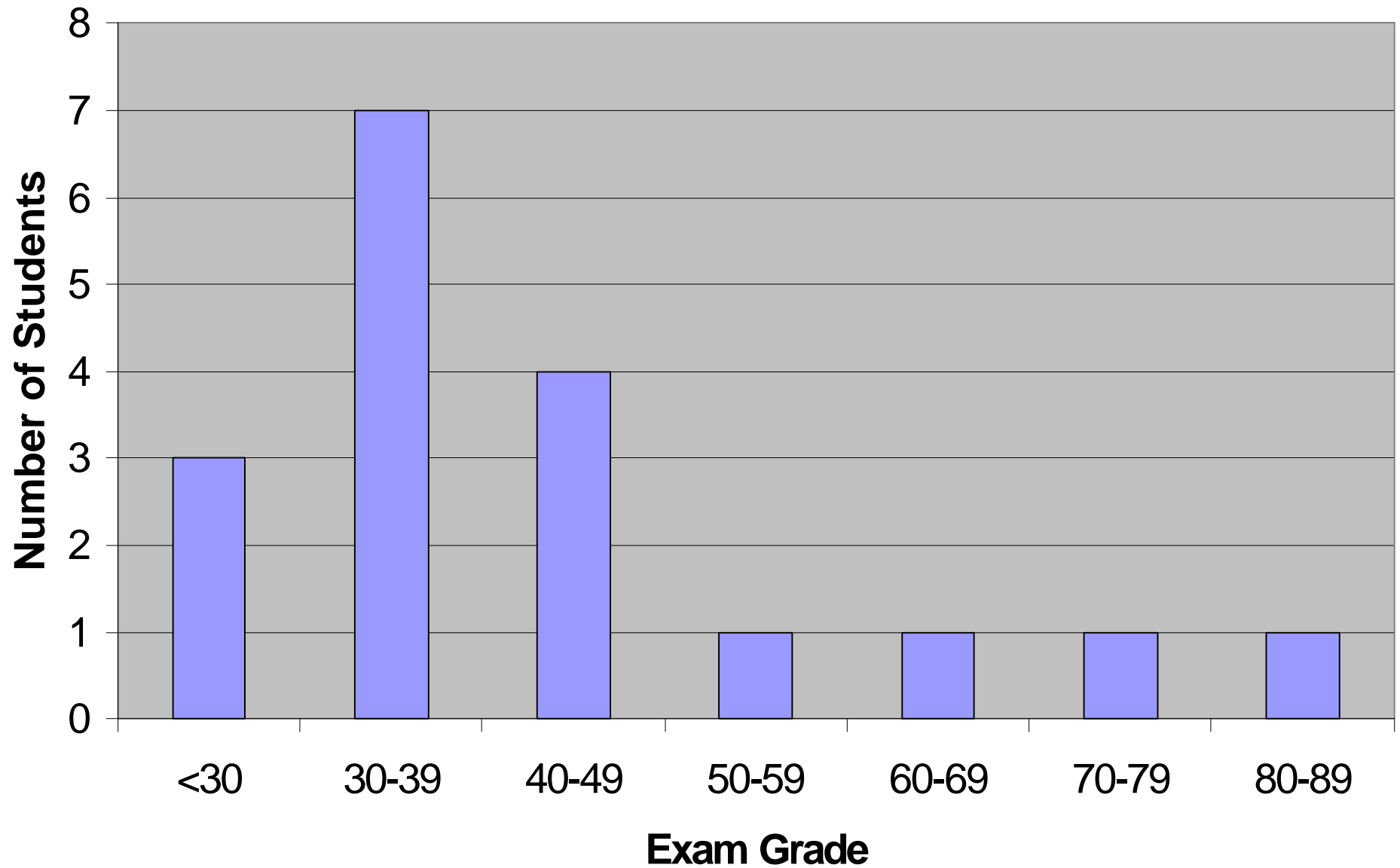




Symphony #1 in D

Last Movement

Exam #1 Grade Distribution

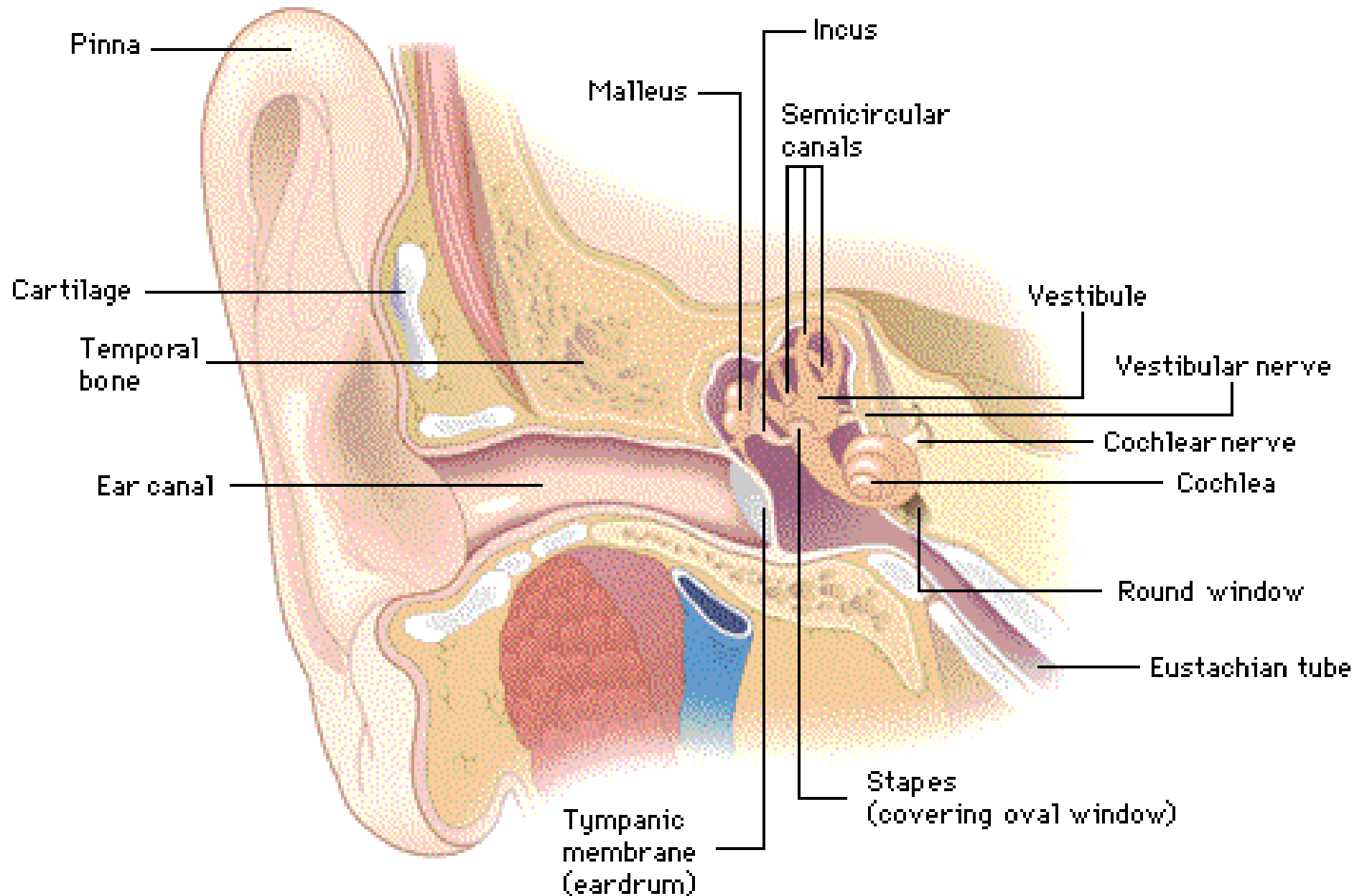


A musical staff with five red lines on a black background. It features four yellow musical notes: a quarter note on the first line, an eighth note on the second line, a quarter note on the third line, and a half note on the fourth line. The staff is enclosed in red brackets at both ends.

