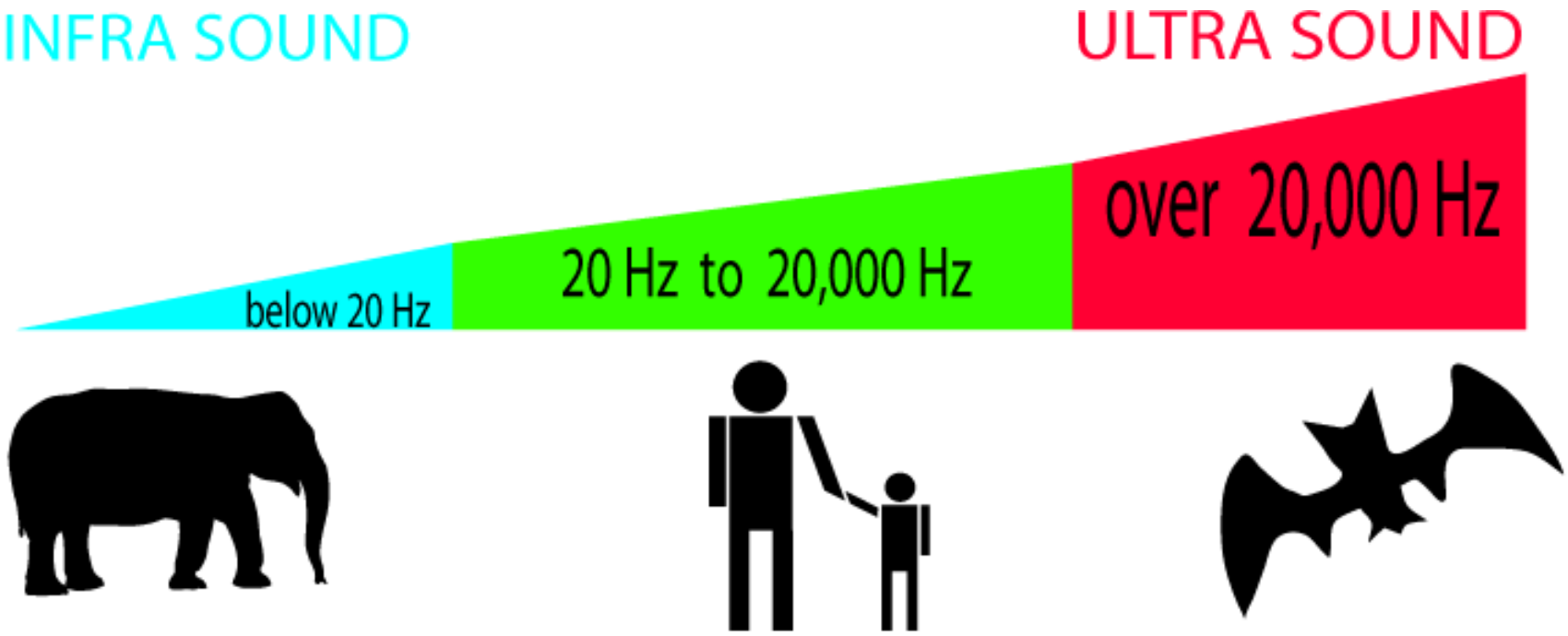
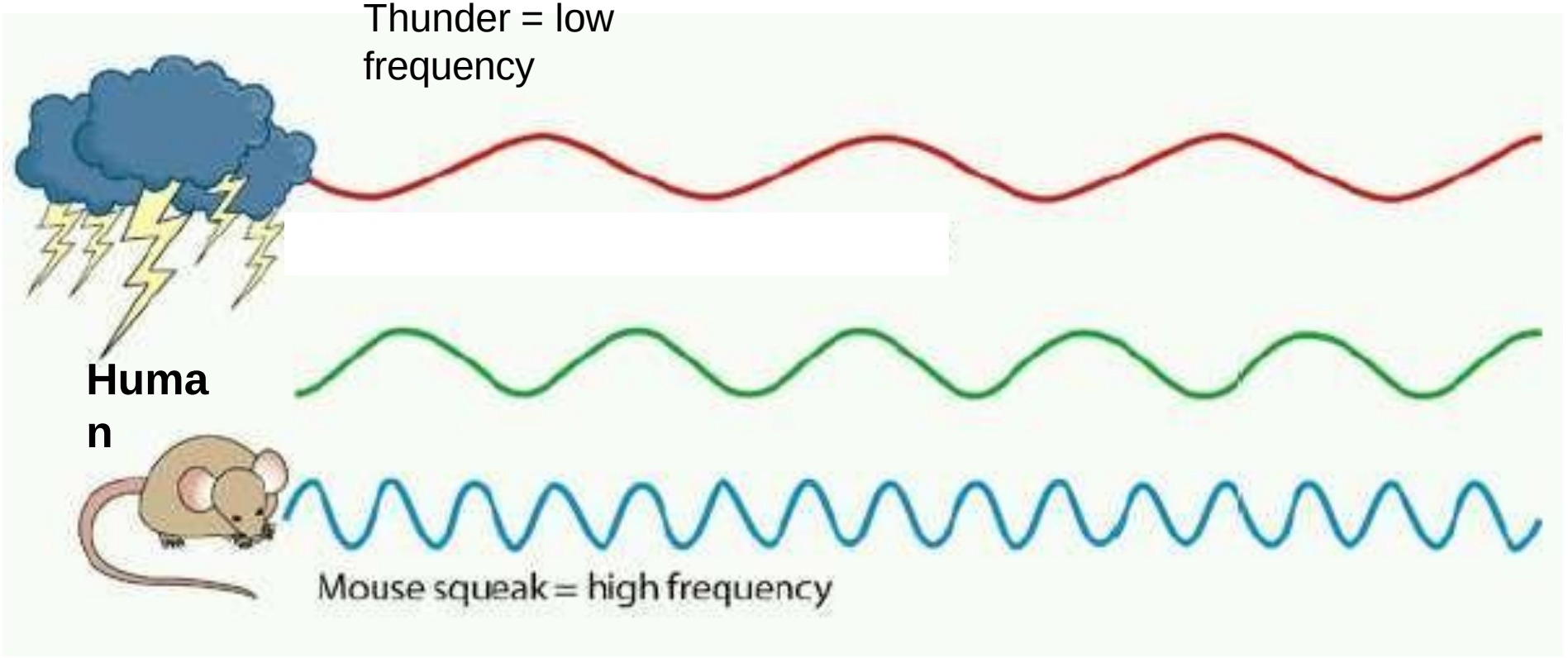
Sound Waves


