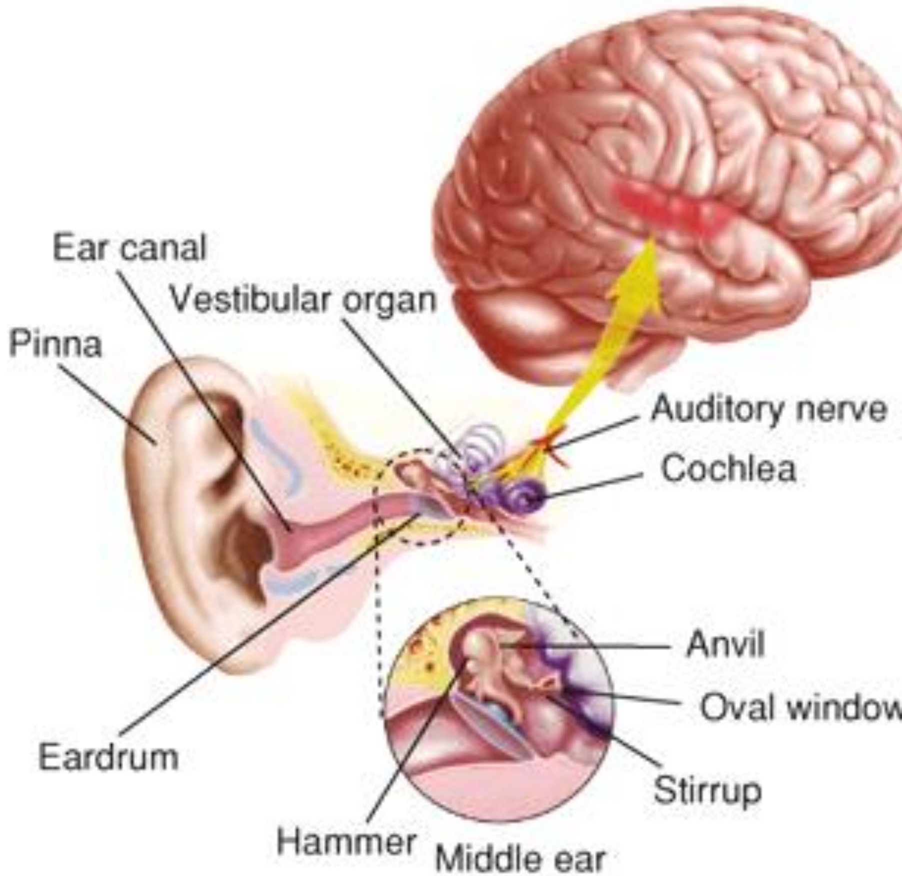
Chapter 26
SOUND

Why it's important:

- Human communication relies on cords vibrating in throats to send waves through gas, liquids, and solids that end up as electrical impulses in listeners' brains.



State Standards Addressed

Waves *Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:*

- *Students know* waves carry energy from one place to another.
- *Students know* how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
- *Students know* how to solve problems involving wavelength, frequency, and wave speed.
- *Students know* sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.
- *Students know* radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3×10^8 m/s (186,000 miles/second).
- *Students know* how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

Chapter 26: Sound

I. The Origin of Sound (26.1)

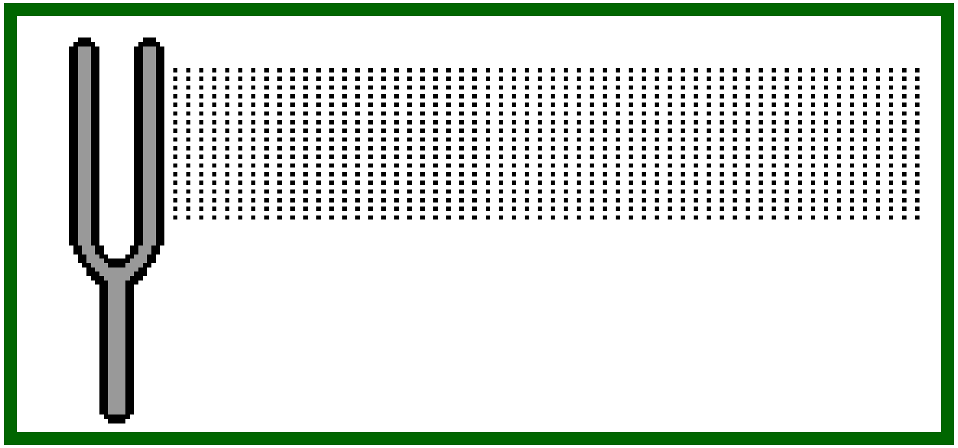
A. All sound is produced by **vibrations** in an object

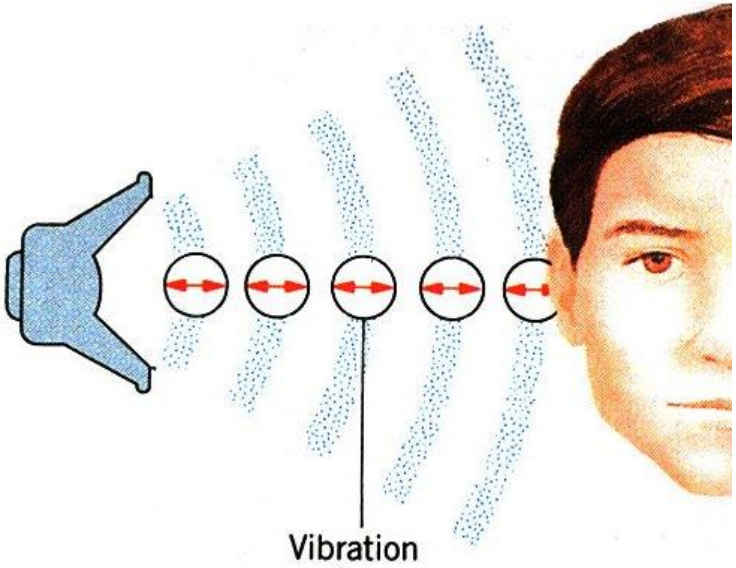
1. Vibrating strings, reed, vocal chords

2. In each case, original vibration **stimulates** the vibration of something **larger** or more **massive**

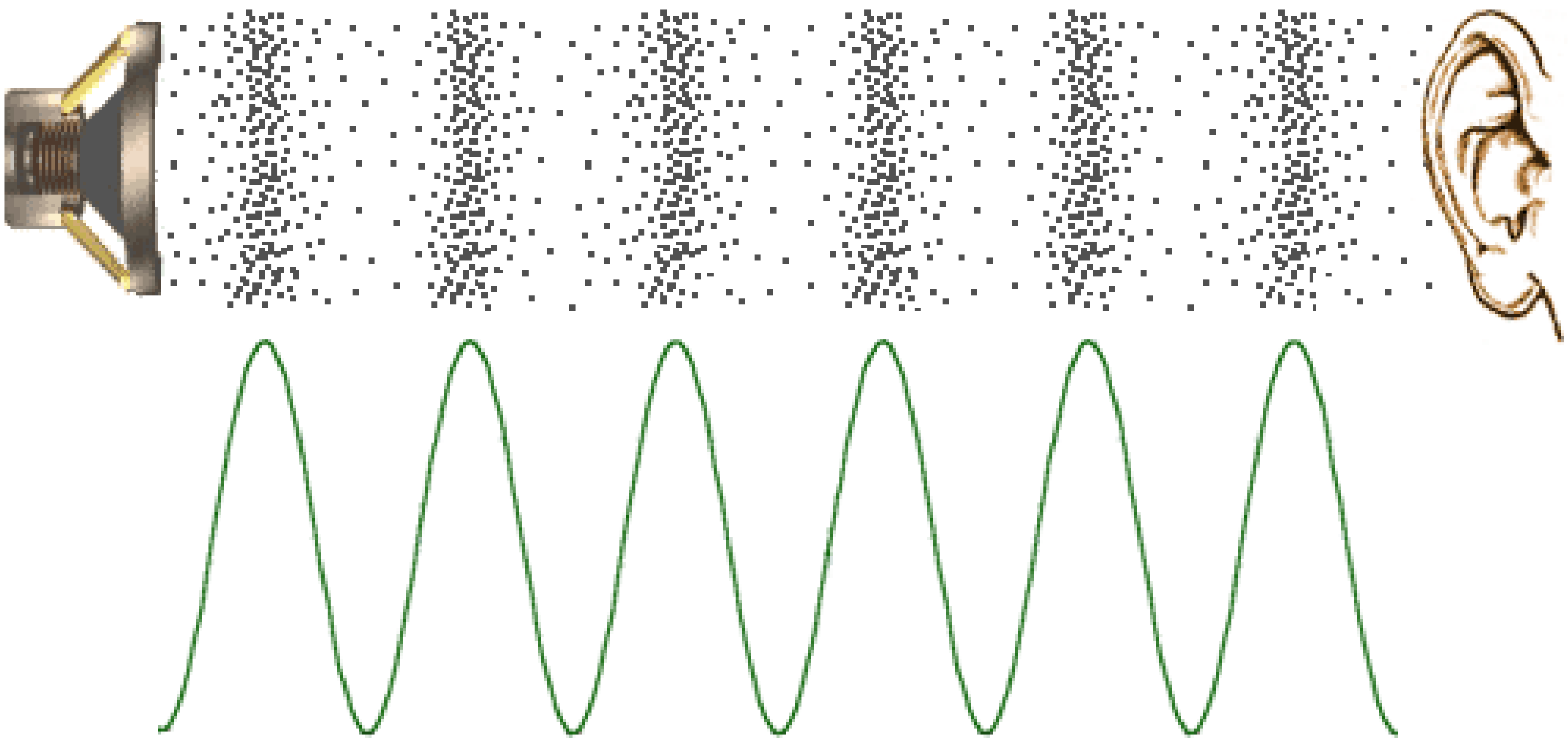
a. E.g. **Sounding board** of a stringed instrument, air column within reed or wind instrument, air in the throat and mouth of singer

b. Then vibrating material sends **disturbance** through a surrounding medium (usually the air)