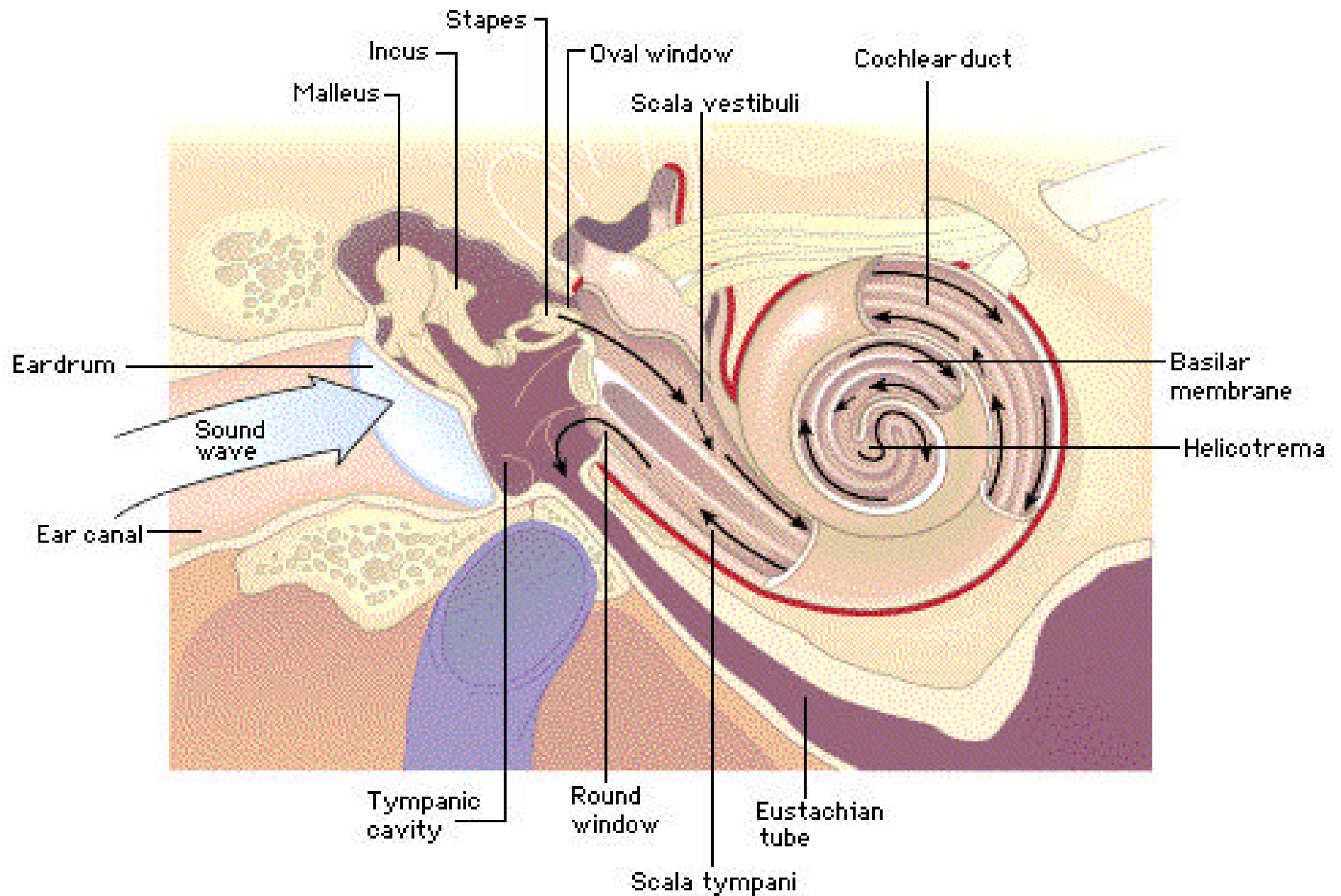
Structure of The Ear

- Outer Ear
- Middle Ear
- Inner Ear

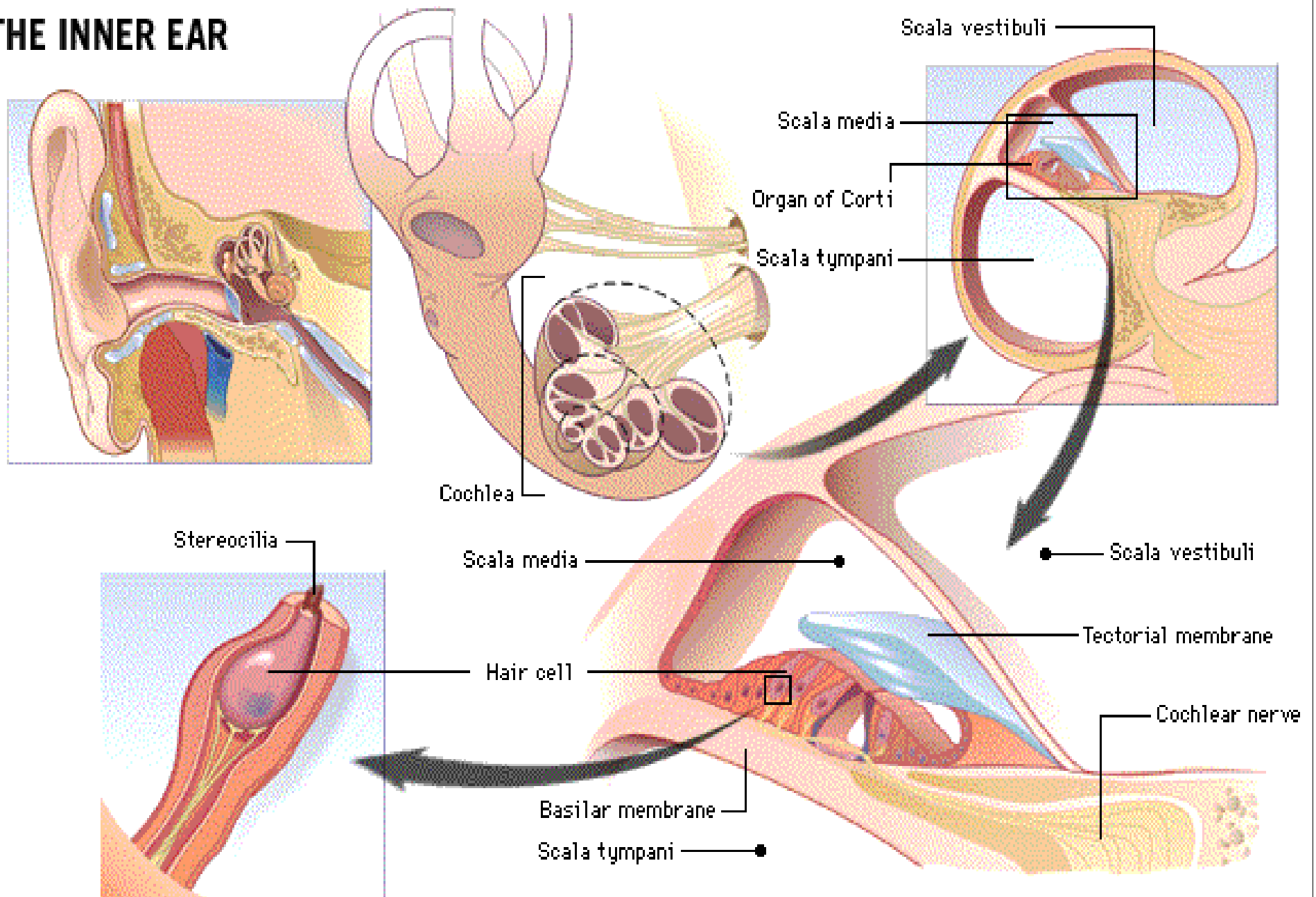
THE HUMAN EAR



THE MIDDLE AND INNER EAR



THE INNER EAR





Music from

*Symphonia Harmonia
Caelestium Revelationum*

A musical staff with five red lines and a red vertical bar on the left. It contains several orange musical notes: a quarter note on the first line, an eighth note on the second line, a quarter note on the third line, and a half note on the fourth line. The title text is overlaid on the staff.

