جامعة دمشق
كلية العلوم الصحية

زرع الحلزون
الأجهزة المساعدة على السمع

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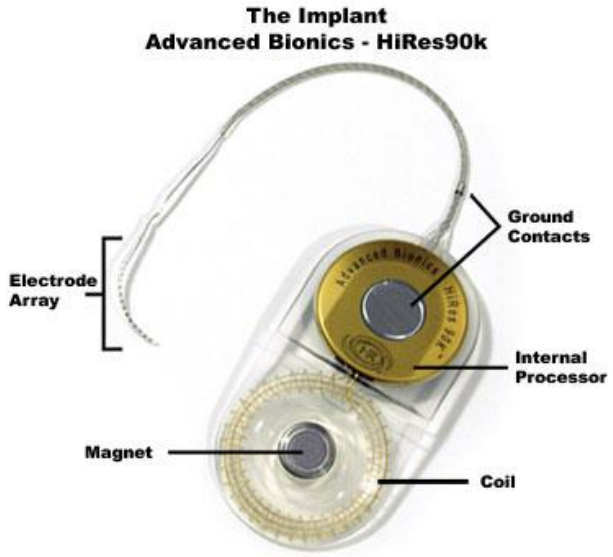
Implantable Treatments

- Bone-anchored devices
  - » Transmission of sound via bone conduction
- Middle ear implants
  - » Transmission of sound via vibratory stimulation
- Cochlear implants
  - » Transmission of sound via electric stimulation of the auditory nerve

What is a Cochlear Implant ?

- Surgically implanted device:
  - Electrode Array and a Receiver-Stimulator
- But it works only if used with:
  - External components:
    - Speech Processor, Headpiece & Battery
- To work, it needs:
    - Programming with a computer
- To work even more optimally:
    - Rehabilitation sessions necessary