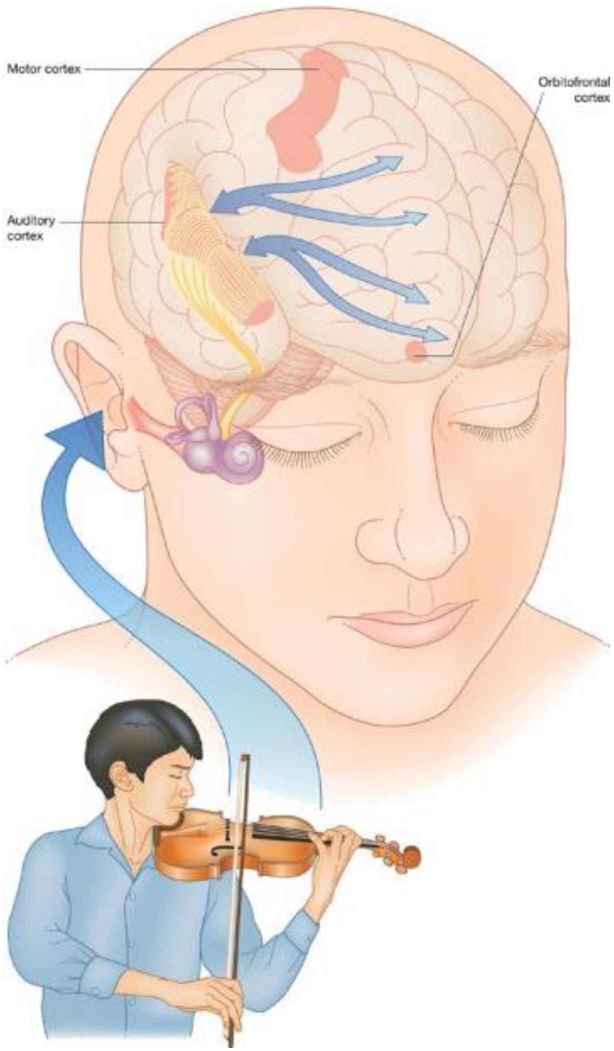




3. Under ordinary conditions, **frequency** of vibrating source **equals** the **frequency** of **sound waves produced**.



B. **Frequency** of sound wave called **pitch**



1. Young person hears pitches from **20 to 20,000 hertz**.
2. As we get older hearing range **shrinks**

3. Sound waves below 20 hertz called **infrasonic**

This frequency range is utilized by seismographs for monitoring earthquakes

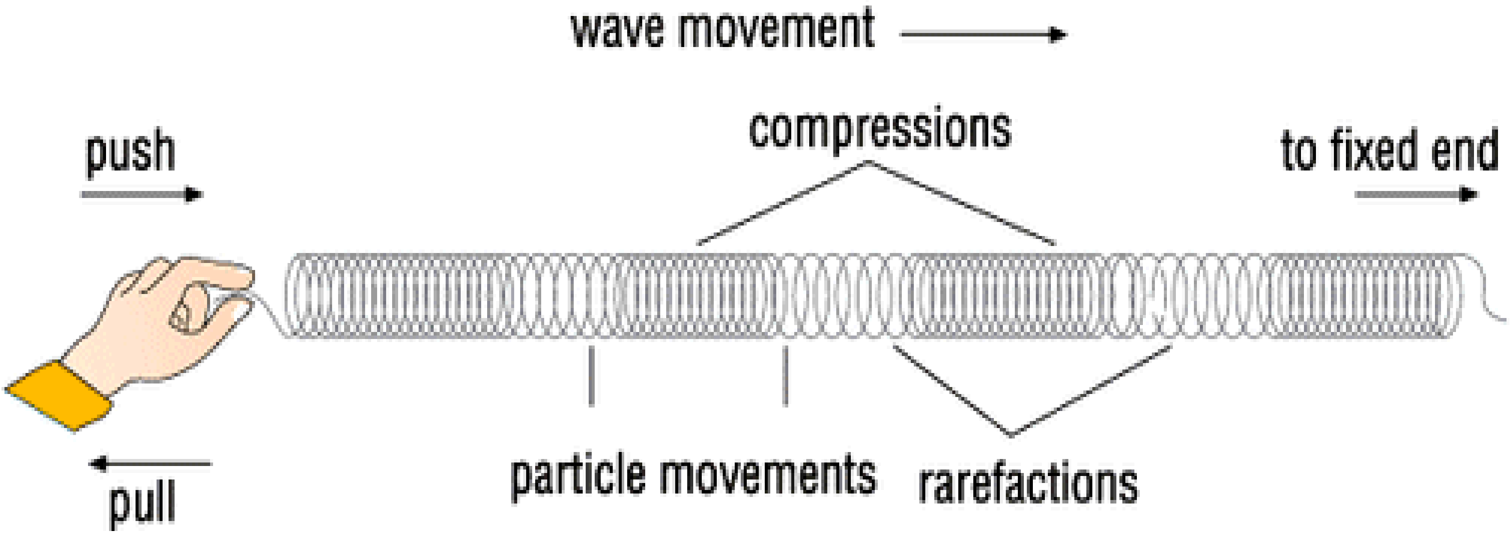
4. Sound waves above 20,000 hertz called **ultrasonic**

5. Cannot hear ultrasonic or infrasonic sound waves

II. Sound in Air (26.2)

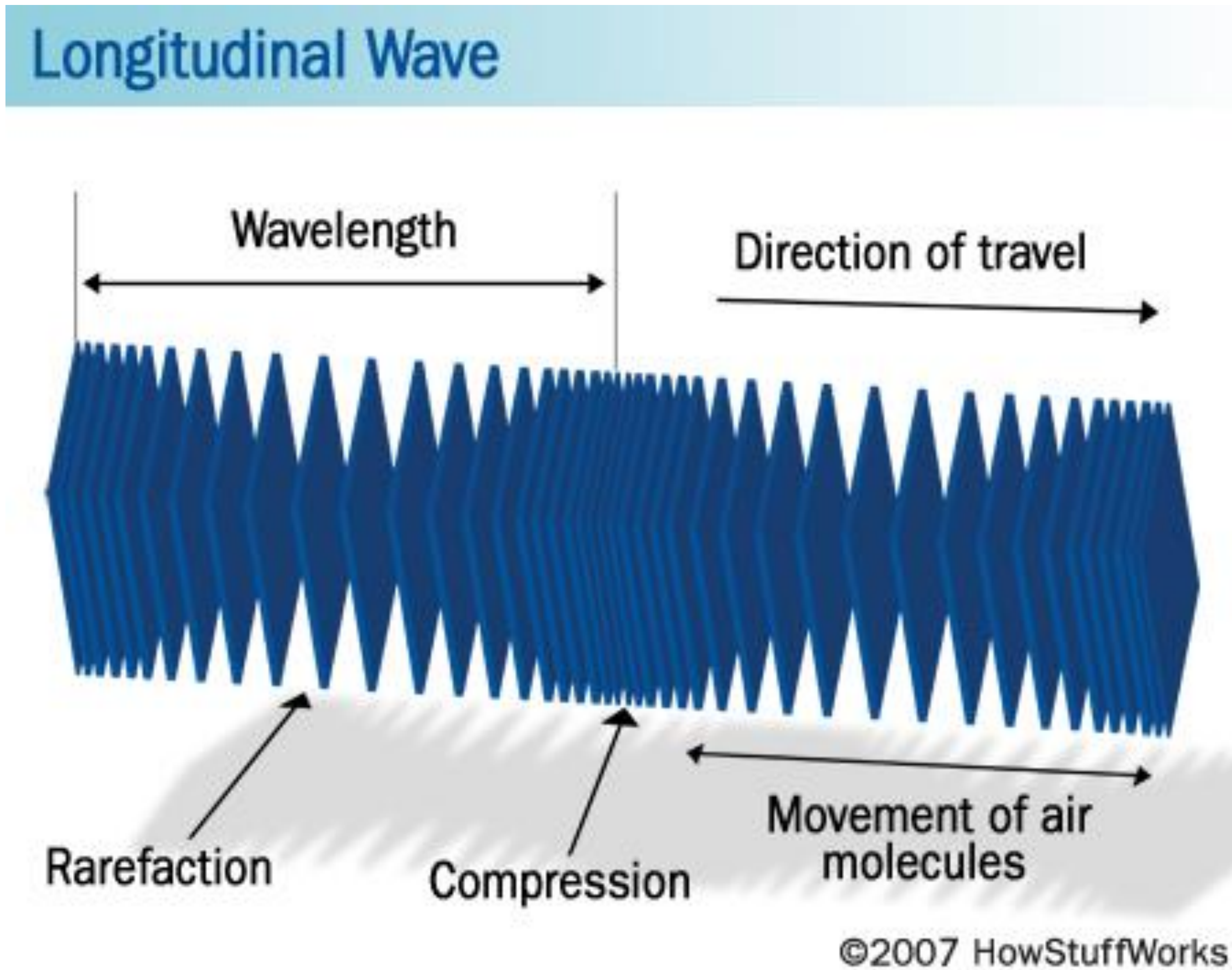
A. Vibration creates **pulse** in air

1. **travels** out in **all directions**
2. **Energy** moves like **compression** wave in spring