Discrimination Between Sounds

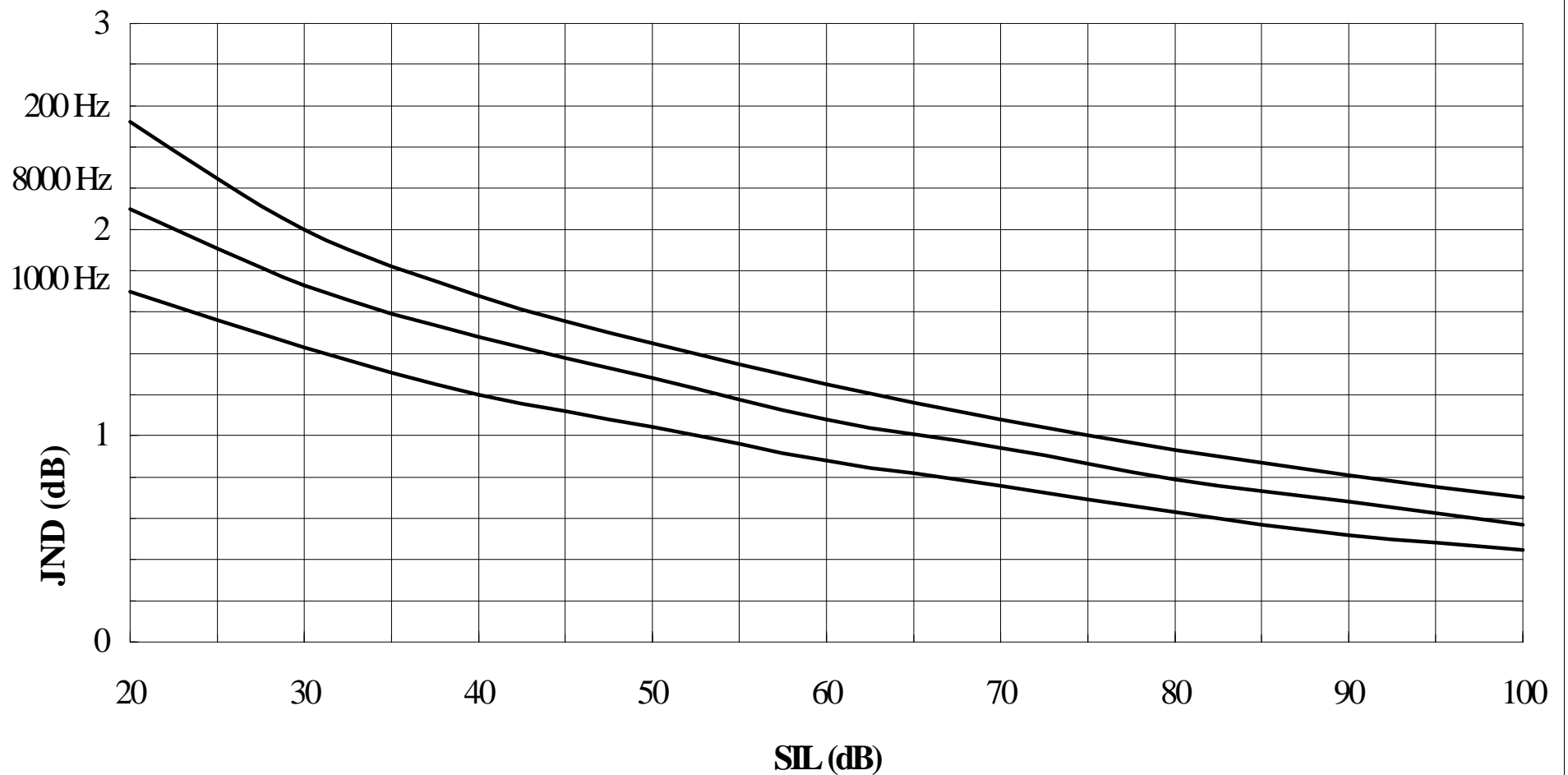
Just Noticeable Difference
or
JND

A musical staff with five red lines on a black background. On the left, there are four yellow notes: a quarter note on the first line, an eighth note on the second line, a quarter note on the third line, and a half note on the fourth line. On the right, there are two yellow notes: a quarter note on the second line and a half note on the third line. The title "2AFC Testing" is written in yellow text across the middle of the staff.