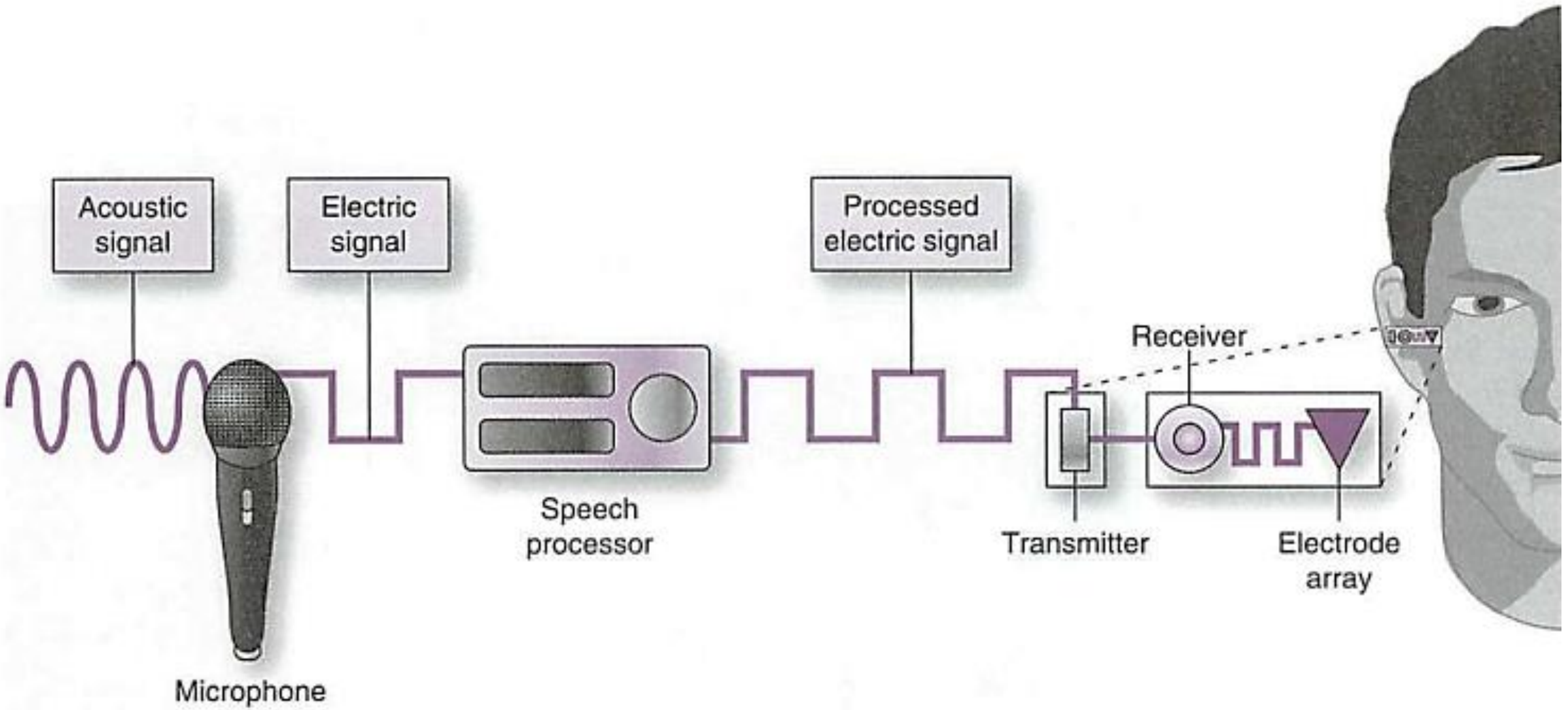
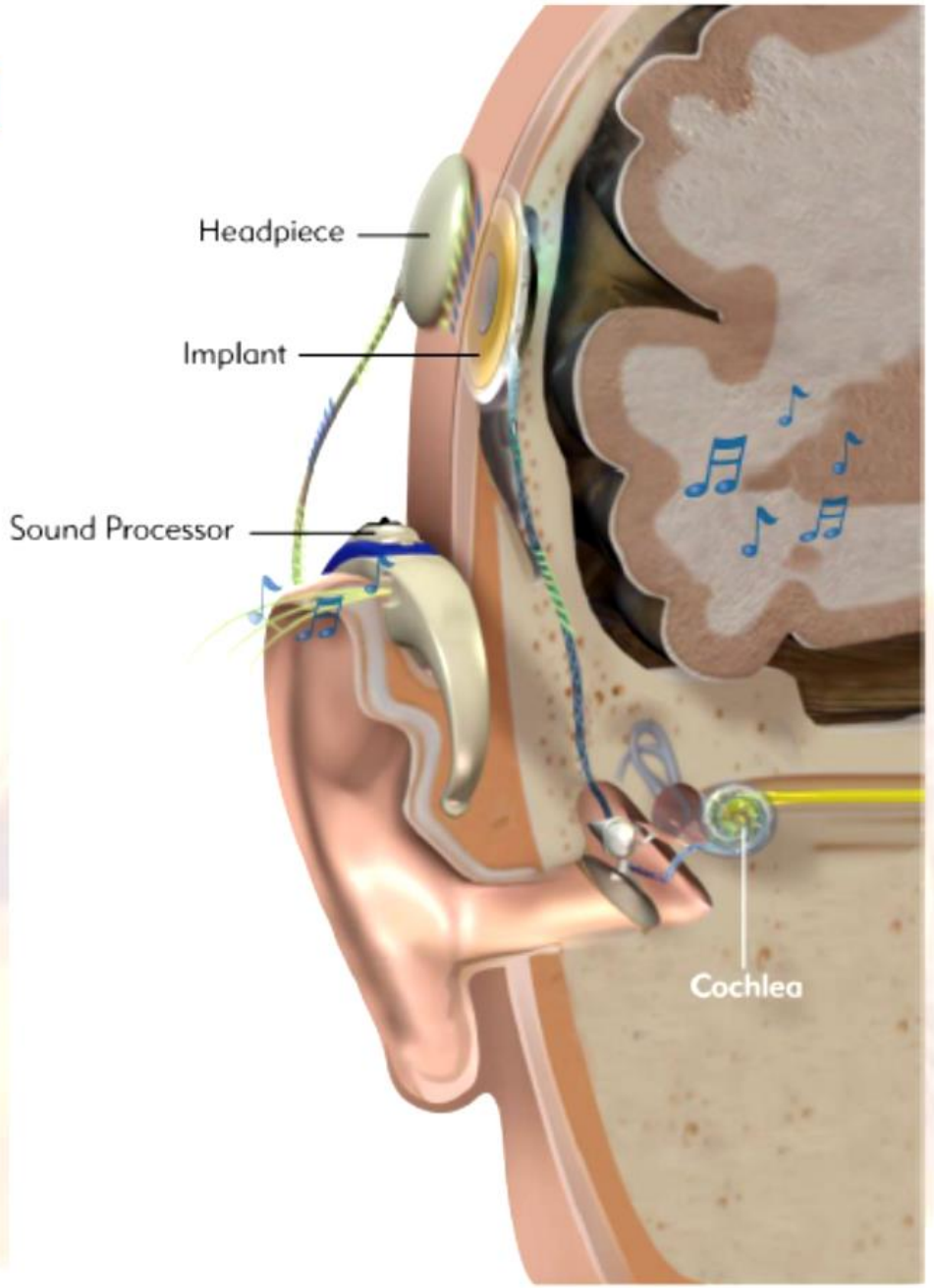