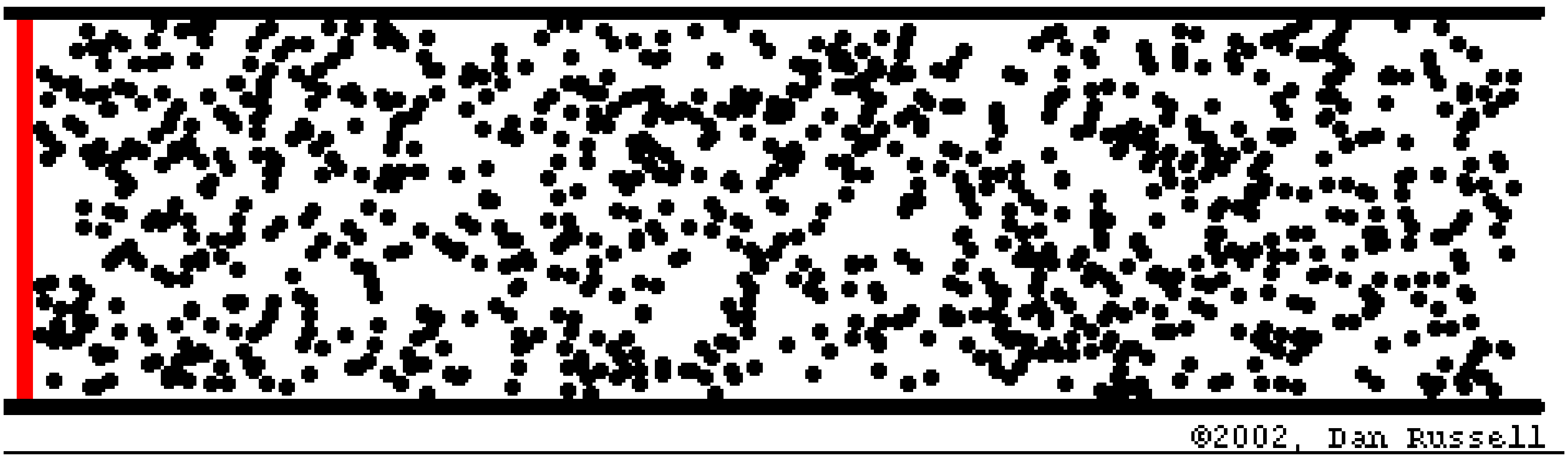


3. Pulse of compressed air is called a **compression**.

4. Areas of lower-pressure air in between compressions called **rarefaction** (rarefied regions)



B. For all waves, it is not the **medium** that travels, but a **pulse** that travels.



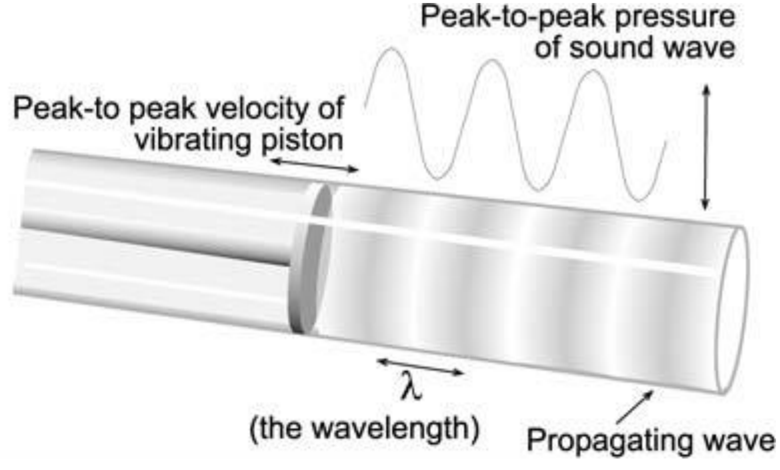
III. Media that Transmit Sound (26.3)

A. Most sounds you hear are transmitted through **air.**

B. **Solids** and **liquids** are generally good conductors of sound.

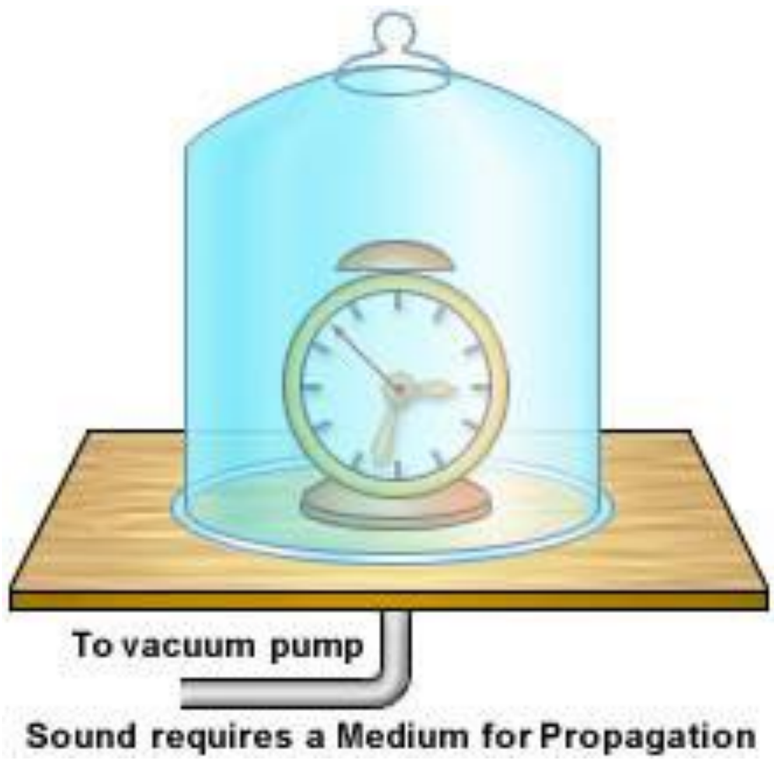
1. In general sound transmitted faster in **liquids** than **gasses.**

2. Faster still in **solids.**



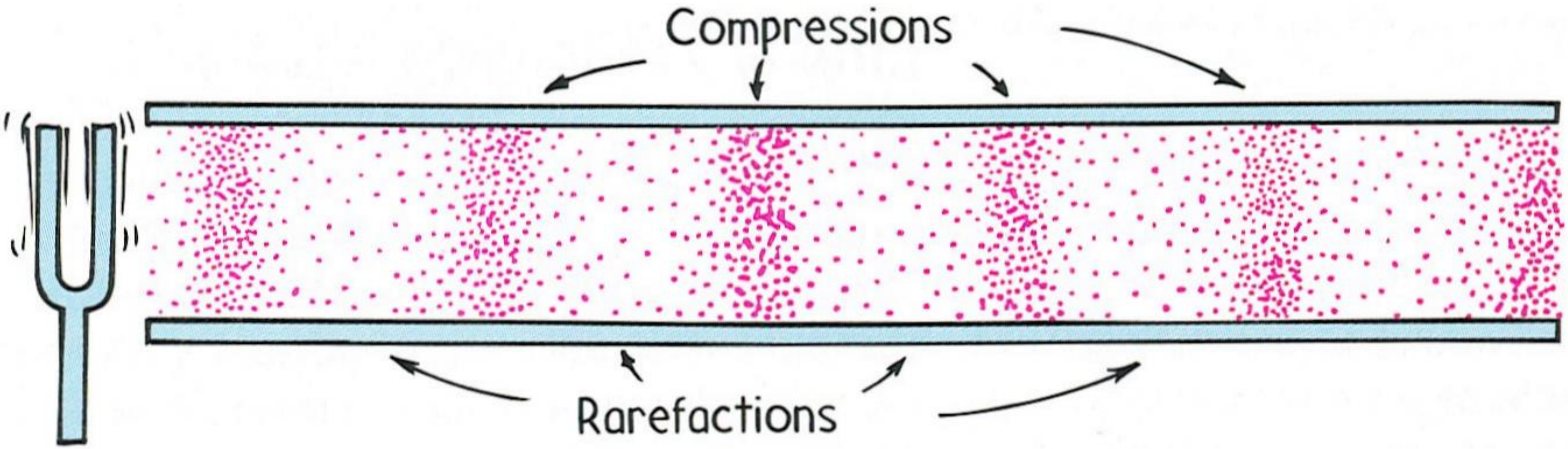
C. Sound **cannot** travel in a vacuum

1. **Transmission of sound requires a medium**
2. There may be a vibration, but without medium, no sound



IV. Speed of Sound (26.4)

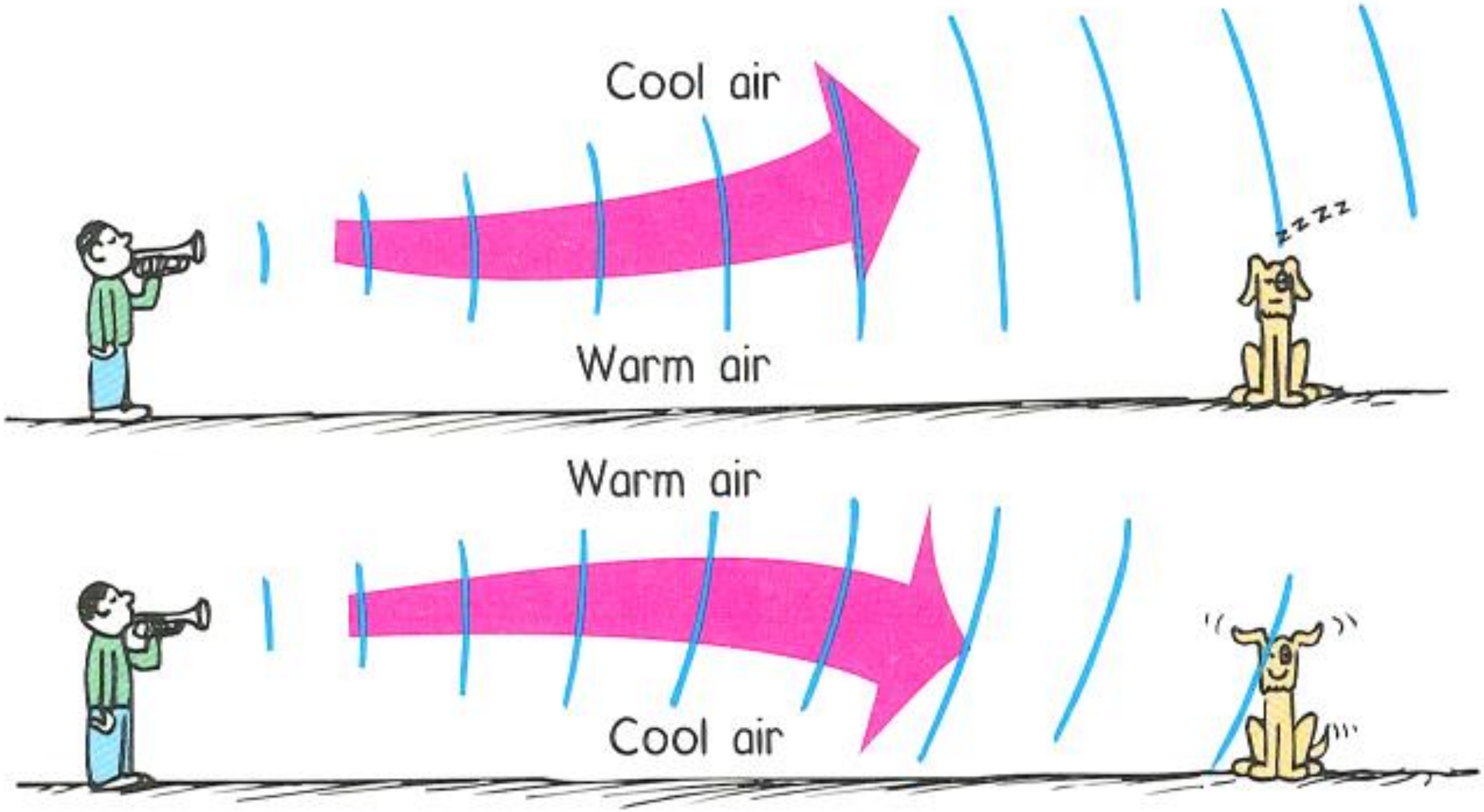
A. Speed of sound in dry air at 0°C is about **330 m/s** (or about 1200 kilometers per hour)