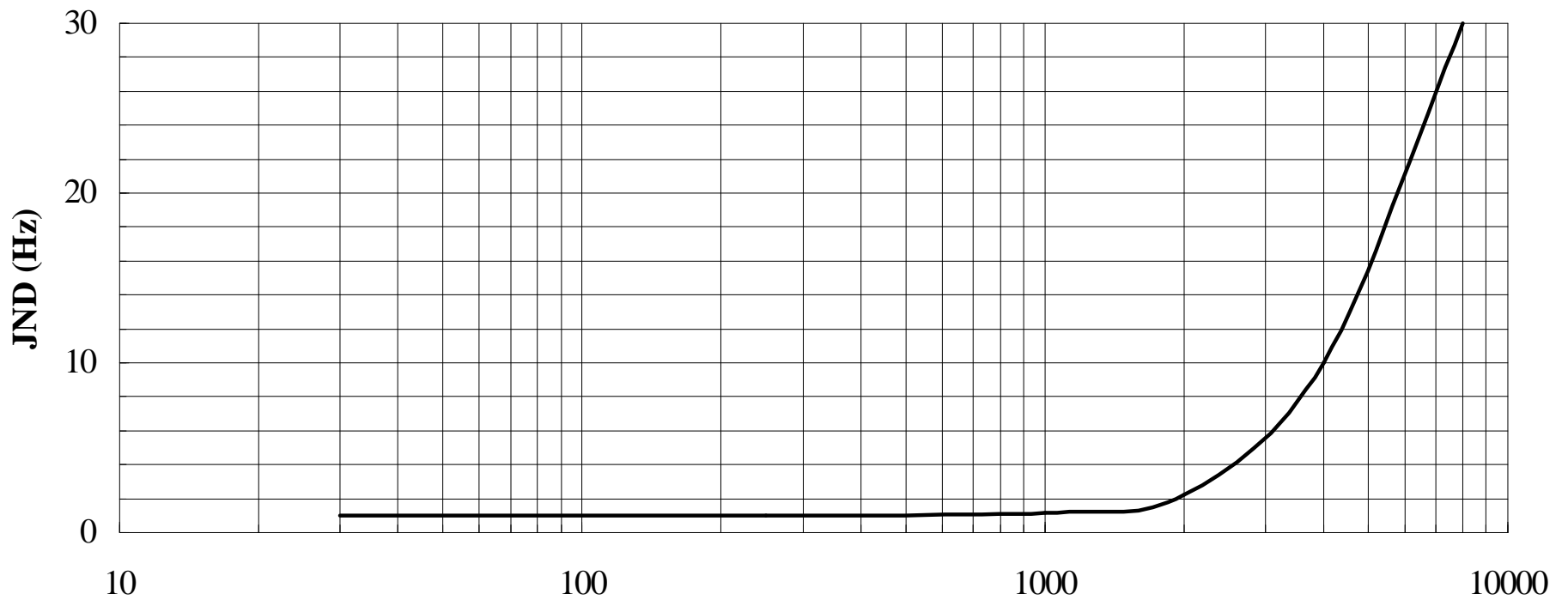
2AFC Testing

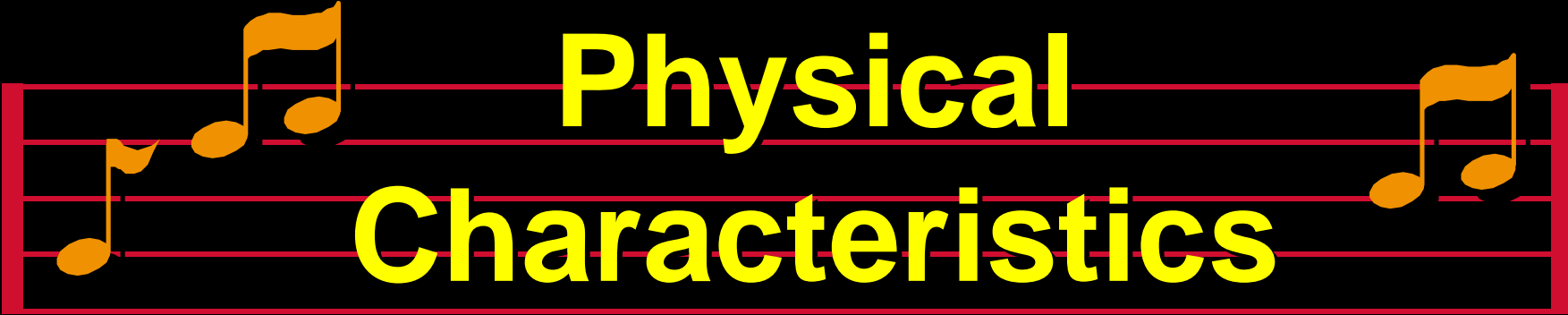
- 100 % correct \Rightarrow Certainty
- 50% Correct \Rightarrow Guess
- Cutoff is defined for 75%