INFRA SOUND
ULTRA SOUND
below 20 Hz
20 Hz to 20,000 Hz
over 20,000 Hz

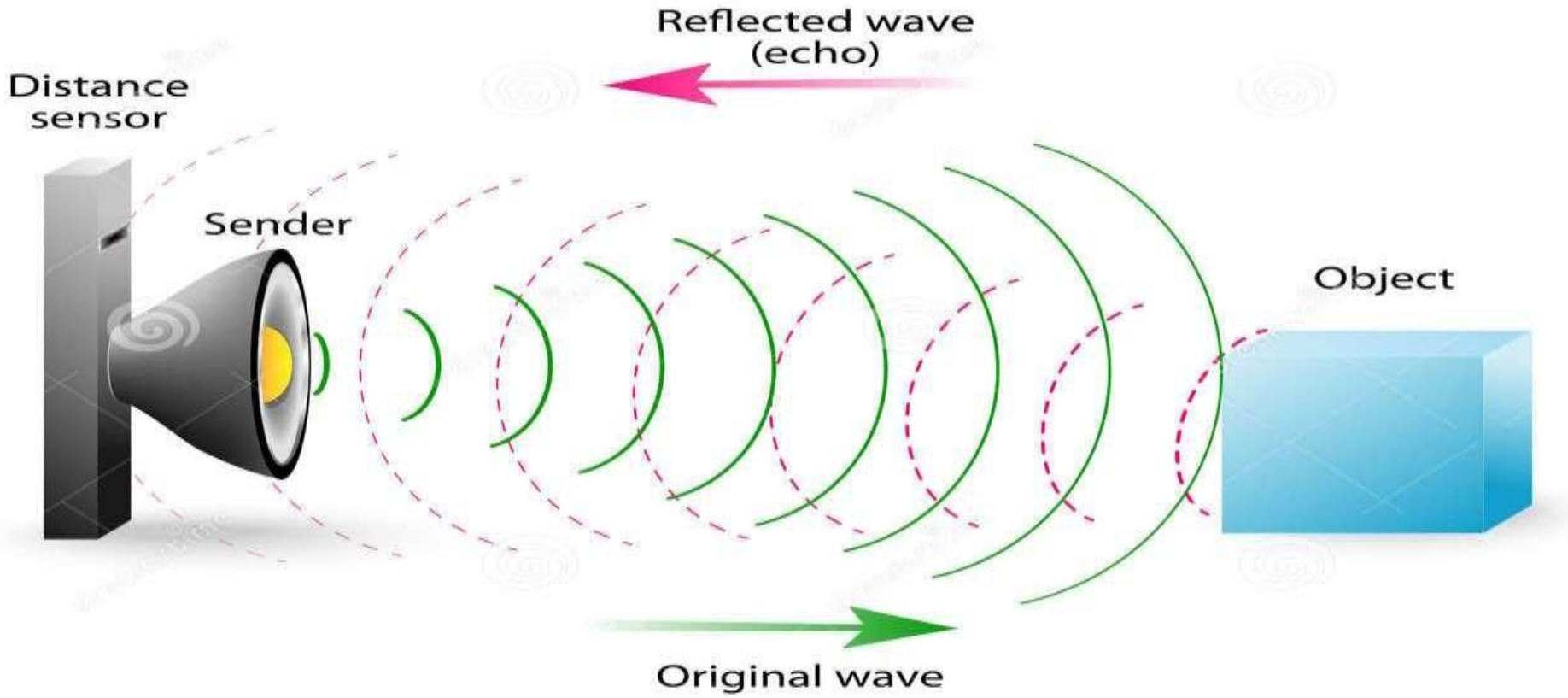
What can they hear?

- **Humans** – up to **20,000** Hz
- **Dogs** – up to **40,000** Hz
- **Cats** – up to **60,000** Hz
- **Bats** – up to **100,000** Hz
- **Dolphins** – up to **150,000** Hz

What do sound waves look like?



What is echo



What is Echolocation ?

"Echolocation is the use of sound waves and echoes to determine where objects are in space"

In other words, echoes help to find the location of an object.

Echolocation calls are usually ultrasonic--ranging in frequency from 20 to 200 kilohertz (kHz), whereas human hearing normally tops out at around 20 kHz.

Echolocating Animals

Bats

- Echolocation is Only found in Microchiropteran bats
- Echolocation help them for navigation & foraging in total darkness.

Dolphins

- Dolphin's habitats have low visibility due to dirty water & Turbidity. Echolocation help them for foraging.

Whales

- Echolocation helps Whales to navigate where vision is extremely limited in range due to Absorption or Turbidity.

