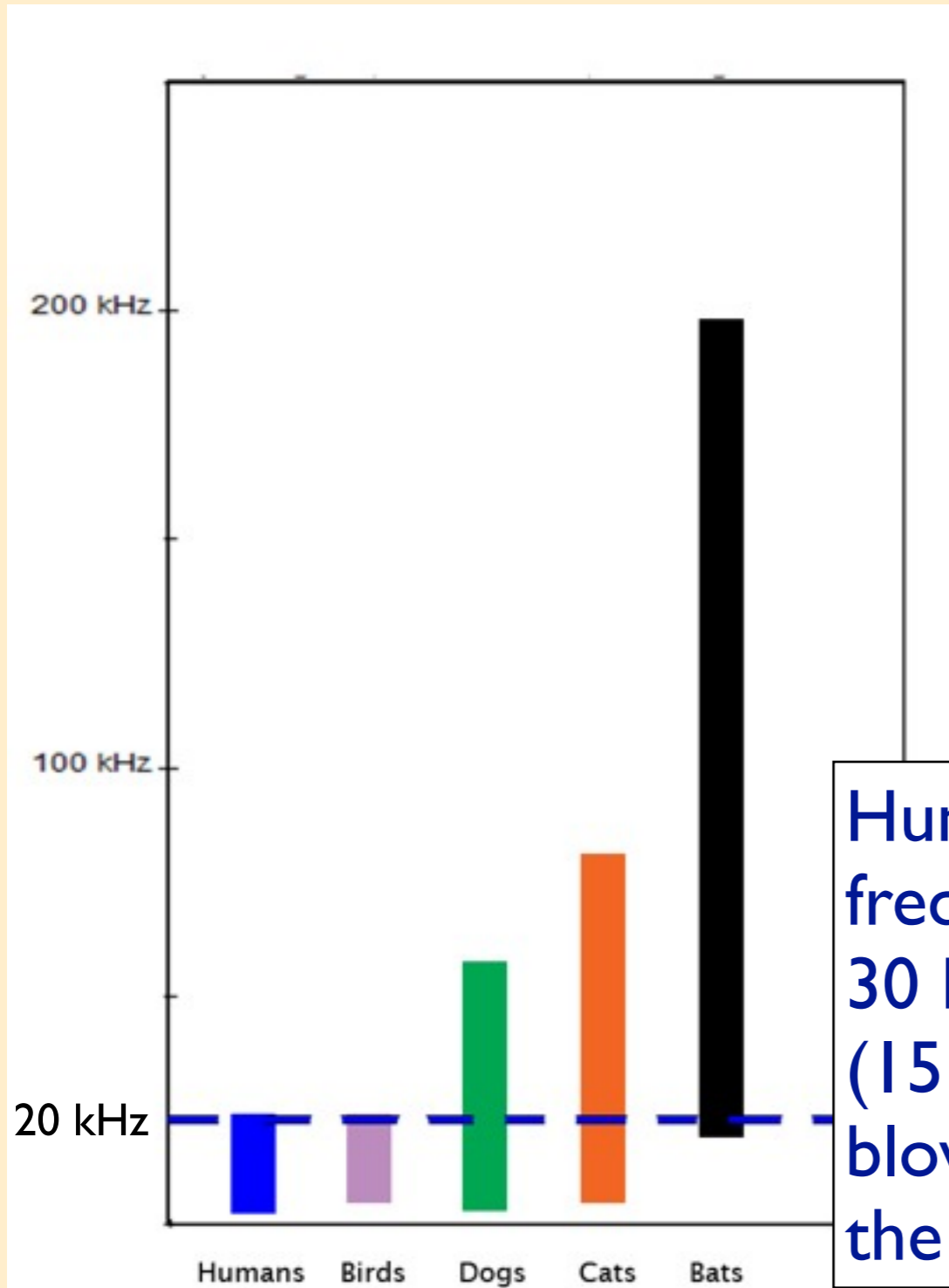


<i>dB Level</i>	<i>Signal</i>
140	Human pain threshold
125	Aircraft jet & Vespertilionidae bat
75	Human speech
20	Quiet whisper
0	Threshold human hearing

(ref: 20.0 μ PA)

I. Acoustics 101

- Audible vs Ultrasonic



Humans can hear frequencies between 30 Hz and 15,000 Hz (15 kHz): the plane will blow-out our eardrums, the bat won't!

dB Level **Signal**

125 Aircraft jet &
 Vespertilionidae bat
(ref: 20.0 μ PA)



(150 Hz)



Thumb-size
Eptesicus fuscus

(35,000 Hz)
[35 kHz]