JND for SIL



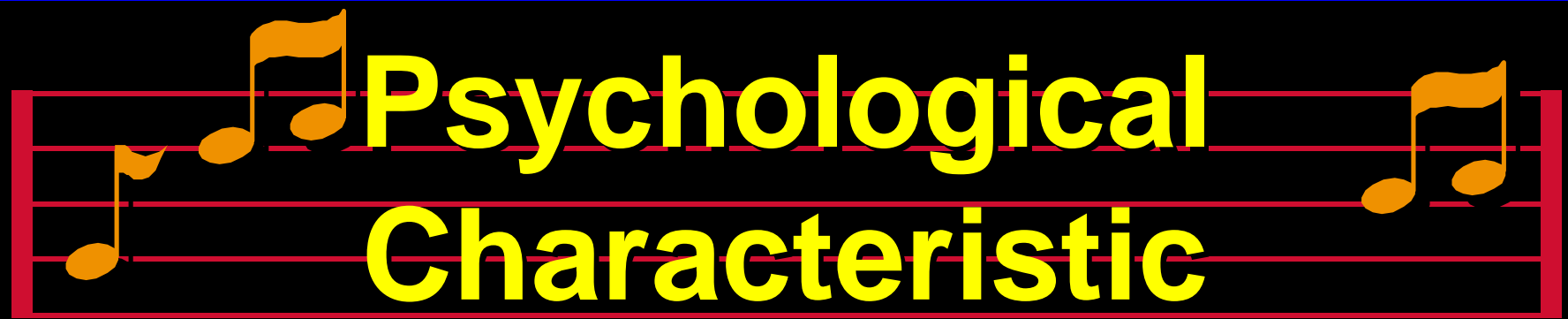
JND for Frequency



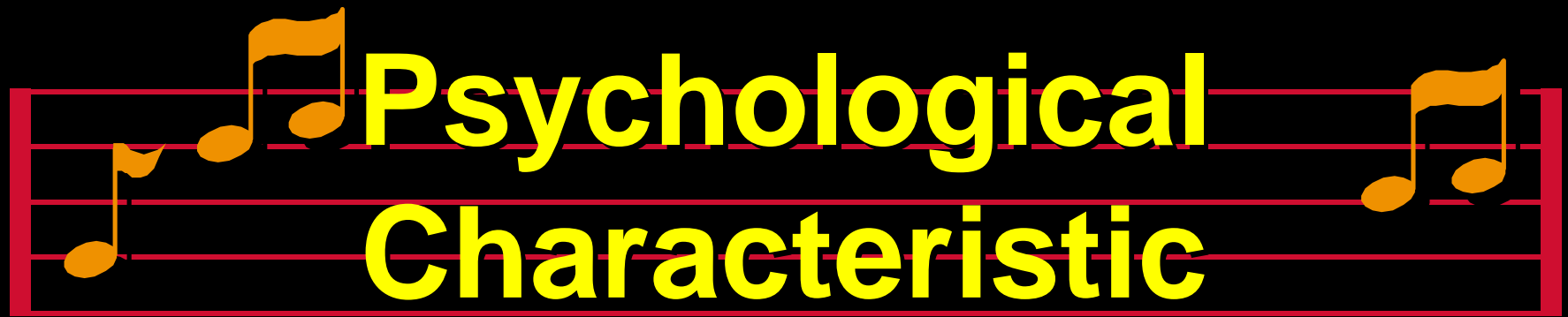
A musical staff with five red lines and two orange notes, one on the left and one on the right, framing the title.

Physical Characteristics

- Intensity = I (W/m²)
- Sound Intensity
Level = SIL (dB)

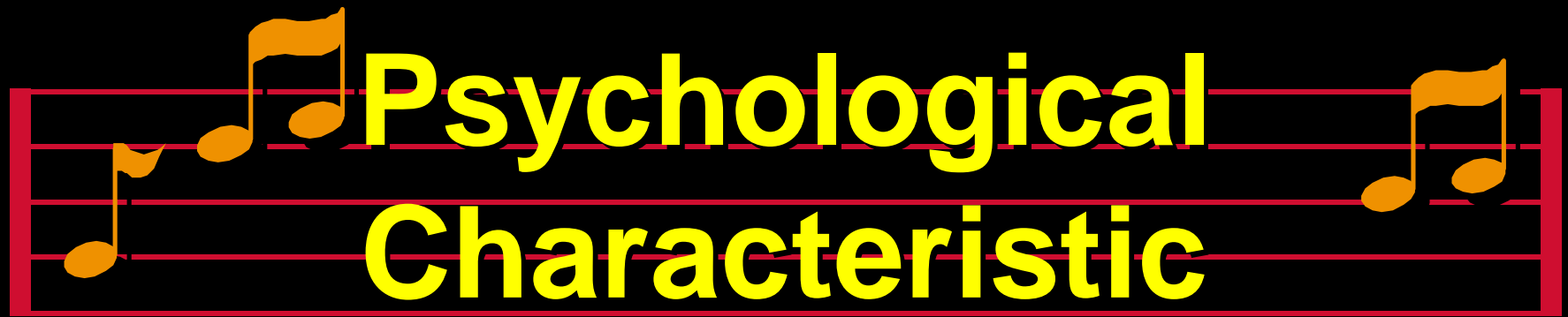


Loudness

A graphic of a musical staff with five red lines. On the left, there are three eighth notes ascending. On the right, there are two eighth notes descending. The title text is centered over the staff.

Psychological Characteristic

For two sounds,
A and **B**,
if $I_A/I_B = 2$,
what do we hear?

A musical staff with five red lines and two orange notes, one on the left and one on the right, framing the title text.

Psychological Characteristic


For two sounds,
A and **B**,
if $SIL_A/SIL_B = 2$,
what do we hear?



The phon is the unit of
Loudness
Level
(LL)




The LL (in phons) of a sound is defined to be numerically equal to the SIL (in dB) of a 1000 Hz tone that sounds equally loud ***to the listener.***

A musical staff with five red lines on a black background. It contains several yellow musical notes: a quarter note on the first line, an eighth note on the second line, a quarter note on the third line, and a half note on the fourth line. There is also a pair of beamed eighth notes on the fourth line. The staff is enclosed in a red rectangular box.