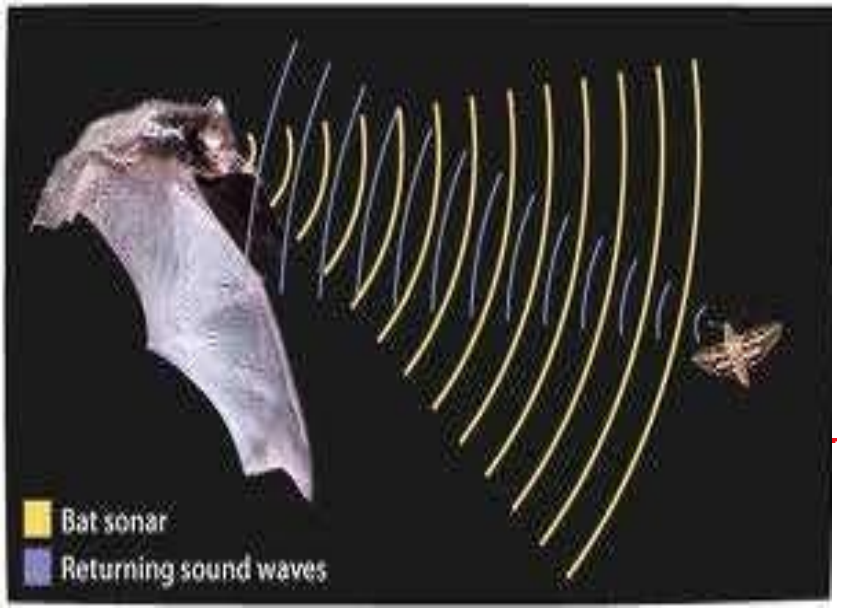
Uses of echolocation?

Dolphins and bats use echolocation to:

- hunt for food
- Locate objects
- Locate offspring and other like organisms

- Bats send out a chirp
- Dolphins, toothed whales and porpoises send out ultrasound clicks or squeaks

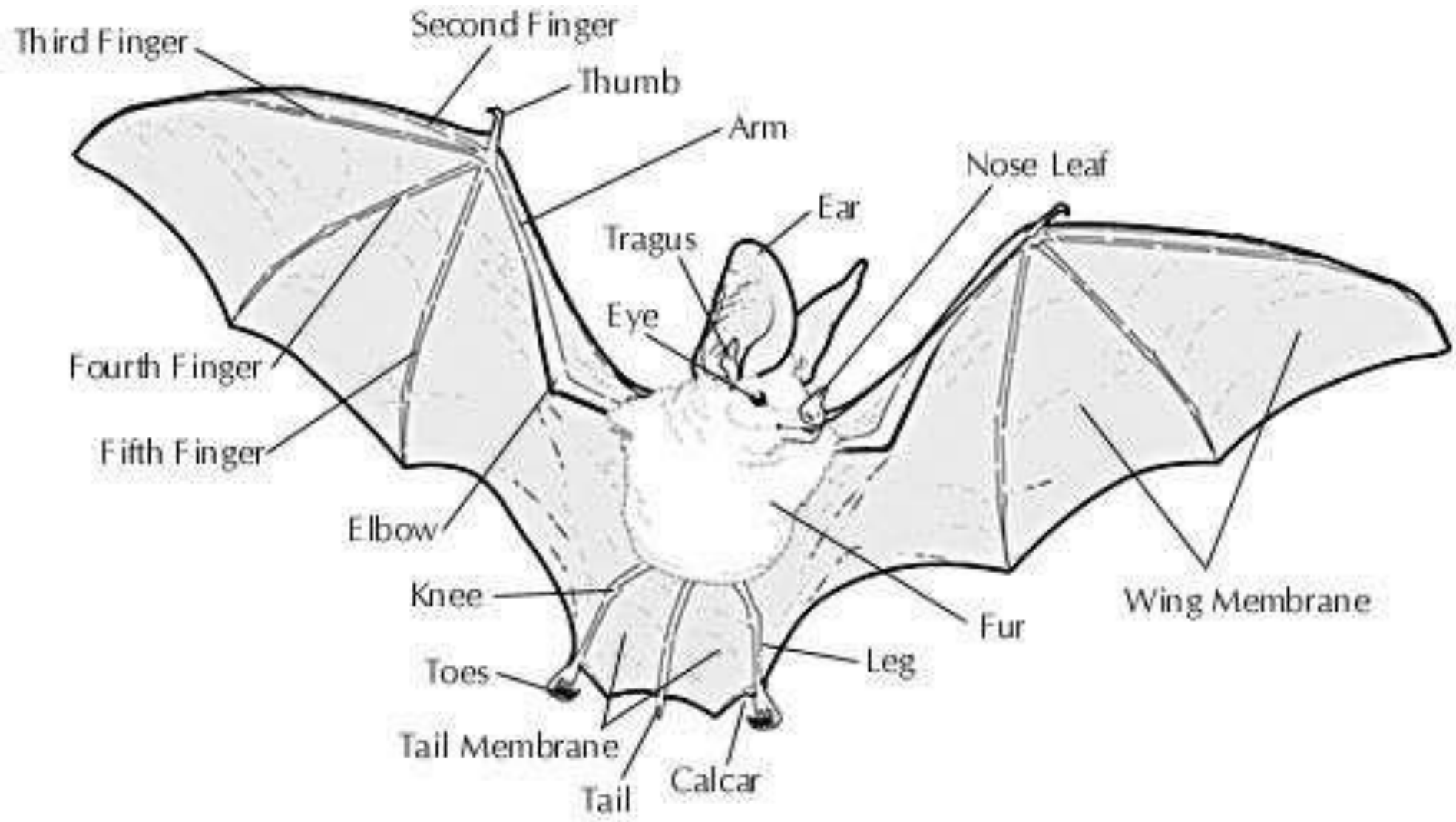
How is Echolocation used by animals ?