1. **Water vapor** in air increases speed slightly
2. **Increased temperature** increases speed (For each degree increase in air temperature, the speed increases by 0.60 m/s)
3. **Speed at room temperature of about 20°C is 340 m/s**

Medium	Velocity of sound at 0□C (m/s)
Air	331
Oxygen	460
Alcohol	1213
Water	1435
Copper	3560
Iron	5130

Temperature □C	Velocity of sound (m/s)
0	331
20	344
100	386
500	553
1000	700

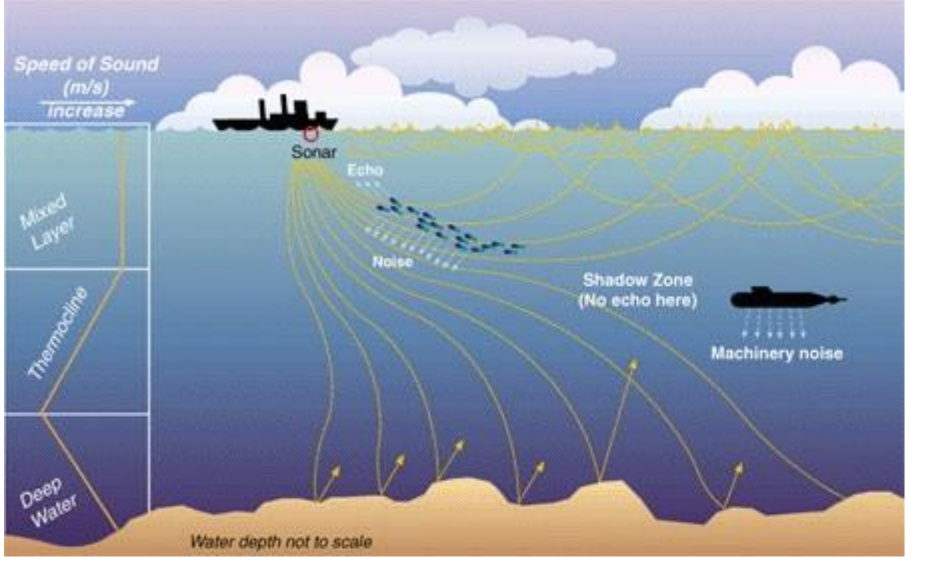

Cool air
Warm air
Warm air
Cool air

B. Speed of sound in a material depends on its **elasticity** not its **density**

1. **Elasticity** is ability of material to change shape in response to an applied force, and then resume its initial shape. Once distortion is removed (steel is elastic, putty is inelastic)

2. Sound travels 15 times faster in steel than air,

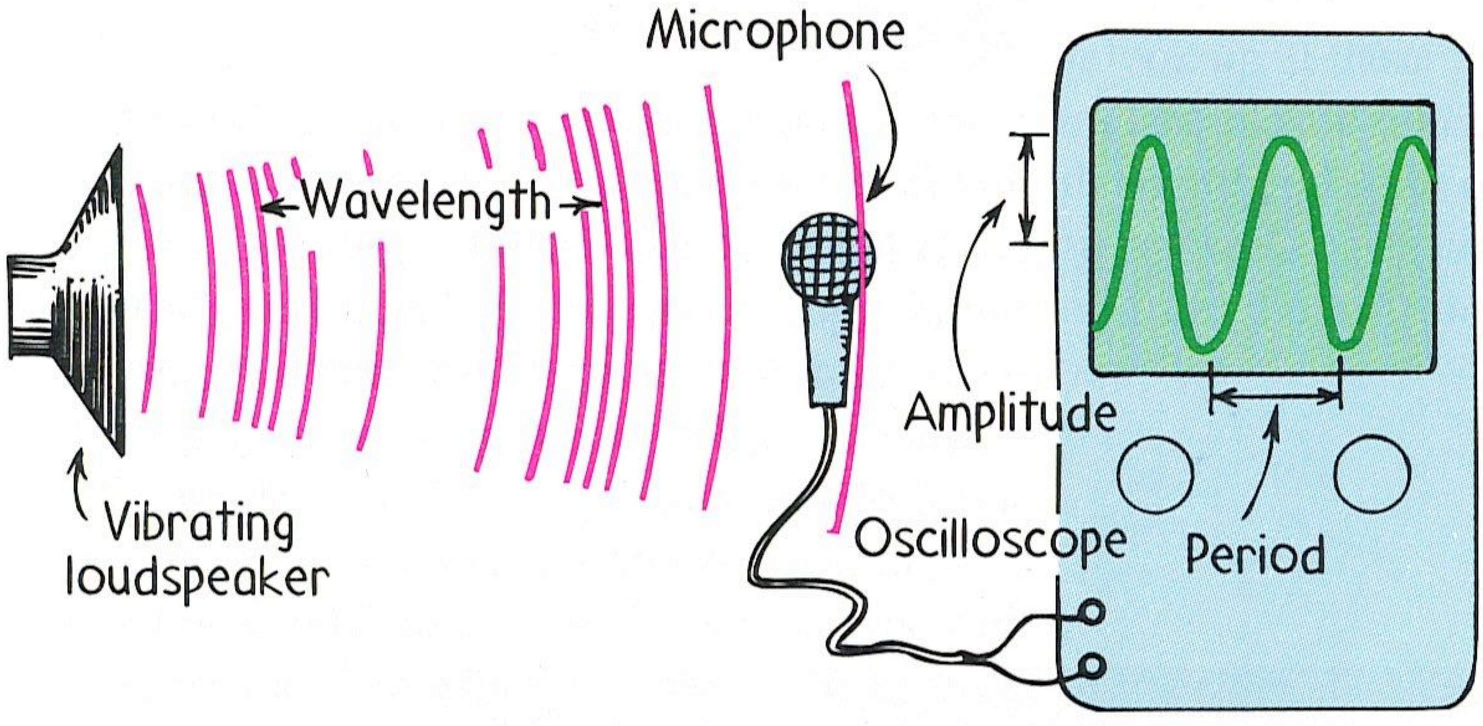
4 times faster in water.



V. Loudness (26.5)

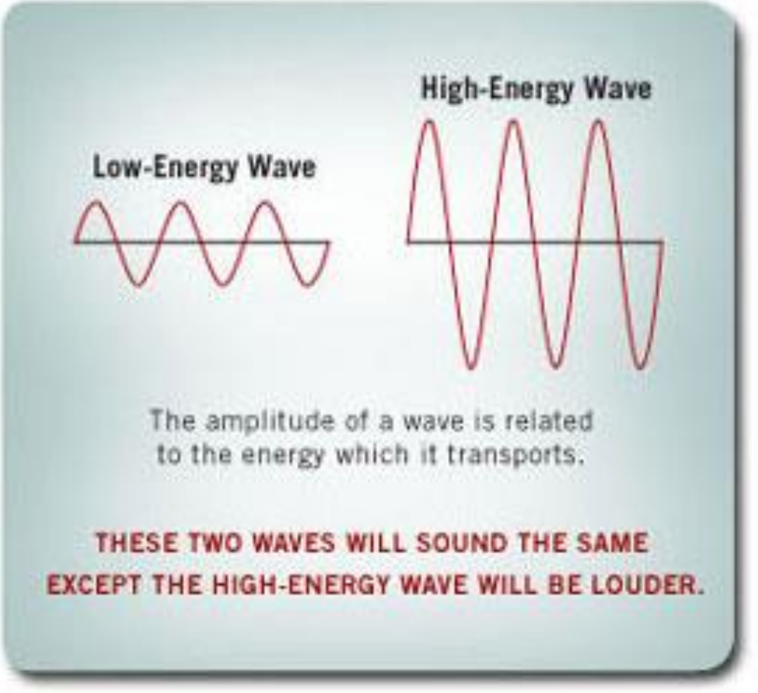
A. **Intensity** of a sound waves is **proportional to square ofamplitude** of a sound wave

1. An **objective** measurement
2. Use **oscilloscope** to measure



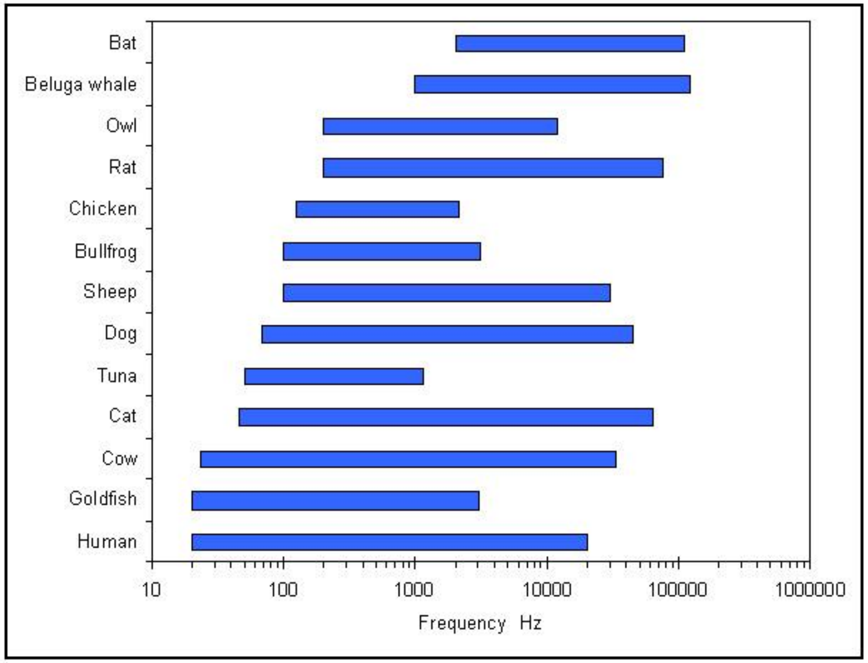
B. **Loudness** is a physiological sensation sensed in the brain