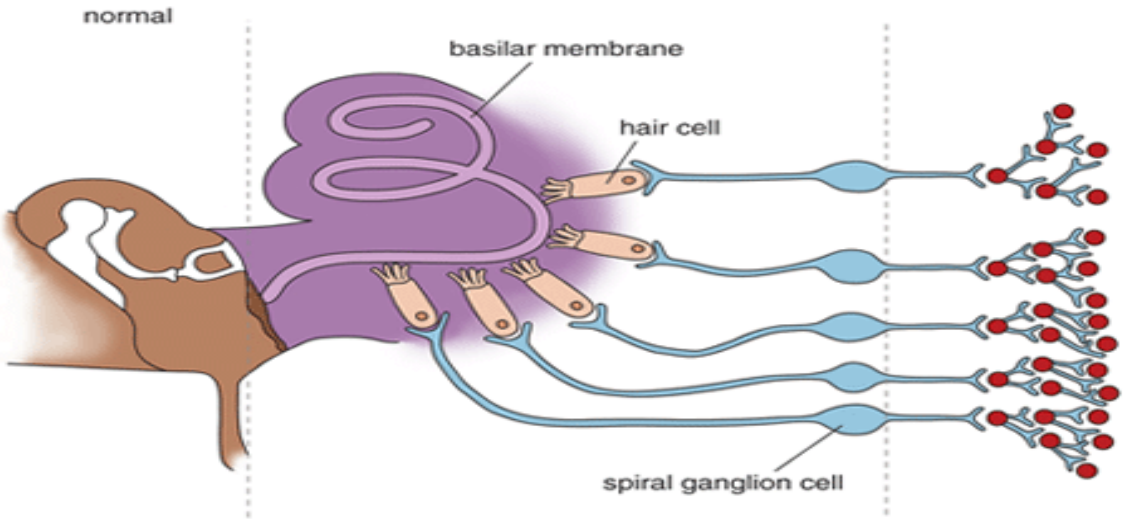
FIGURE 3-8. Schematic of a cochlear implant.

Cochlear Implantation

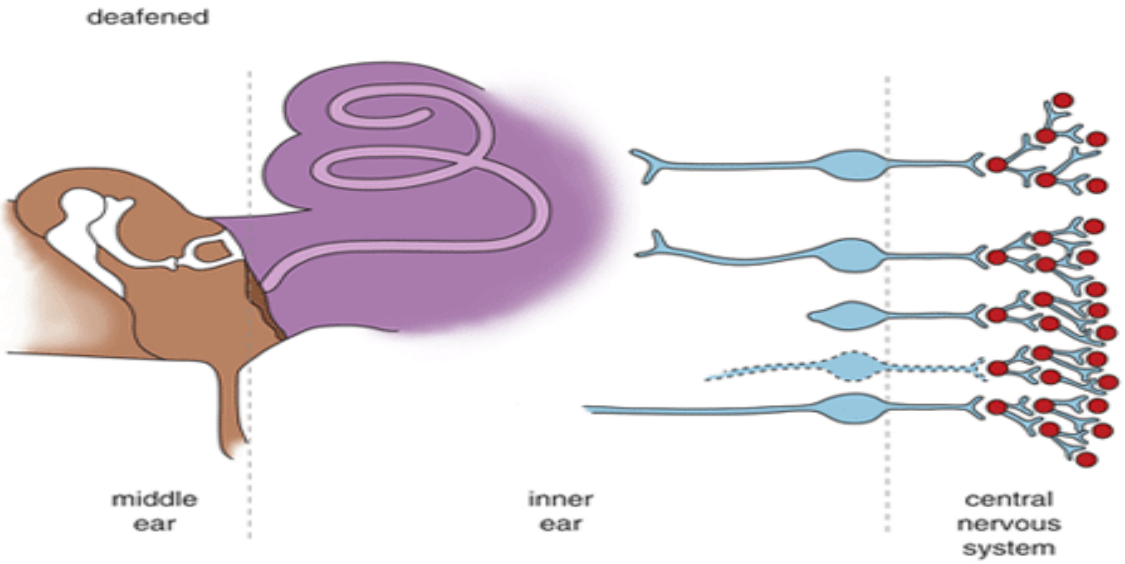
- Electrical representation of an acoustic signal
  - Insertion into scala tympani of the cochlea
  - Bypass damaged sensory cells



Components of the Cochlear Implant System



Normal Ear



Deafness

Normally functioning *hair cells damaged or not present;* there is some *atrophy of 8th N dendrites* in most cases.