•Bats produce sounds with the larynx, an organ in the throat that has undergone certain adaptations that make it unusually effective in producing intense, high-frequency sounds.

- When the sound hits an object, an echo comes back.
- The bat can identify an object by the sound of the echo.

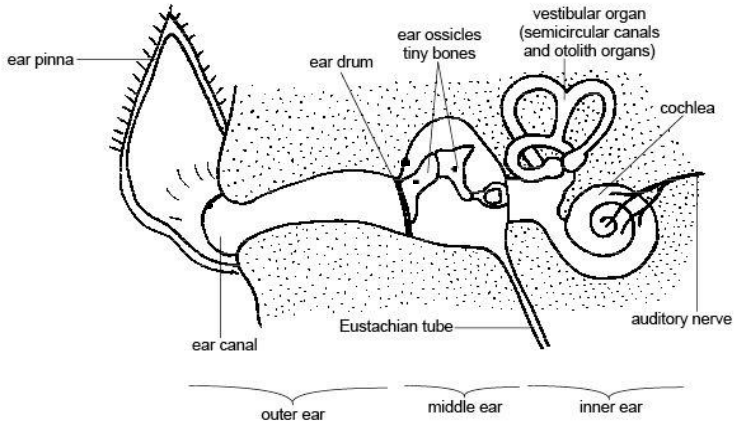
In terms of pitch, bats produce echolocation calls with both constant frequencies (CF calls) and varying frequencies that are frequently modulated (FM calls). Most bats produce a complicated sequence of calls, combining CF and FM components. Although low frequency sound travels further than high-frequency sound, calls at higher frequencies give the bats more detailed information--such as size, range, position, speed and direction of a prey's flight.


Third Finger
Second Finger
Thumb
Arm
Nose Leaf
Ear
Tragus
Eye
Fourth Finger
Fifth Finger
Elbow
Knee
Fur
Wing Membrane
Toes
Leg
Tail Membrane
Tail
Calcar

Adaptations in bats for echolocation

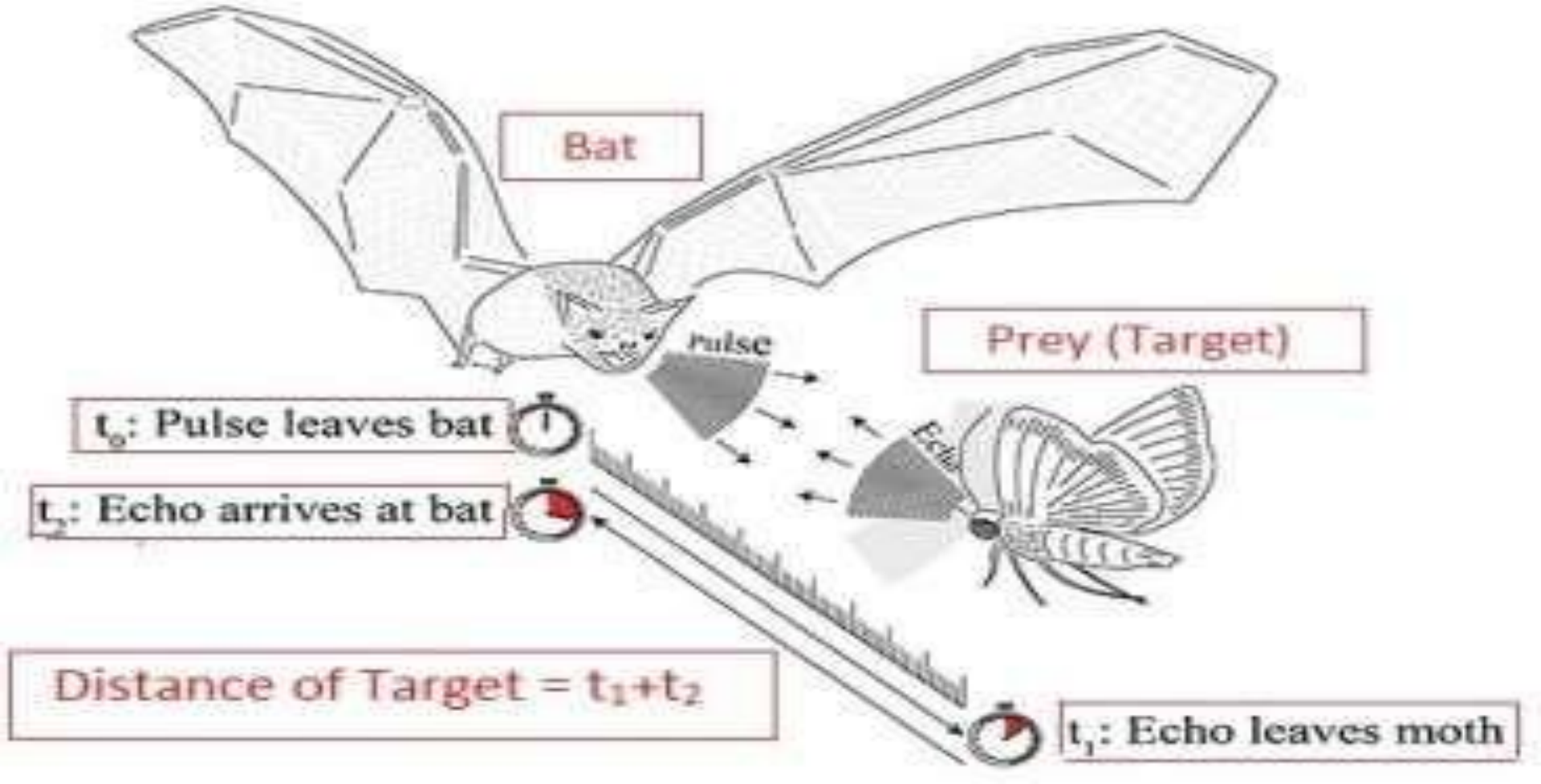
The ears and brain cells in bats are especially tuned to the frequencies of the sounds they emit and the echoes that result. A concentration of receptor cells in their inner ear makes bats extremely sensitive to frequency changes:

the middle ear muscle (called the stapedius) contracts to separate the three bones there--the malleus, incus and stapes, or hammer, anvil and stirrup--and reduce the hearing sensitivity.