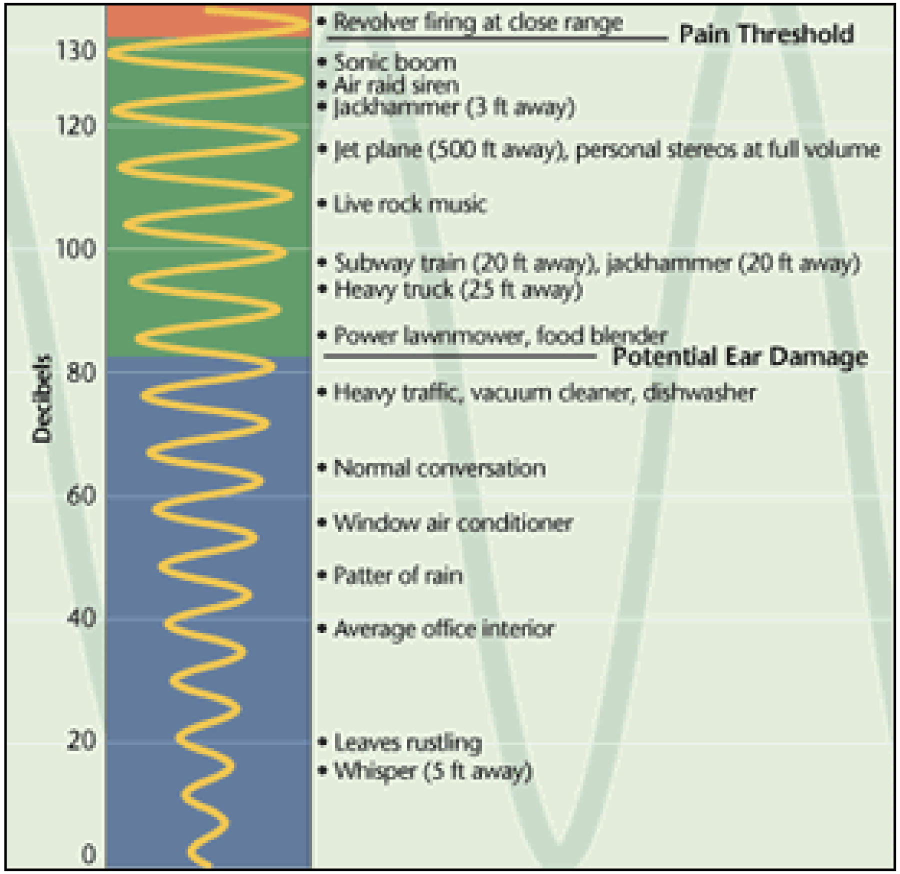
1. Is a **subjective** measurement, but related to **sound intensity**
2. Loudness varies as the logarithm of intensity (**powers of ten)**



C. Intensity measured in **decibels (dB)**

1. **0 dB** threshold of hearing for normal ear
2. Increase of 10 dB is increase by factor of **ten** (20 dB is 100 times more intense than 0 dB)

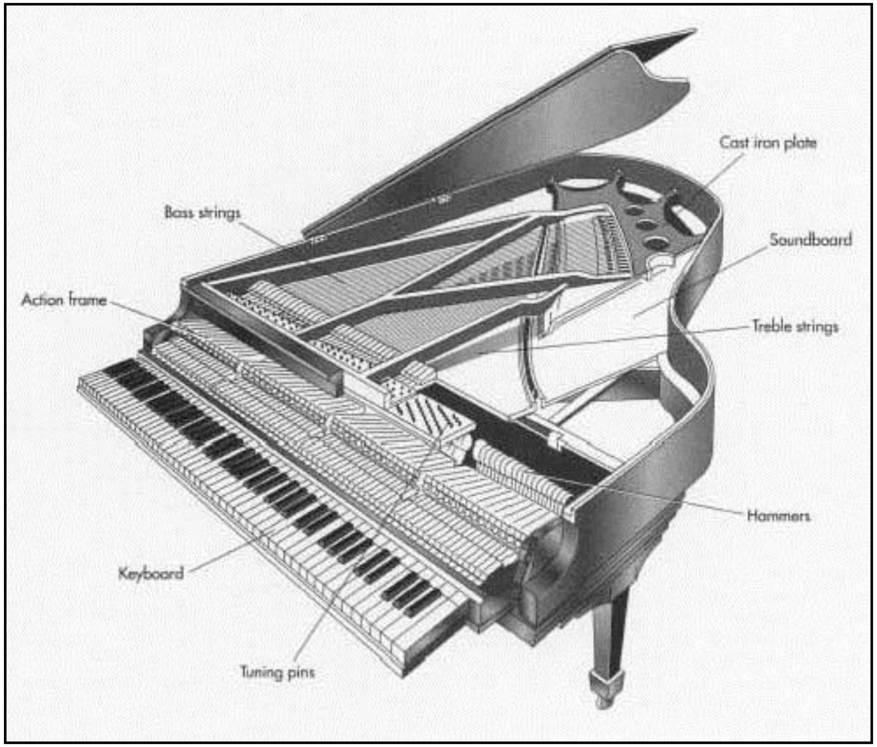




VI. Forced Vibration (26.6)

A. **Forced vibration**- like the soundboard on a guitar. Is forced to vibrate by vibrations of strings

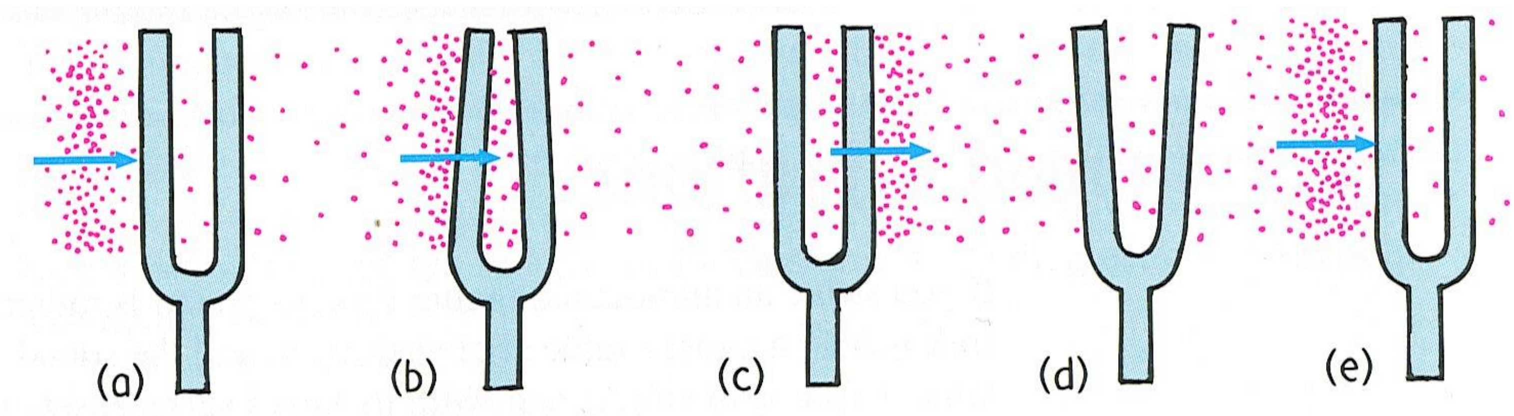
B. Increases the loudness. Important for all stringed musical instruments



VII. Natural Frequency (26.7)

A. Every object composed of an elastic material will vibrate at its own special set of frequencies when disturbed, which together form its special sound. Natural frequency-unique to each object

B. **natural frequency** is one at which **minimum energy** is required to produce forced vibrations and frequency that requires the least energy to continue vibration

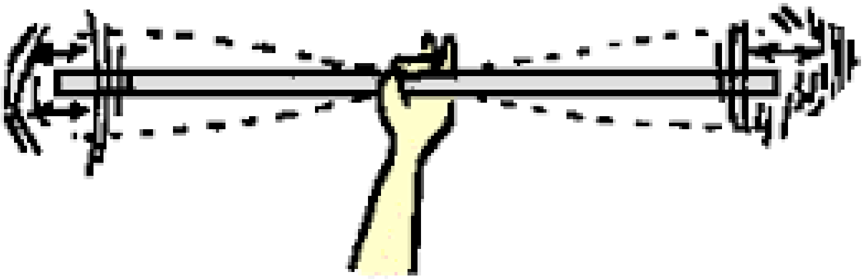


VIII. Resonance (26.8)

A. **resonance**- increase in amplitude when frequency of forced vibration matches the objects natural frequency.

1. resonance means to “resound” of “sound again”