I. Acoustics 101

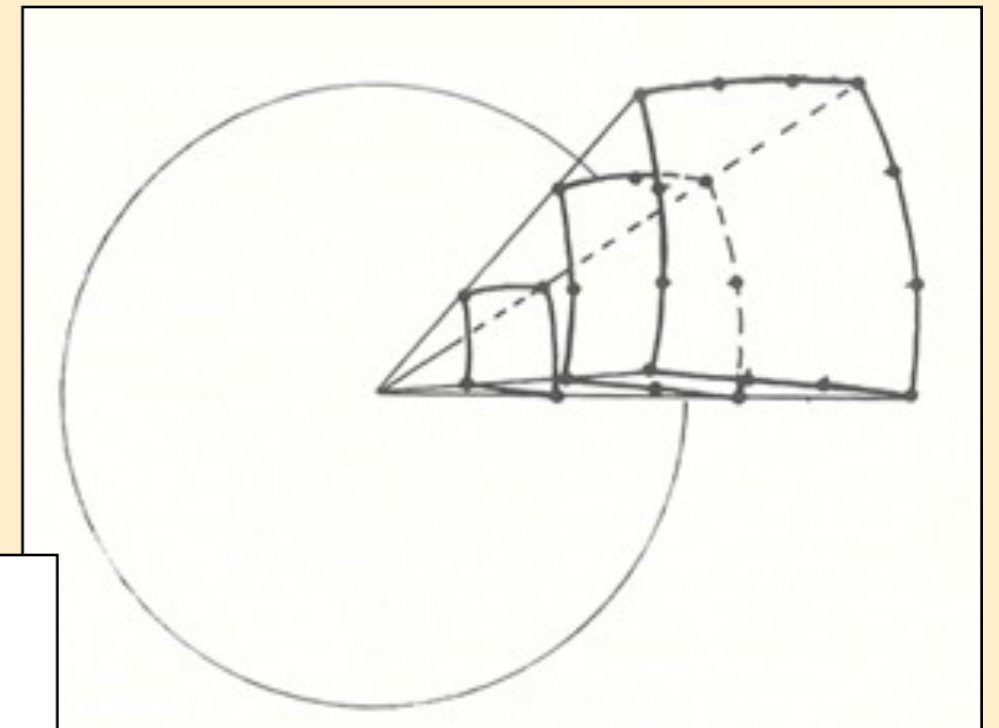
- General Rules of Wave Propagation

1. Lower frequency waves (sound) carry farther
2. Higher frequencies **attenuate** more quickly (i.e. the Sound Pressure Level (intensity / energy) decreases with distance)

I. Acoustics 101

- General Rules of Wave Propagation

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Intensity halves with doubling of distance

I. Acoustics 101

- General Rules of Wave Propagation

1. Lower frequency waves (sound) carry farther
2. Higher frequencies **attenuate** more quickly (i.e. the Sound Pressure Level (intensity / energy) decreases with distance)
3. Higher frequencies give better “resolution”

I. Acoustics 101

- General Rules of Wave Propagation

1. Lower frequency waves (sound) carry farther

2. Higher frequencies **attenuate** more
the Sound Pressure Level (intensity
decreases with distance)

3. Higher frequencies give
better “resolution”

(e.g., like more pixels in
an image)



I. Acoustics | 0 |

- General Rules of Wave Propagation

1. Lower frequency waves (sound) carry farther
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$$\lambda \text{ 340 Hz} = 100 \text{ cm}$$

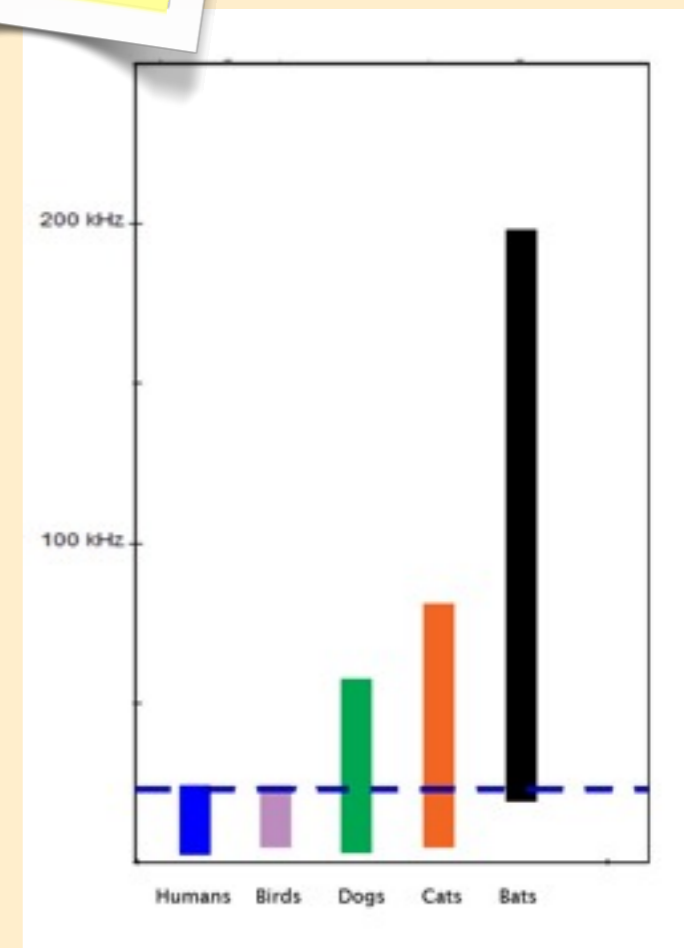
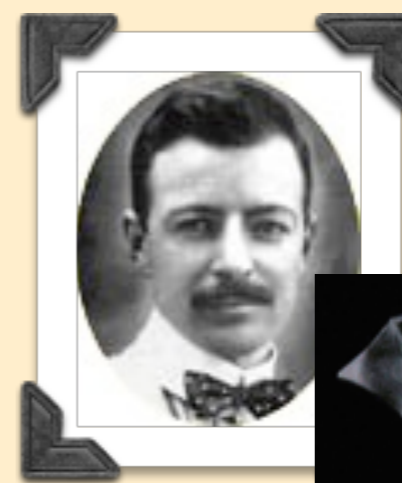
$$\lambda \text{ 3,400 Hz (3.4 kHz)} = 10 \text{ cm}$$

$$\lambda \text{ 34,000 Hz (34 kHz)} = 1 \text{ cm}$$

Or more detail because a higher-frequency wave has a shorter wavelength and covers a shorter distance in one cycle

I. Acoustics 101

2015



SCENARIO: “I need a survey of bat foraging habitat”

SOLUTION: Ultrasonic Bat detector!

PROBLEMS: Advertise vs. Navigate
Rules of Wave Propagation

Q: What is the detection capability of a bat detector ?

Q: How close do I need to be to detect a bat ?