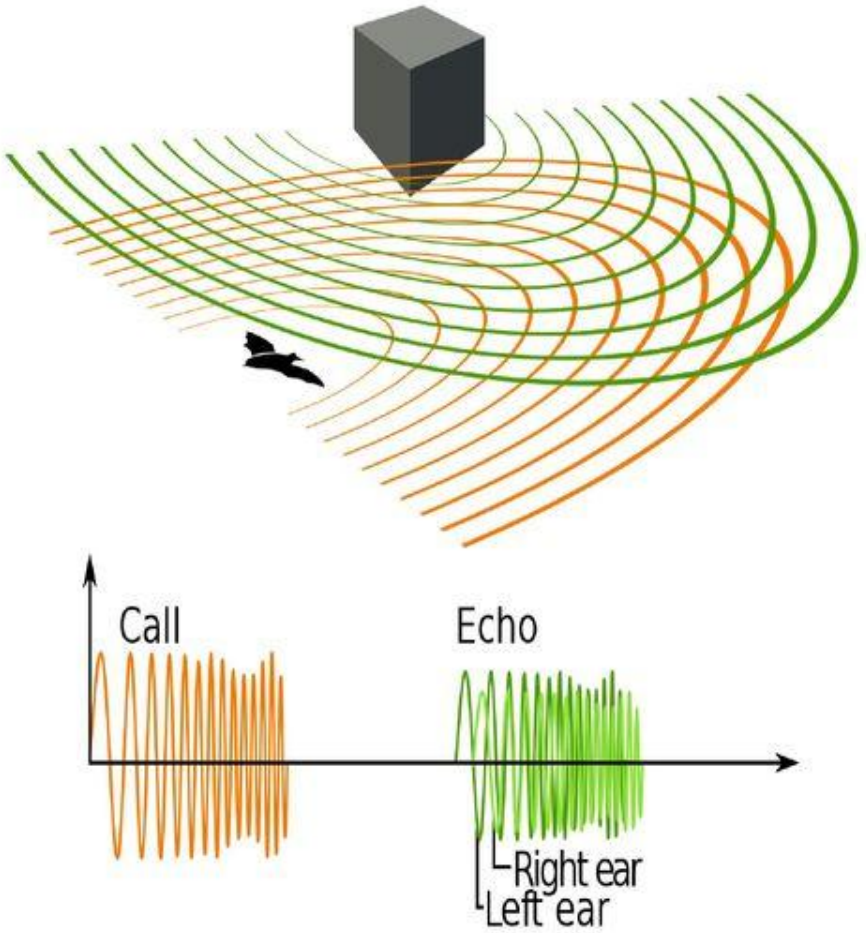
The external structure of bats' ears also plays an important role in receiving echoes. The large variation in sizes, shapes, folds and wrinkles are thought to aid in the reception and funneling of echoes and sounds emitted from prey.

Principle Of Echolocation



THE PROCESS OF ECHOLOCATION

- Ranging is done by measuring the time delay between the animal's own sound emission and any echoes that return from the environment.
- The relative intensity of sound received at each ear as well as the time delay between arrival at the two ears provide information about the horizontal angle (azimuth) from which the reflected sound waves arrive.[7]



What a bat can detect by using echolocation

- Distance(Range)- by comparing the time of emitted pulse to the time of the returning Echo.
- Size- larger animals reflect more sound(high intensity) and smaller animal reflect less sound (low intensity).
- Movement- by comparing amount of echo obtained on Left & Right ear.
- Velocity- by taking advantage of Doppler Shift.

Echo of higher frequency = Target is gaining.

