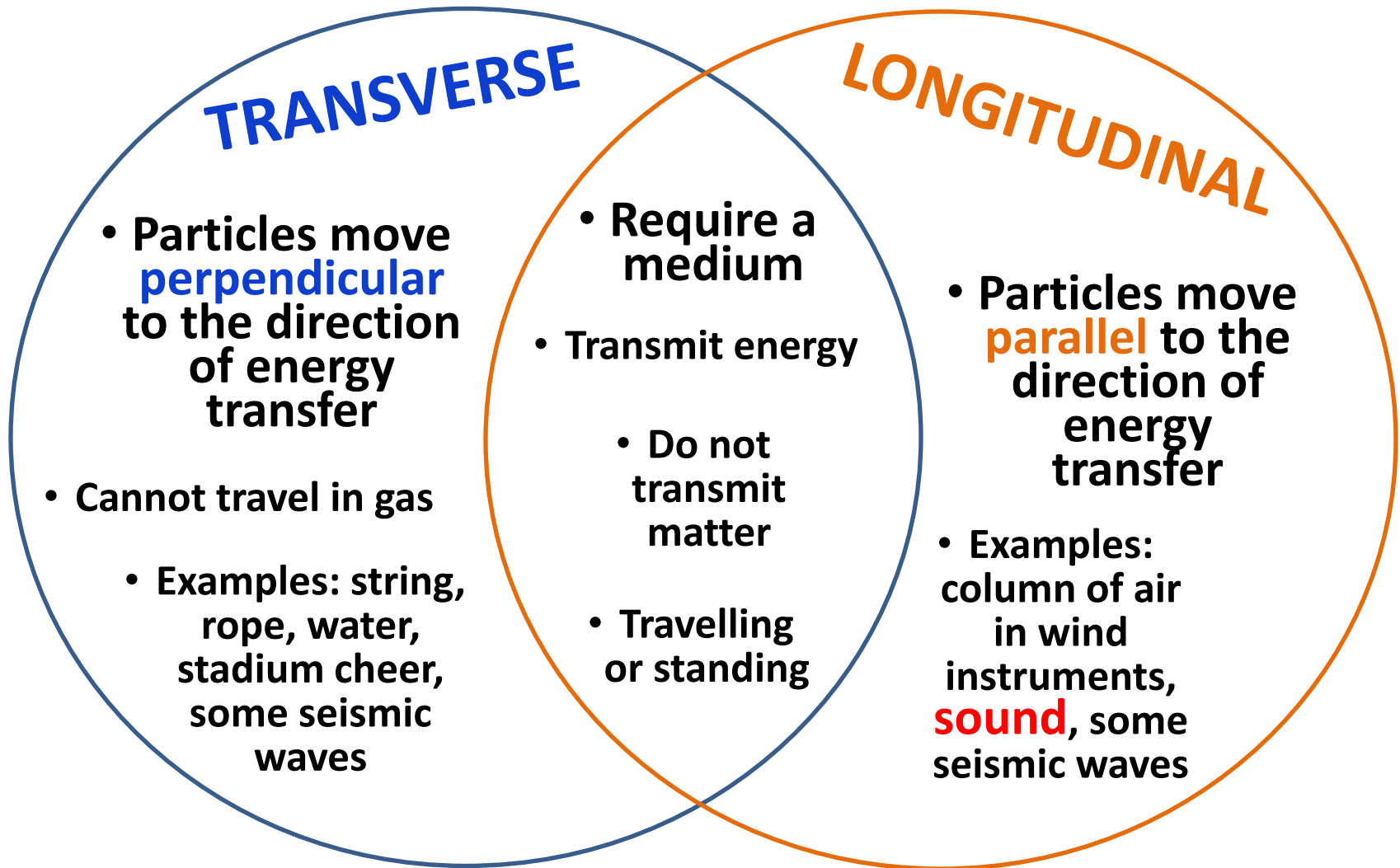
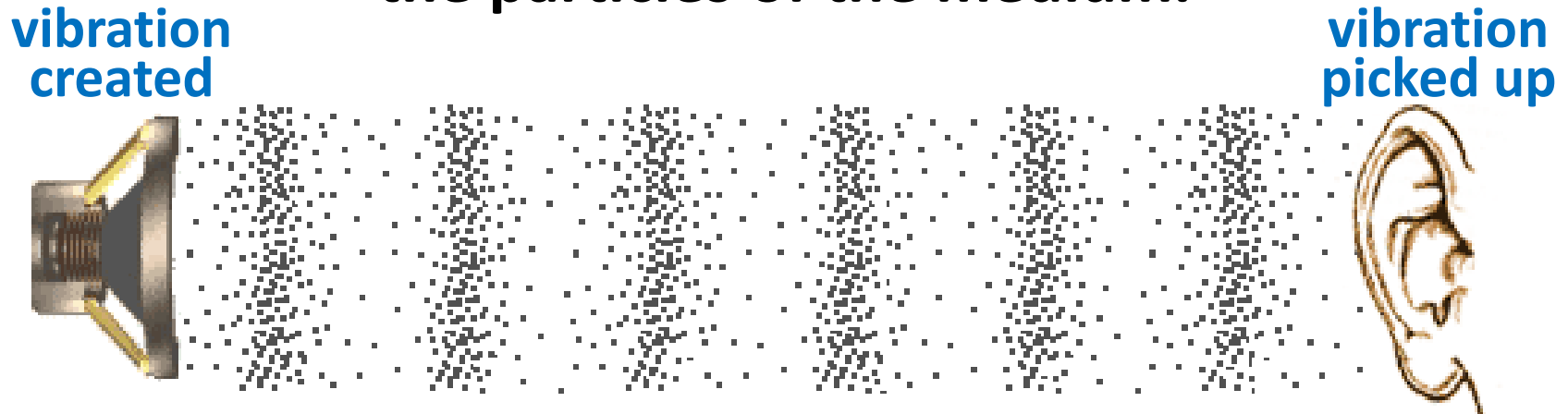