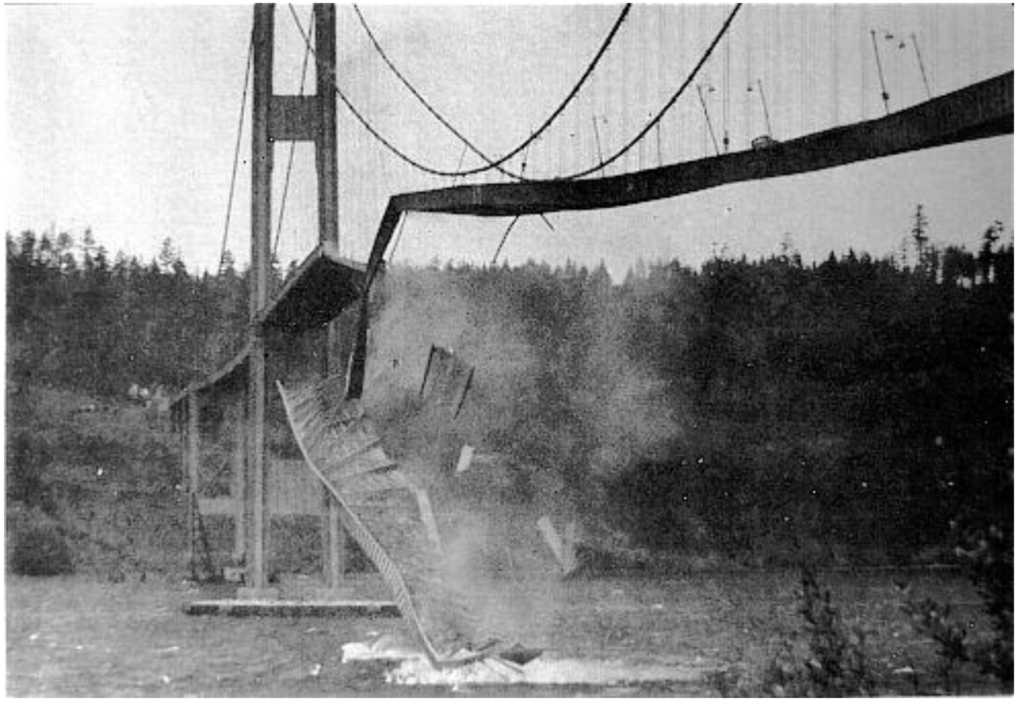
2. requires force to pull it back to starting position and enough energy to keep it vibrating

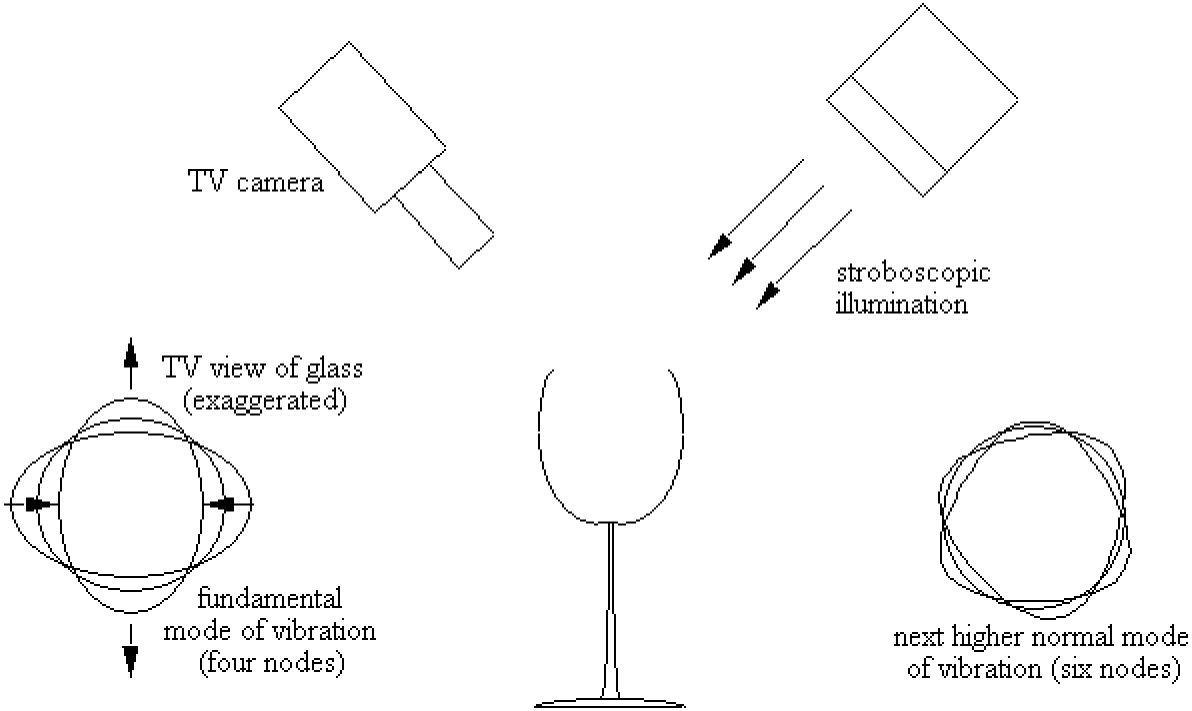


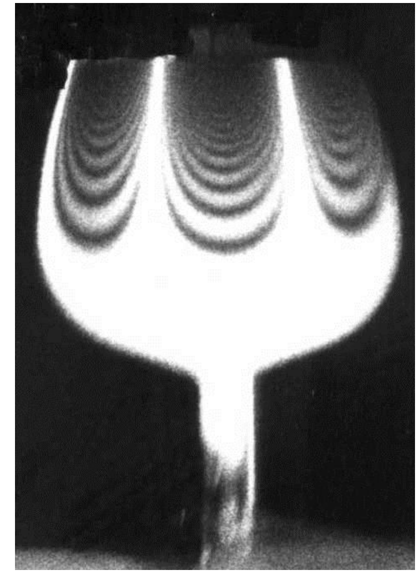
A vibrating metal rod forces the air column inside into vibrations at the same frequency - resonance occurs.

B. Resonance <u>not</u> restricted to wave motion

1. Occurs whenever successive impulses are applied to vibrating object in rhythm with its natural frequency
2. Example- Tacoma Narrows Bridge collapse




TV camera
stroboscopic
illumination
TV view of glass
(exaggerated)
fundamental
mode of vibration
(four nodes)
next higher normal mode
of vibration (six nodes)




B&W camera
DAT Recorder (optional)
Amplifier
Strobe
Digital Counter
Bias Voltage
Support Clamp
Frequency
Generator
Fuse Holder
Eye and Ear Protection

IX. Interference (26.9)

A. Sound waves (like any waves) can be made to interfere

1. Crest overlaps crest of another wave (**constructive interference**) = **increase** in amplitude

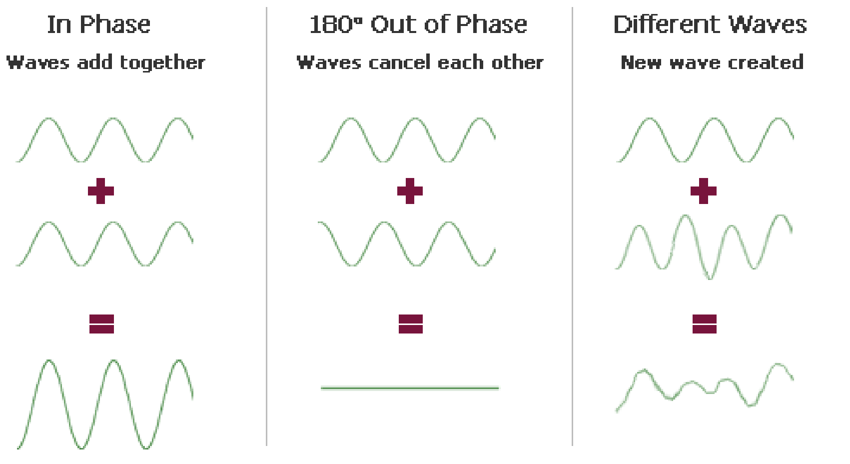
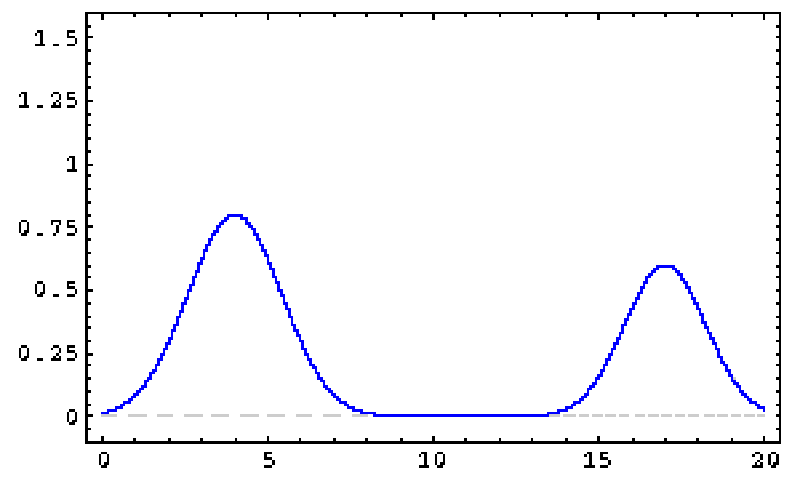
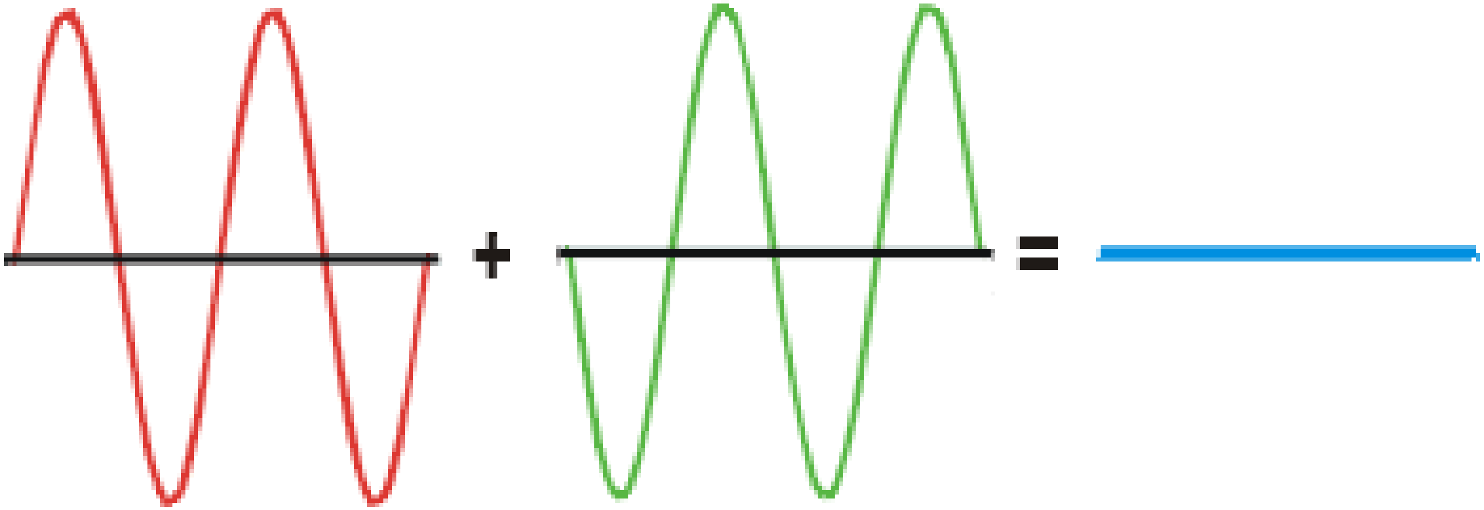