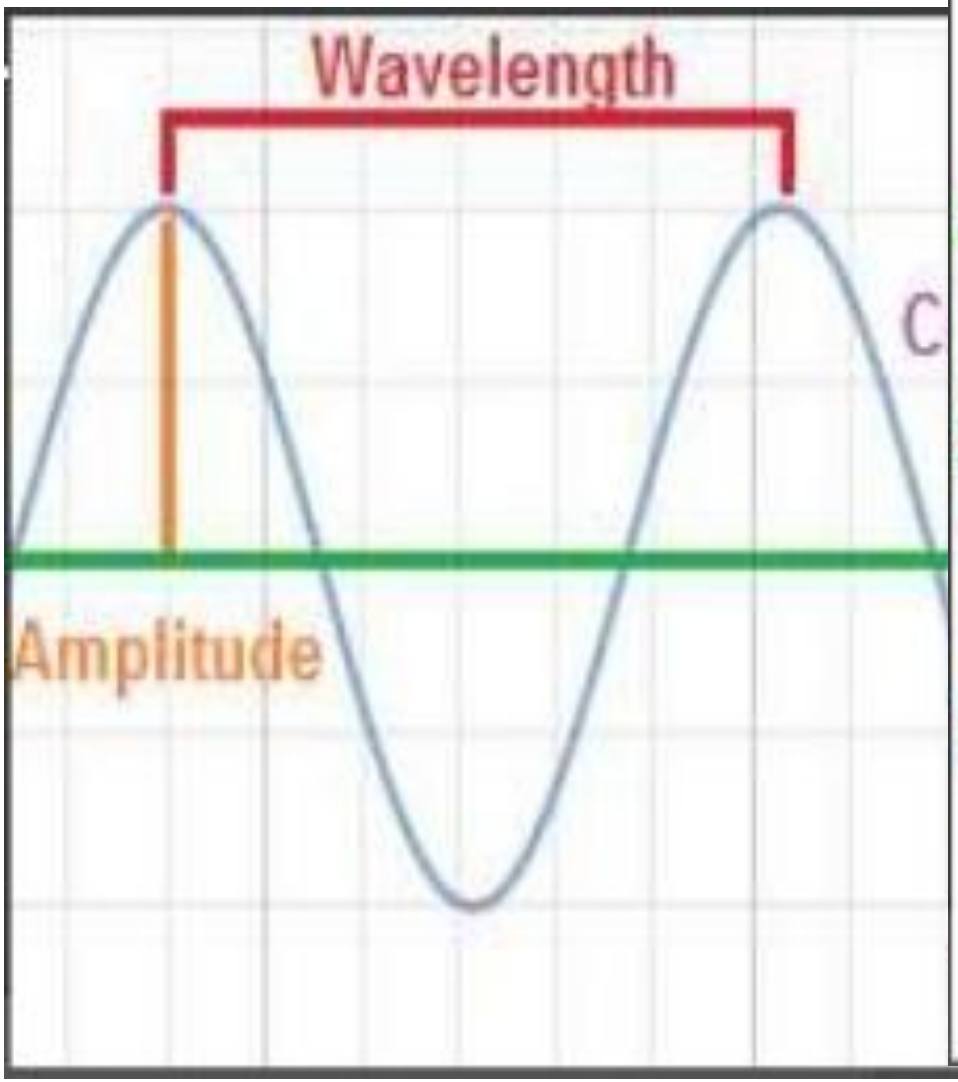
Echo of lower frequency = Target is outstanding.

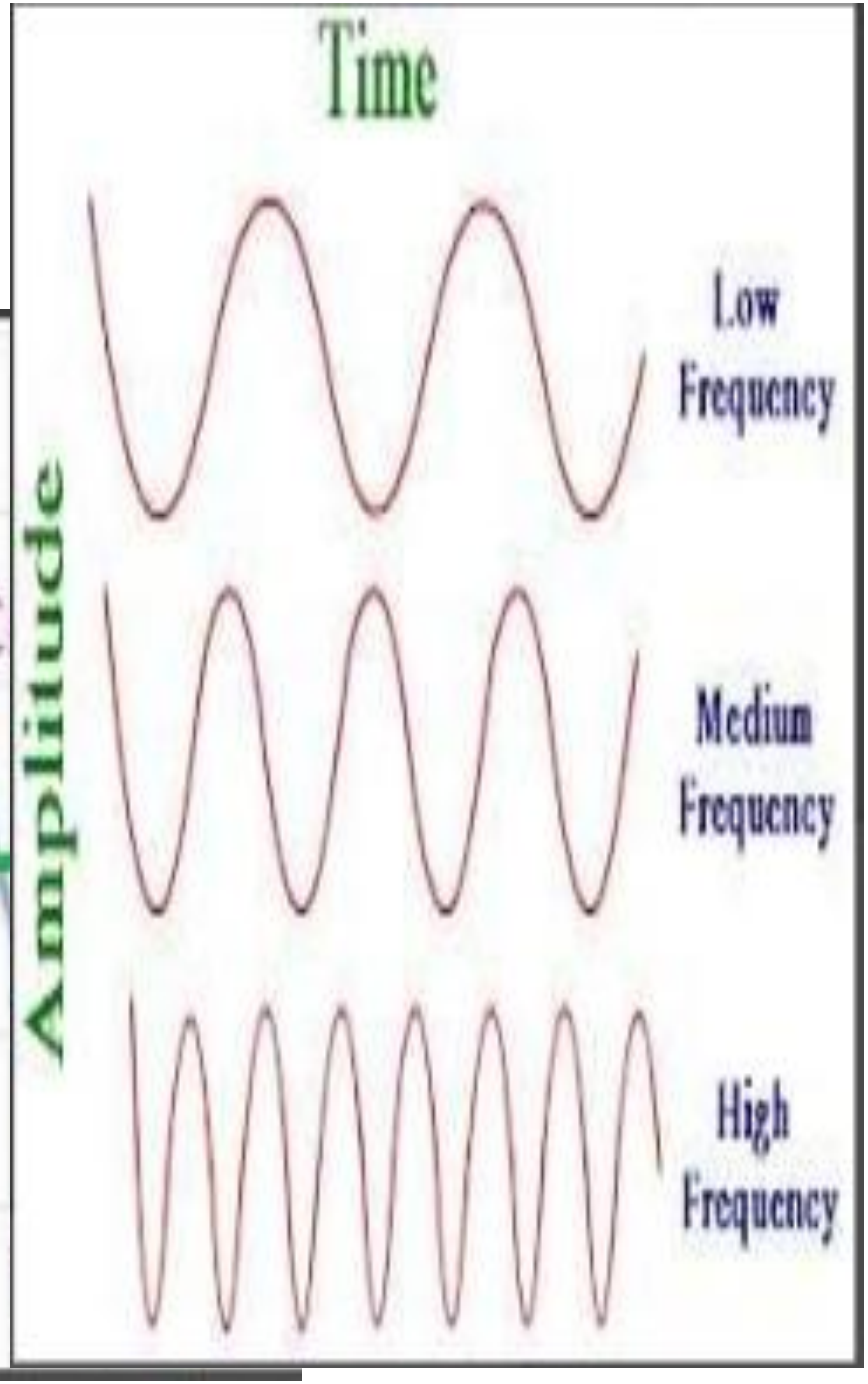
Doppler effect

What is doppler effect?