Mechanical Waves Summary



What is SOUND?

- Sound is a travelling longitudinal mechanical wave, that results from the back-and-forth vibration of the particles of the medium.

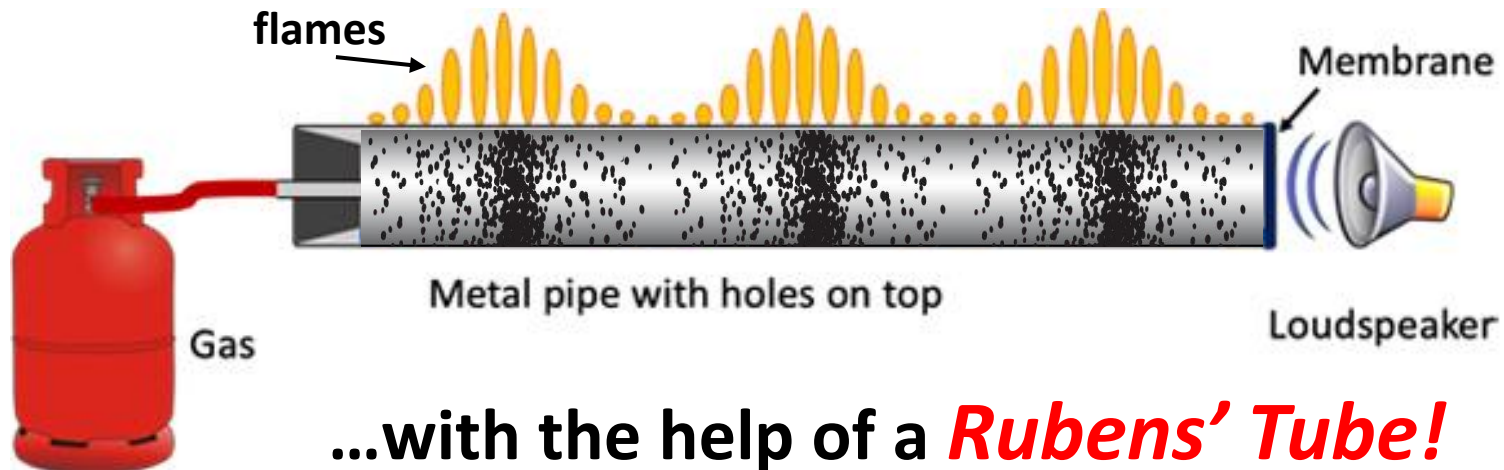


- Sound waves consist of areas of high and low pressure and therefore can be regarded as **pressure waves**:
 - “*compressions*” correspond to *higher pressure*
 - “*expansions*” or “*rarefactions*” correspond to *lower pressure*

How to describe sound?