Image courtesy of www.mediacollege.com



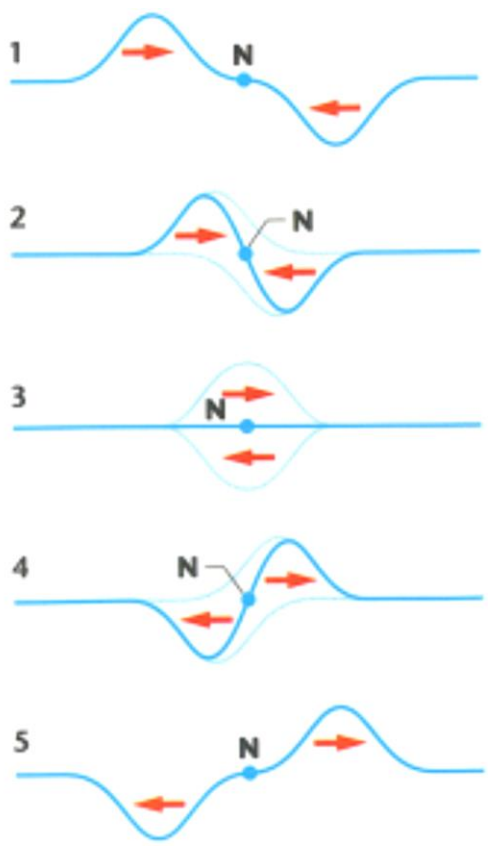
2. Crests overlaps troughs of another wave (**destructive interference**) = **decrease** in amplitude

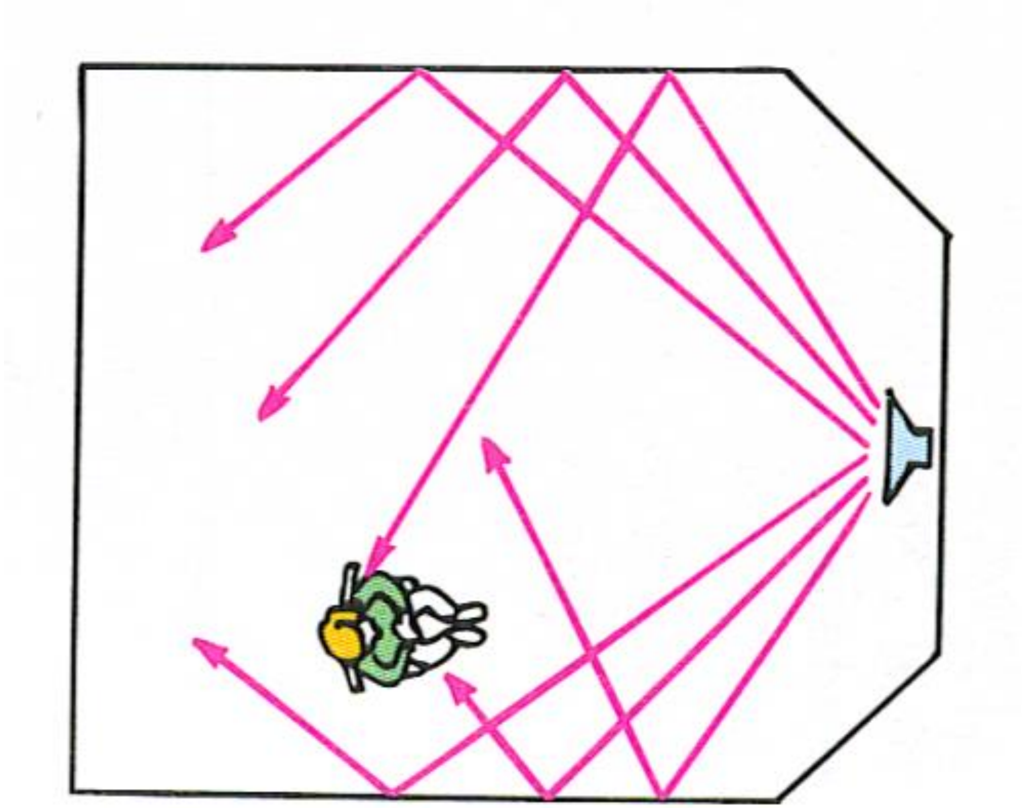


B. Interference affects loudness

1. Waves arrive **in phase** then waves **add**

2. Waves arrive out of phase then destructive

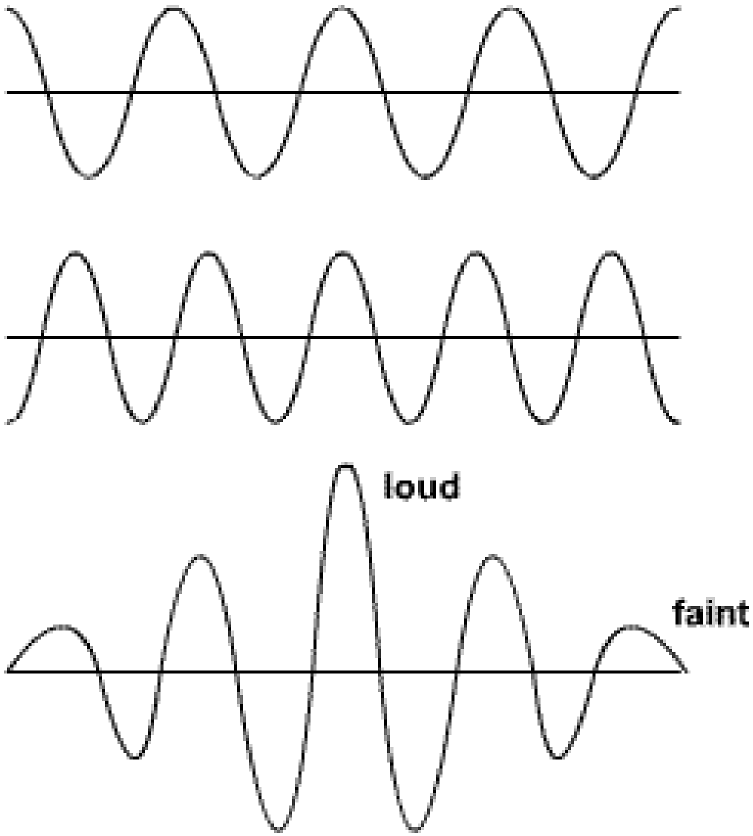




X. Beats (26.10)

A. Interesting case of interference

1. Occurs when tones of slightly different frequency are sounded together.

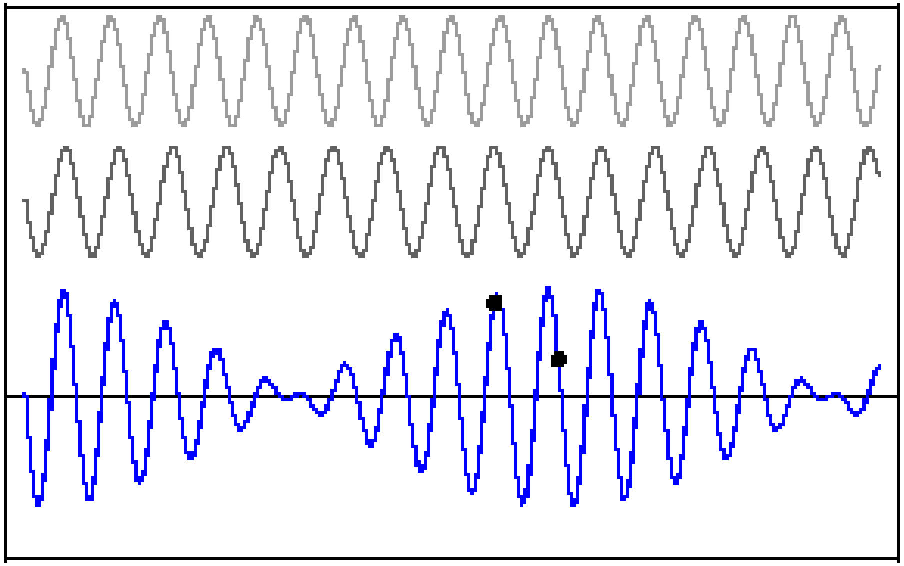


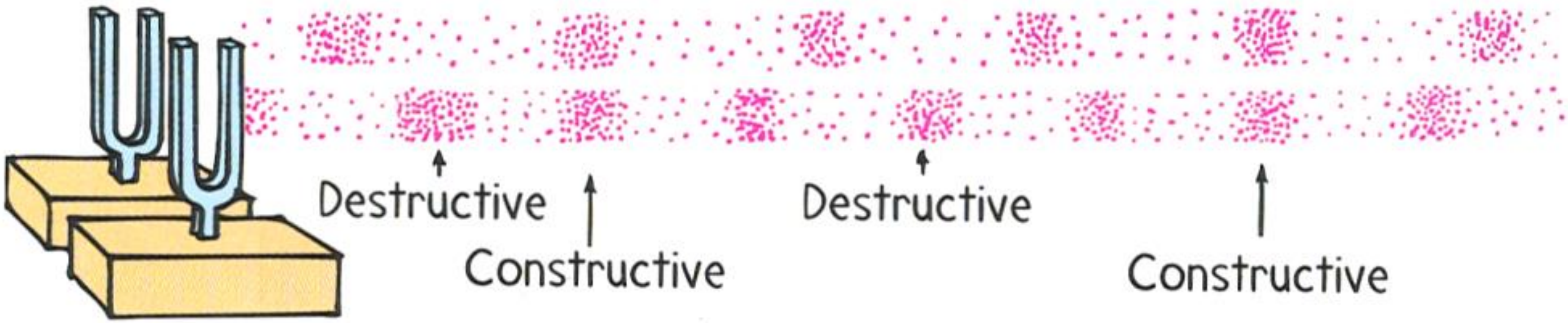
2. Fluctuation of loudness of combined sounds is heard (sound is loud, then faint, then loud, then faint, and so on)
3. Called **beats**