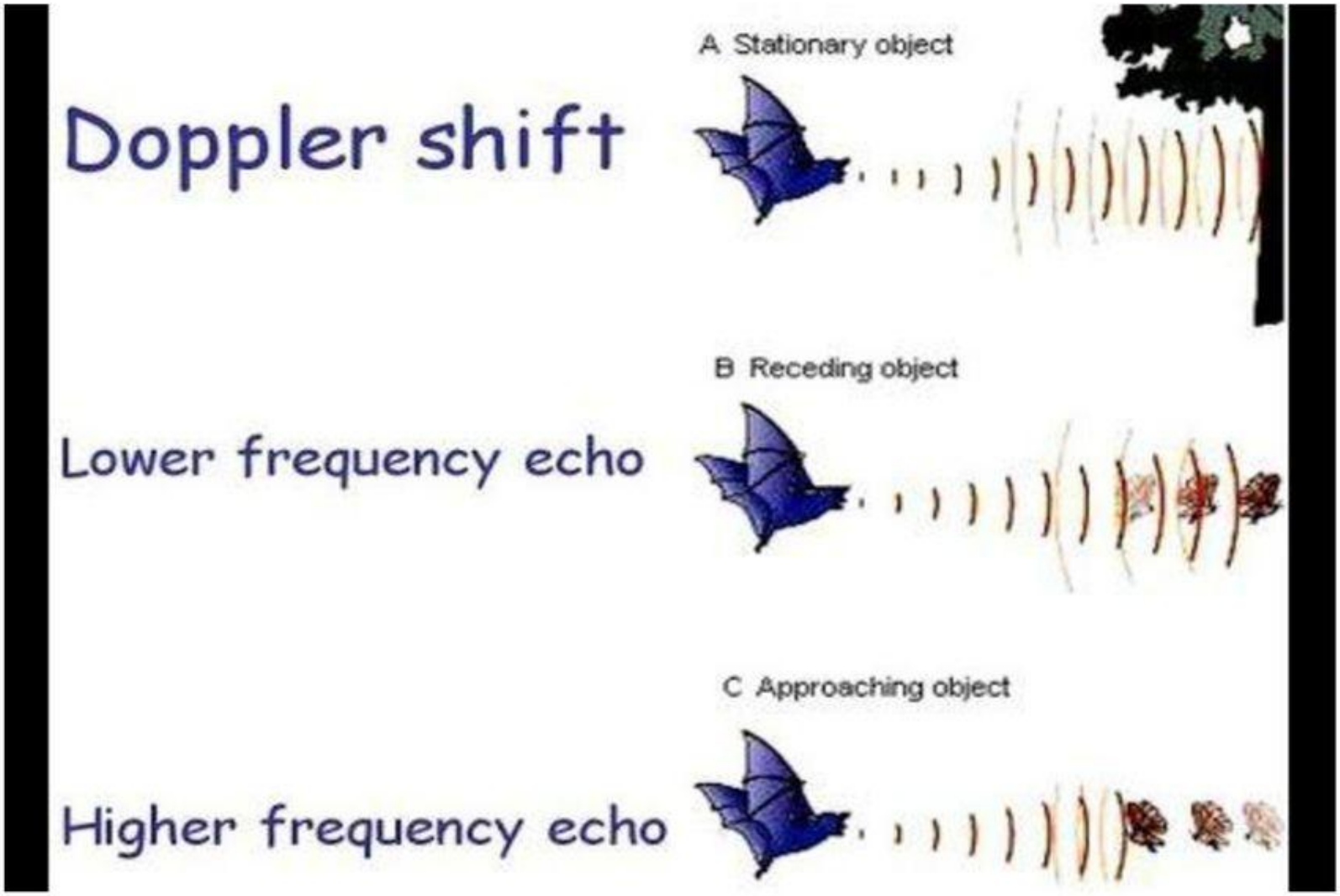
- **Doppler effect** is the change in frequency of a wave for an observer moving relative to its source.
- the observer observes an upward shift in frequency when the wave source is approaching,
- And a downward shift in frequency when the wave source is retreating