Loud/Soft
Amplitude
High/Low
Speed
Frequency

We *hear* sound, but we also can *visualize* sound waves...

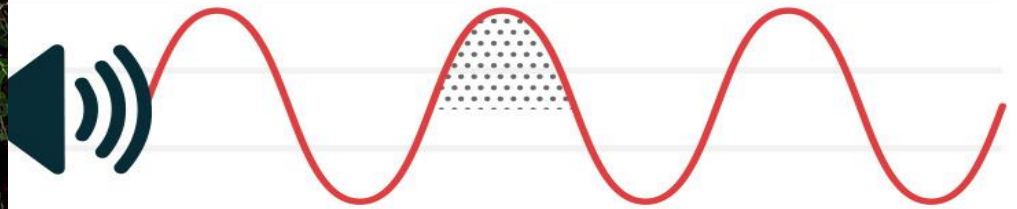


...with the help of a *Rubens' Tube!*

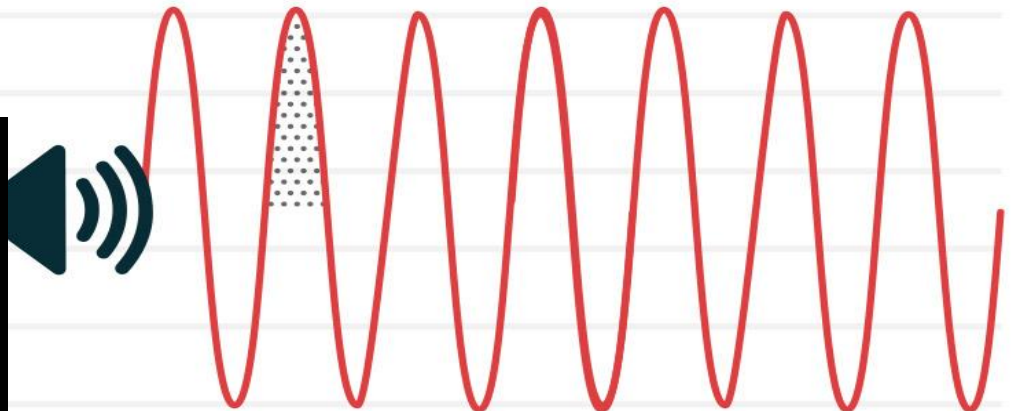
Sound waves: Pitch



Low **Frequency** = Low Pitch

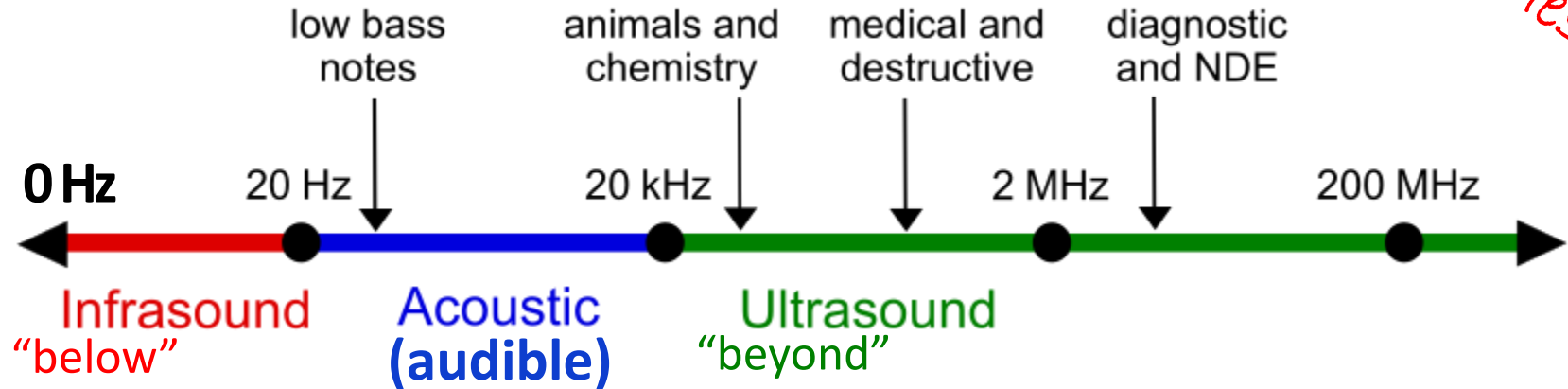


High **Frequency** = High Pitch

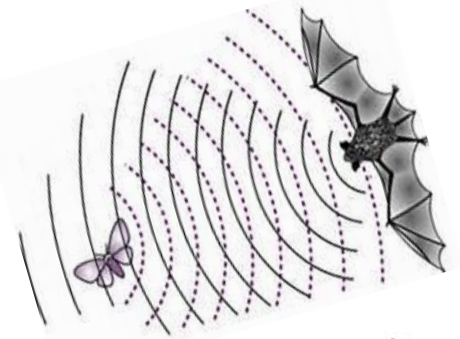


Sound waves spectrum

all possible pitches



- Humans can **hear** sound waves that have **frequencies between about 20 Hz and 20 kHz**.
- Sound waves **above 20 kHz** are known as **ultrasound**. Animals such as bats and porpoises use ultrasound for locating prey and obstacles.
- Sound waves **below 20 Hz** are known as **infrasound**. Whales, elephants and other animals can detect infrasound and use it to communicate.



Natural sounds: fun facts

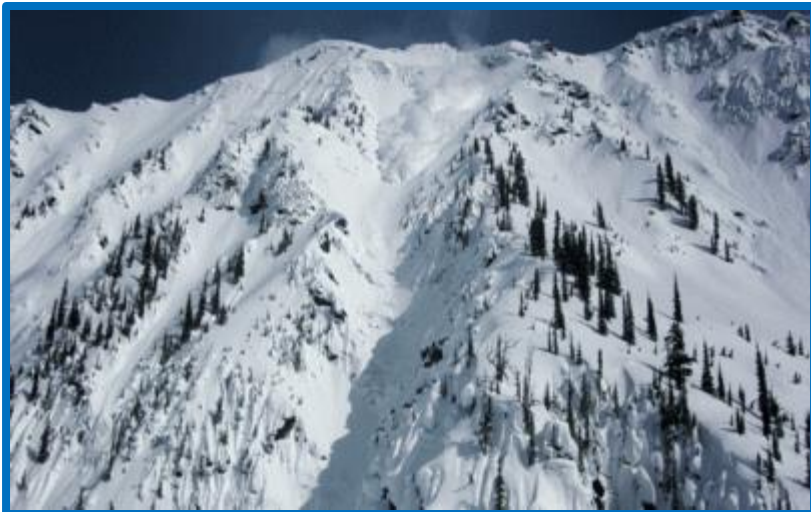
- ❖ Bats use **ultrasound** for hunting purposes...so many nocturnal insects have good ultrasonic hearing to help them escape being caught.
- ❖ *Tiger moth* can even produce ultrasound “clicks” itself!
- ❖ Hearing range of many medium-sized mammals, including dogs, cats and deer, extends into the **ultrasound** range; however they are not able to produce ultrasound themselves.



- ❖ Among all animals, the lowest **infrasound** frequencies (~3 Hz) are produced by *Sumatran rhinos*.

Natural sounds: more facts

- ❖ The rumbling vocalizations of *elephants* extend well into **infrasound** range and, being extremely loud, are used for long-distance (up to 10 km or over 6 miles!) communication.
- ❖ Sources of **infrasound** in nature include volcanoes, avalanches, earthquakes, hurricanes, and meteorites.



What is Music?

Music (from Greek “Art of the Muses”) is the **art of arranging sounds in time** to produce a composition through the elements of melody, harmony, rhythm, and timbre.