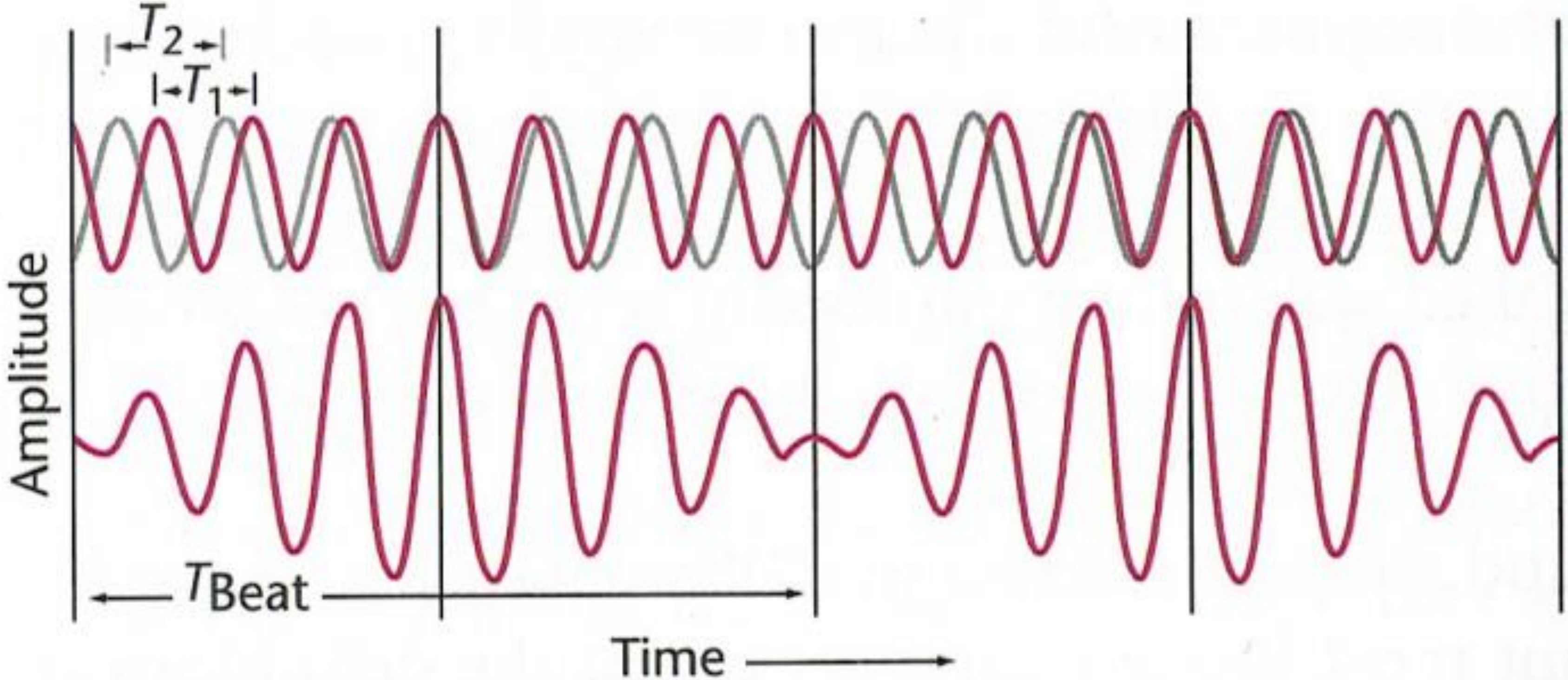
B. Beats can occur in any kind of waves

1. Used to tune musical instruments

2. When frequencies the <u>same</u> the beats **disappear**




Destructive
Constructive
Destructive
Constructive

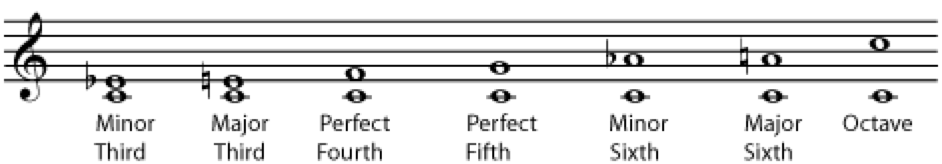

T_2
T_1
Amplitude
T_{Beat}
Time

Detection of Pressure Waves

The human ear

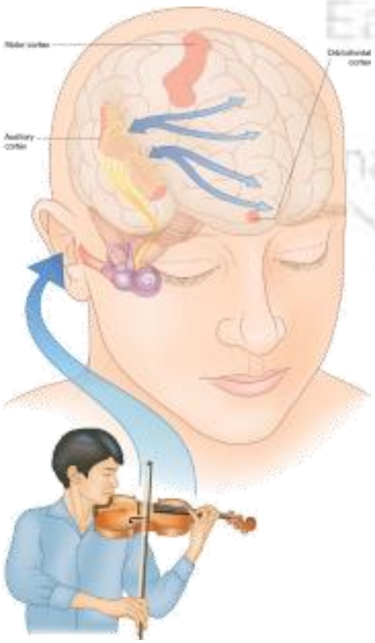
Sensitive to both **frequency**, **amplitude**, and different **qualities** of sound (***dissonance*** and ***consonance***)

dissonance- an unpleasant set of pitches



consonance- pleasant combination of pitches

Human ear collects **pressure waves** and converts them to **electrical impulses**



Sound waves enter ear and cause vibrations of the ***tympanic membrane***

Tiny bones transfer vibrations to fluid in ***cochlea*.**

Tiny hairs in **cochlea** pick up certain frequencies out of the ***fluid vibration***

Hairs stimulate ***nerve cells*,** sending impulse to brain - producing sensation of sound

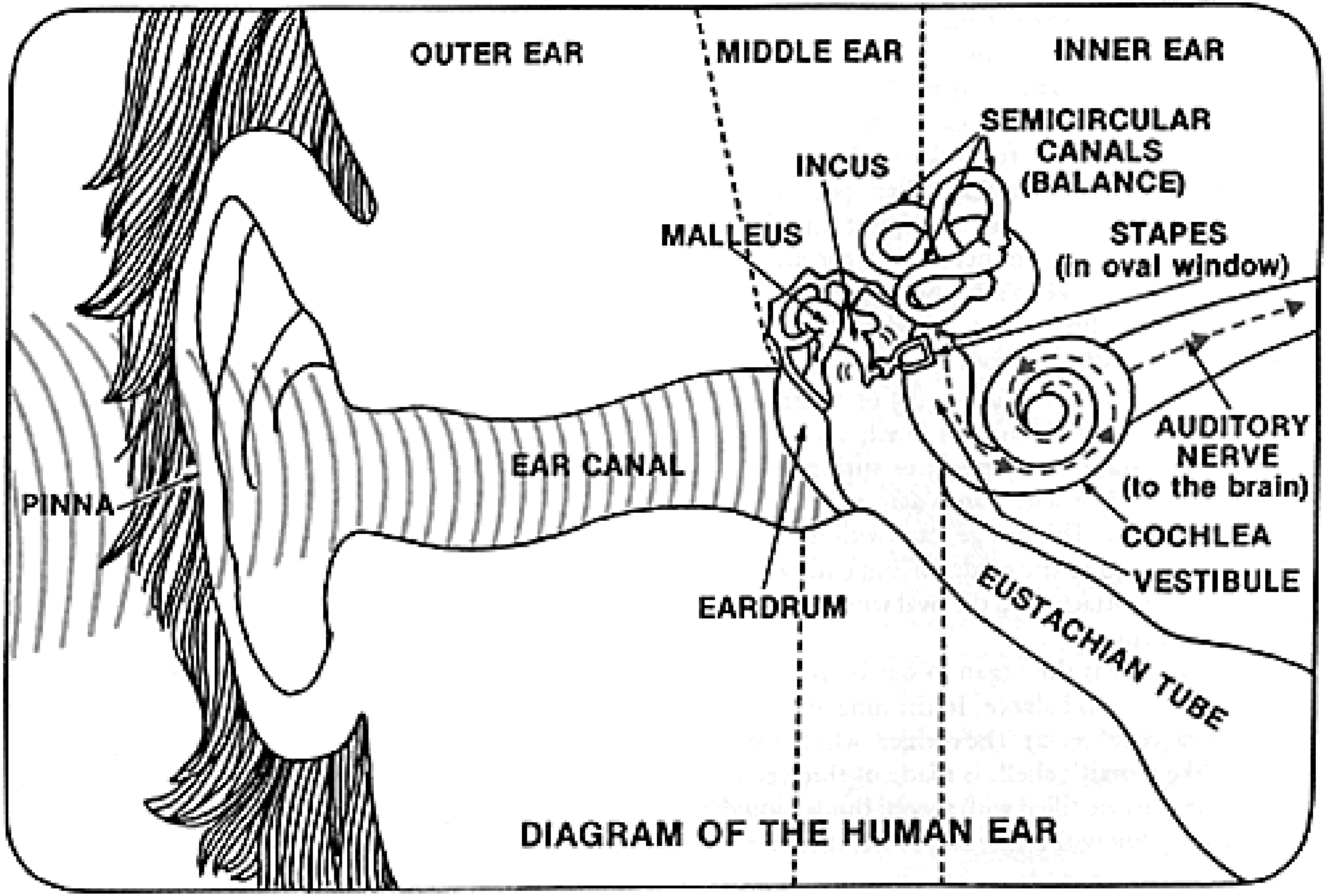


DIAGRAM OF THE HUMAN EAR