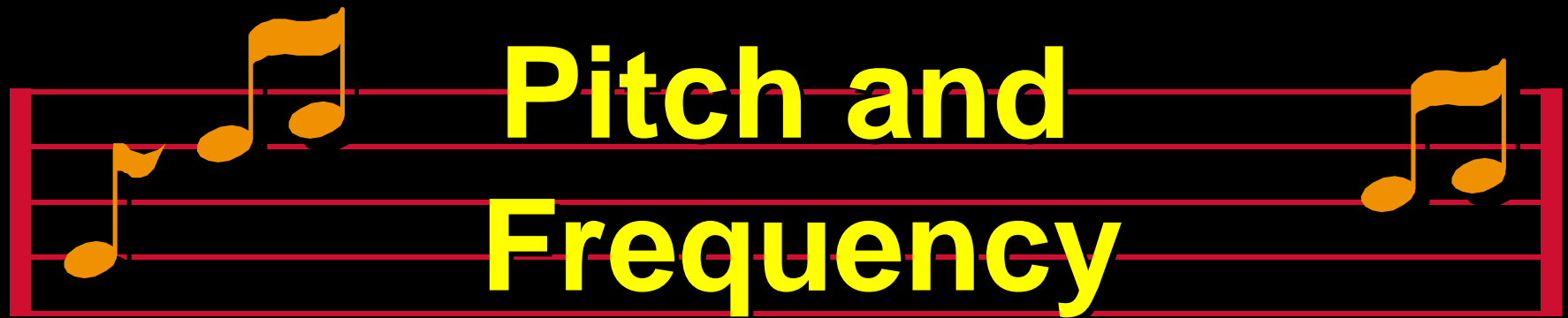
Physical Characteristics

Frequency

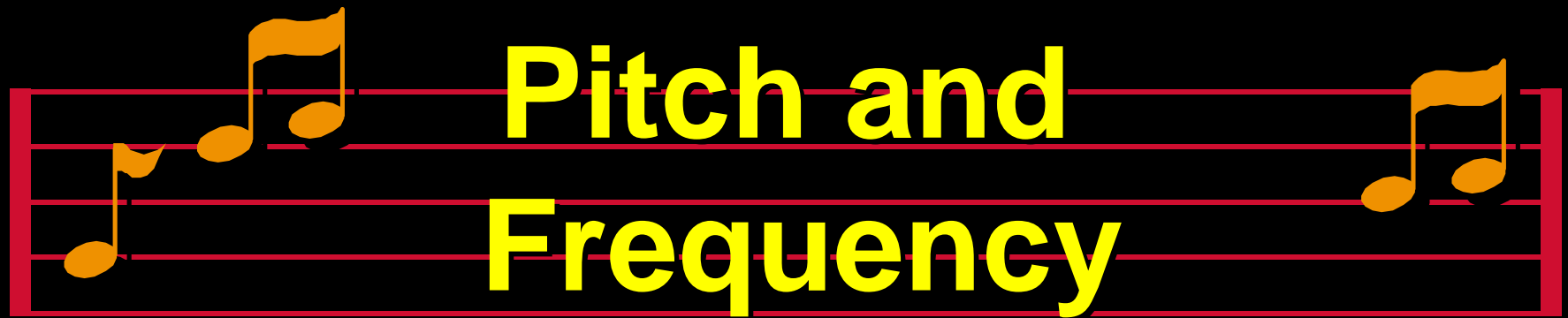
A musical staff with five red lines on a black background. It contains several orange musical notes: a quarter note on the first line, an eighth note on the second line, a quarter note on the third line, and a half note on the fourth line. There are also some smaller, less distinct notes. The staff is enclosed in a red rectangular box.

Psychological Characteristic

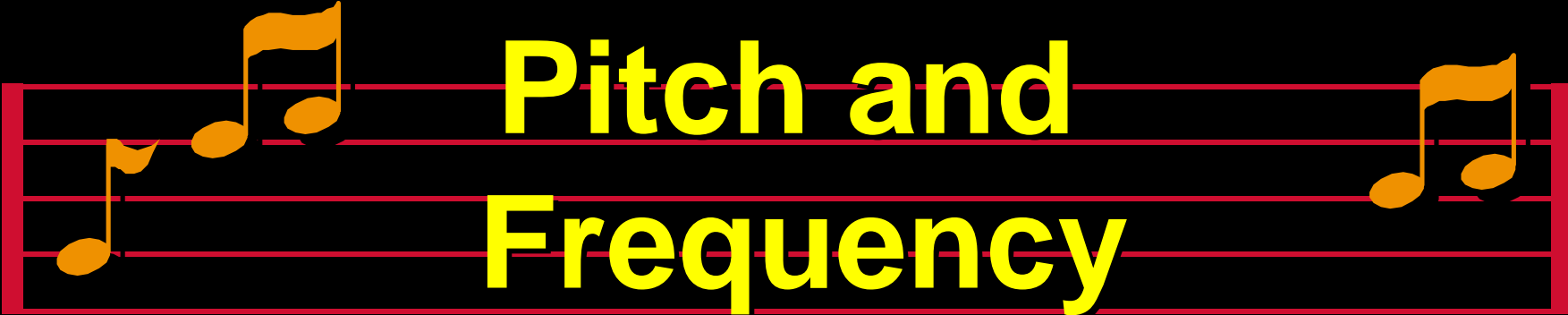
Pitch



If note **A** *sounds* twice as high in pitch as note **B**, it is found that the *frequency* of **A** is twice that of **B**.



- Natural unit of pitch is the **Octave**.
- Simple relationship between pitch and frequency.

A musical staff with five red lines on a black background. On the left, there are three orange eighth notes ascending in pitch. On the right, there are two orange eighth notes descending in pitch. The title text is centered over the staff.