(this definition is from "The American Heritage Dictionary")



Nine Muses:

Calliope, Clio, Euterpe, Thalia, Melpomene, Terpsichore, Polyhymnia, Erato, Urania.

- Both *harmony* (simultaneously played sounds) and *melody* (sequence of sounds) are based on the use of **intervals**.
- An **interval** is the **difference in pitch** between two sounds.

Mathematics of Intervals

- From *perception point of view*, musical intervals can be typically described as **consonant** (stable, pleasant) and **dissonant** (unstable, tense).



- *Scientifically speaking*, the human ear is a **sound detector that is sensitive to RATIOS of frequencies** (pitches of the sounds) rather than to just *differences* in establishing musical intervals.

- *Mathematically*, music **intervals perceived to be most consonant** are composed of **small integer ratios of frequency**.

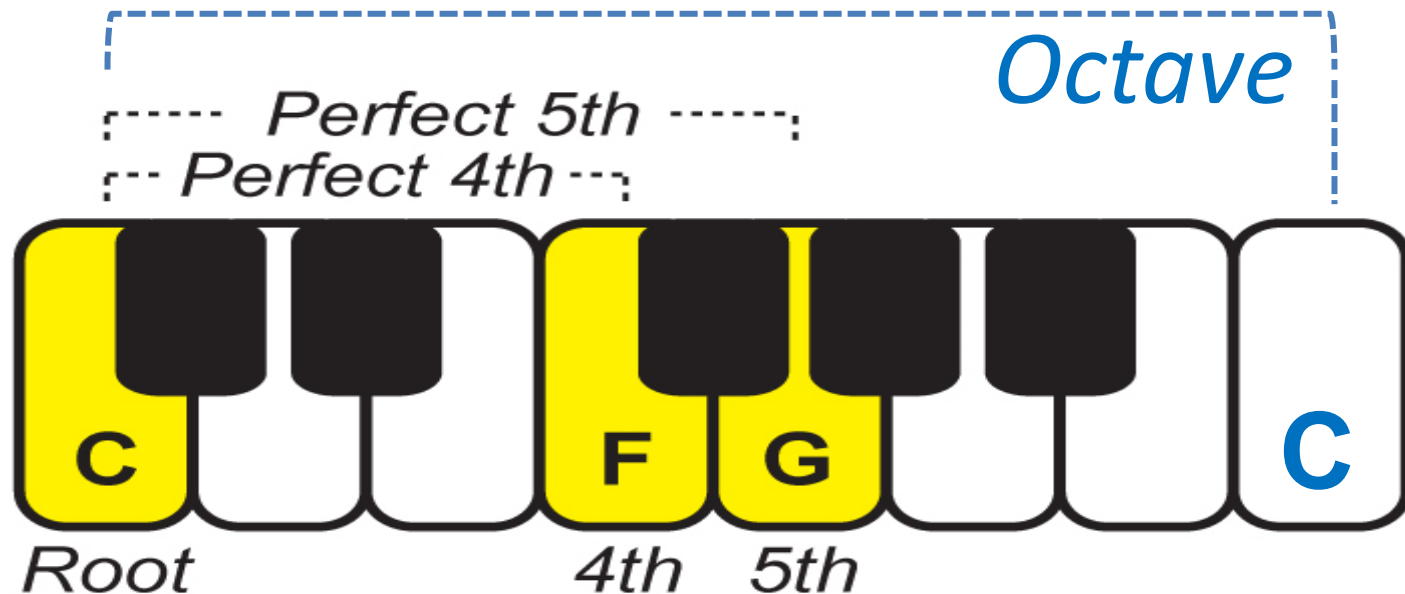


(Examples of *small integer ratios*: 1:2, 3:2, 5:4 and so on)

This “mathematical simplicity” is believed to be the very reason for universally “pleasant” sensation of consonant intervals!

Perfect Musical Intervals

have been **considered to be consonant throughout history by essentially all cultures** and therefore form the basis for music scales.



Perfect 4th – 5 semitones (“here comes the bride”)

Perfect 5th – 7 semitones (“twinkle, twinkle little star”)

Octave – 12 semitones (“somewhere over the rainbow”)