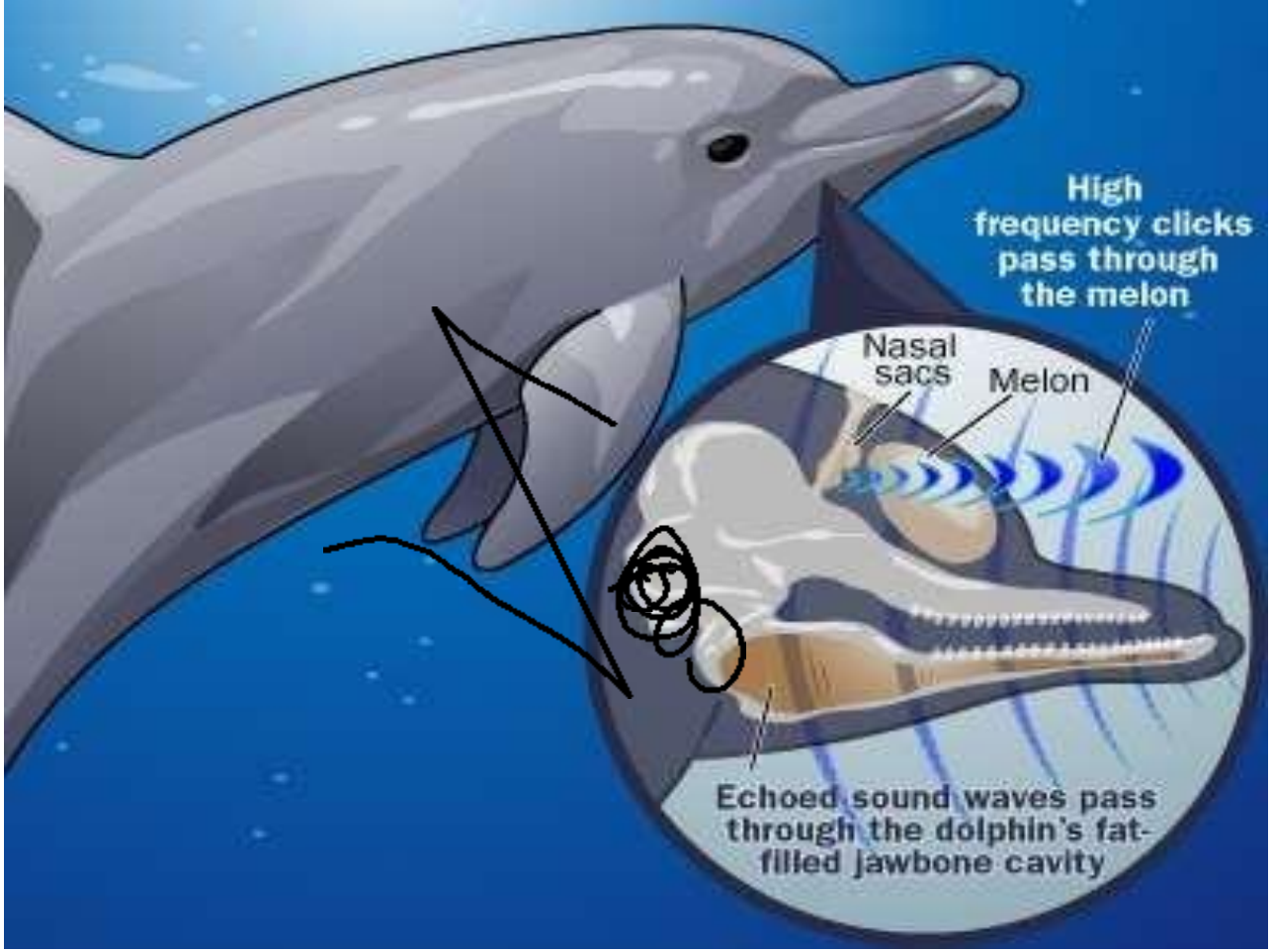
Wavelength and frequency



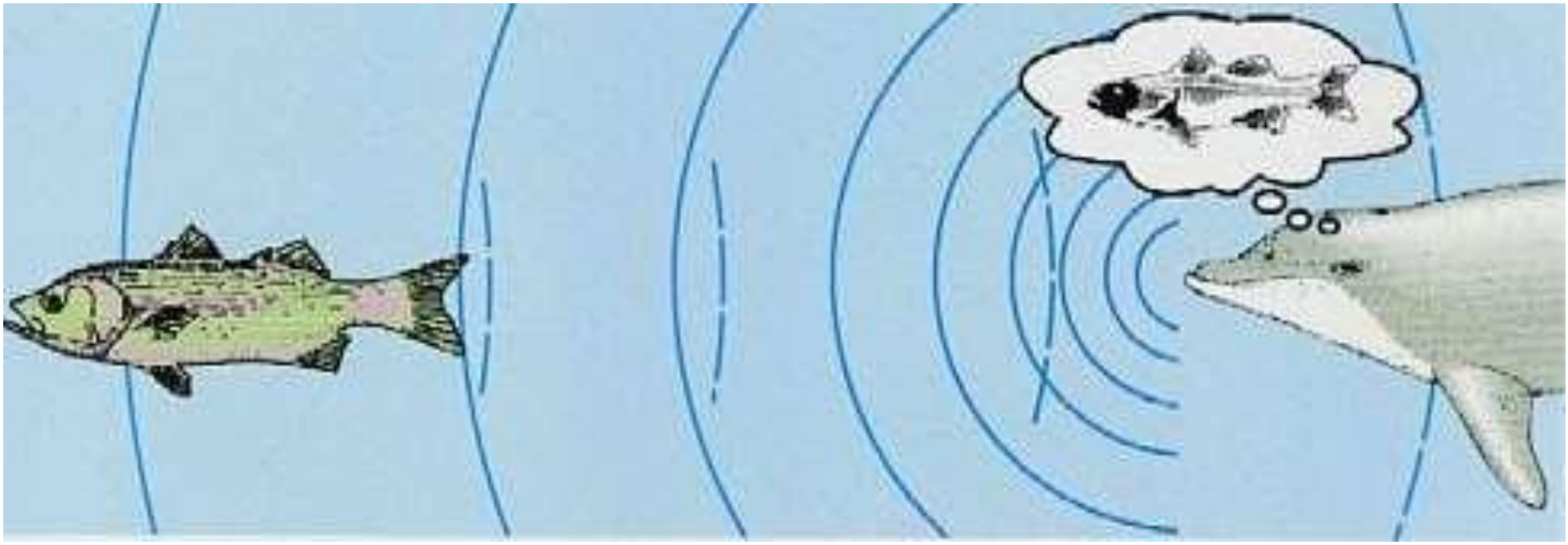


DOPPLER SHIFT AND ECHOLOCATION





The **Dolphin** uses nasal passages to make a click and sends it through its forehead, which focuses the sounds together into a beam before sending it into the water.



- When the sound hits an object in the water, it bounces back to the dolphin as an echo.
- The dolphin absorbs this returning echo through its jaw.
- A passage of fat from the jaw conducts the sound to the dolphin's inner ear
- The dolphin can tell things about the object, such as size, shape and material.

Science ➡ Technology ➡ Engineering

From watching animals and through scientific experiments, humans have learned to use *Echolocation*, *SONAR* and also *RADAR* in many different ways.