Pitch and Frequency

Demo with keyboard.



The loudness of a sound depends on the frequency of the sound.



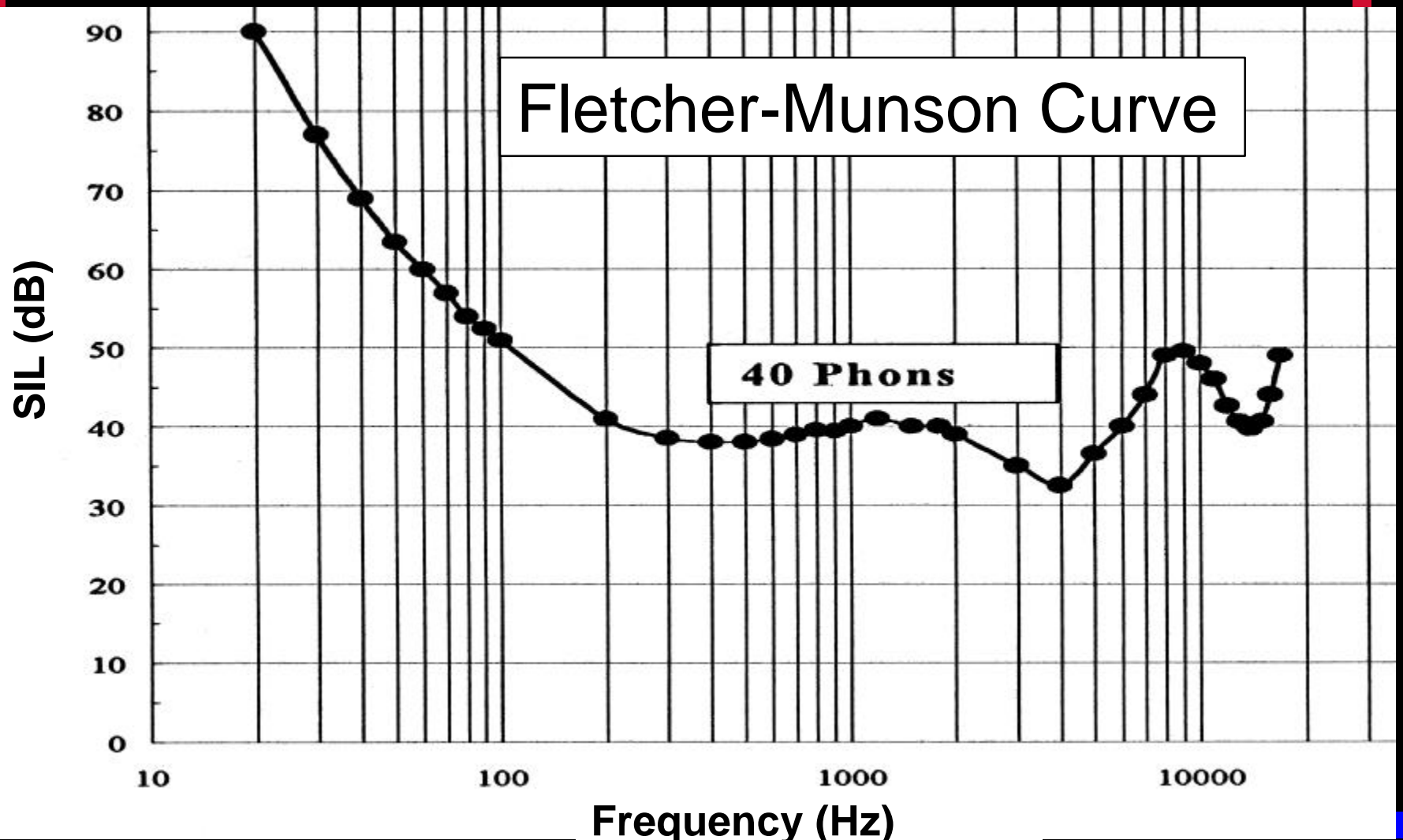
1. Play 1000 Hz at $SIL=40$ dB.
2. Play 100 Hz. Ask listener to adjust for the same loudness.
3. Repeat for many frequencies



Experiment

<u>f(Hz)</u>	<u>SIL (dB)</u>	<u>f(Hz)</u>	<u>SIL (dB)</u>
20	90	2000	39
50	64	4000	32
100	51	6000	36
500	38	8000	49
1000	40 defined	10000	48
1500	40	15000	41

Equal Loudness Contour



A graphic of a musical staff with five red lines. Several yellow musical notes are placed on the staff, some with stems and flags. The text "Loudness changes with Frequency" is written in yellow across the staff.

Loudness changes with Frequency

Auditory Demo CD
Tracks 17 and 18



Hearing is most sensitive in the range 2,500 – 5,000 Hz. Why?

Ear canal is a tube closed at one end

$$\lambda = 4L = 4(2.5 \text{ cm}) = 10 \text{ cm}$$

$$f = v/\lambda = 344 \text{ m/s} / 0.1 \text{ m} = 3,440 \text{ Hz!}$$

A musical staff with five red lines on a black background. It contains four orange notes: a quarter note on the first line, an eighth note on the second line, a quarter note on the third line, and a half note on the fourth line. The text "Repeat for all SIL's" is written in yellow across the middle of the staff.

Repeat for all SIL's

SIL (dB)

Frequency (Hz)