Dorman (2004)

COCHLEAR IMPLANT SYSTEMS

HARDWARE:

microphone, a speech processor, and an implanted receiver-stimulator

A Cochlear implant system consists of two main parts:

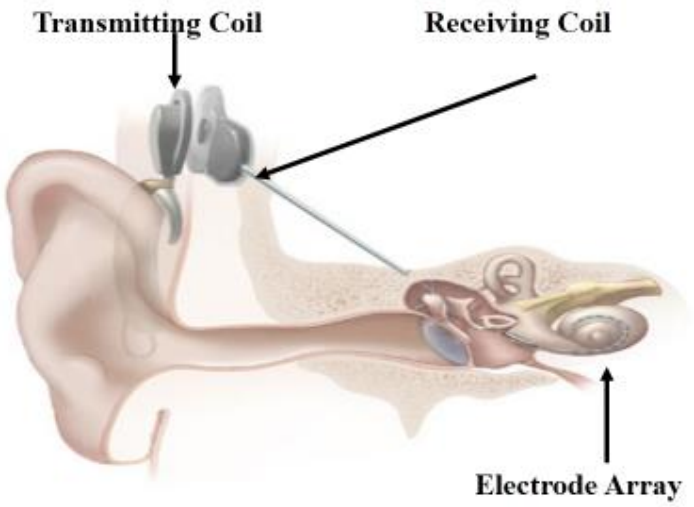
Internal Implant

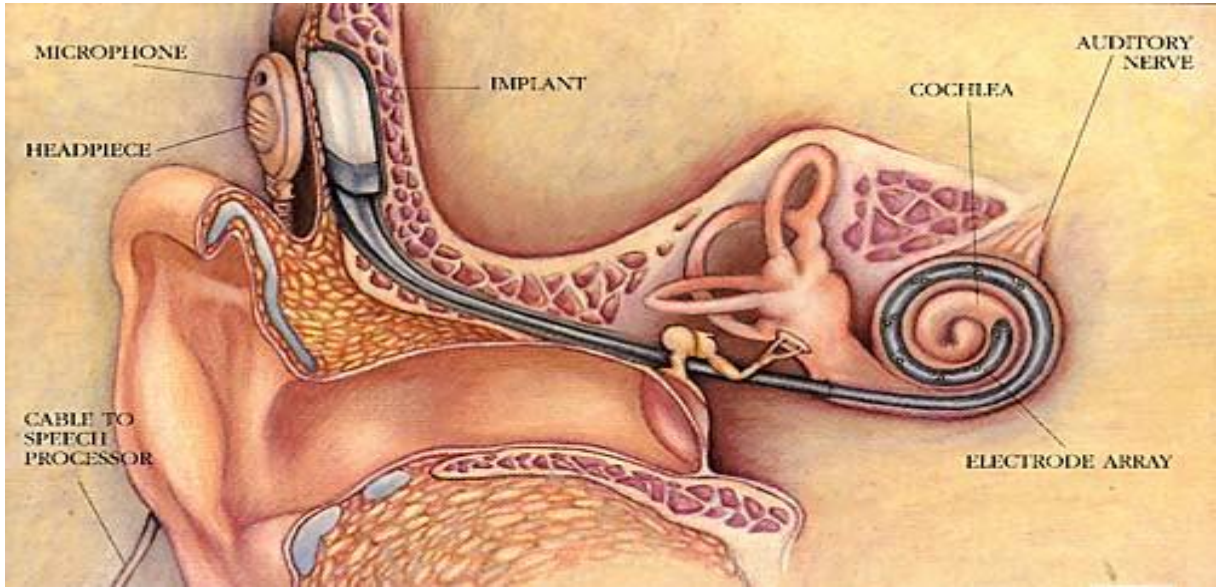
External Equipment

or

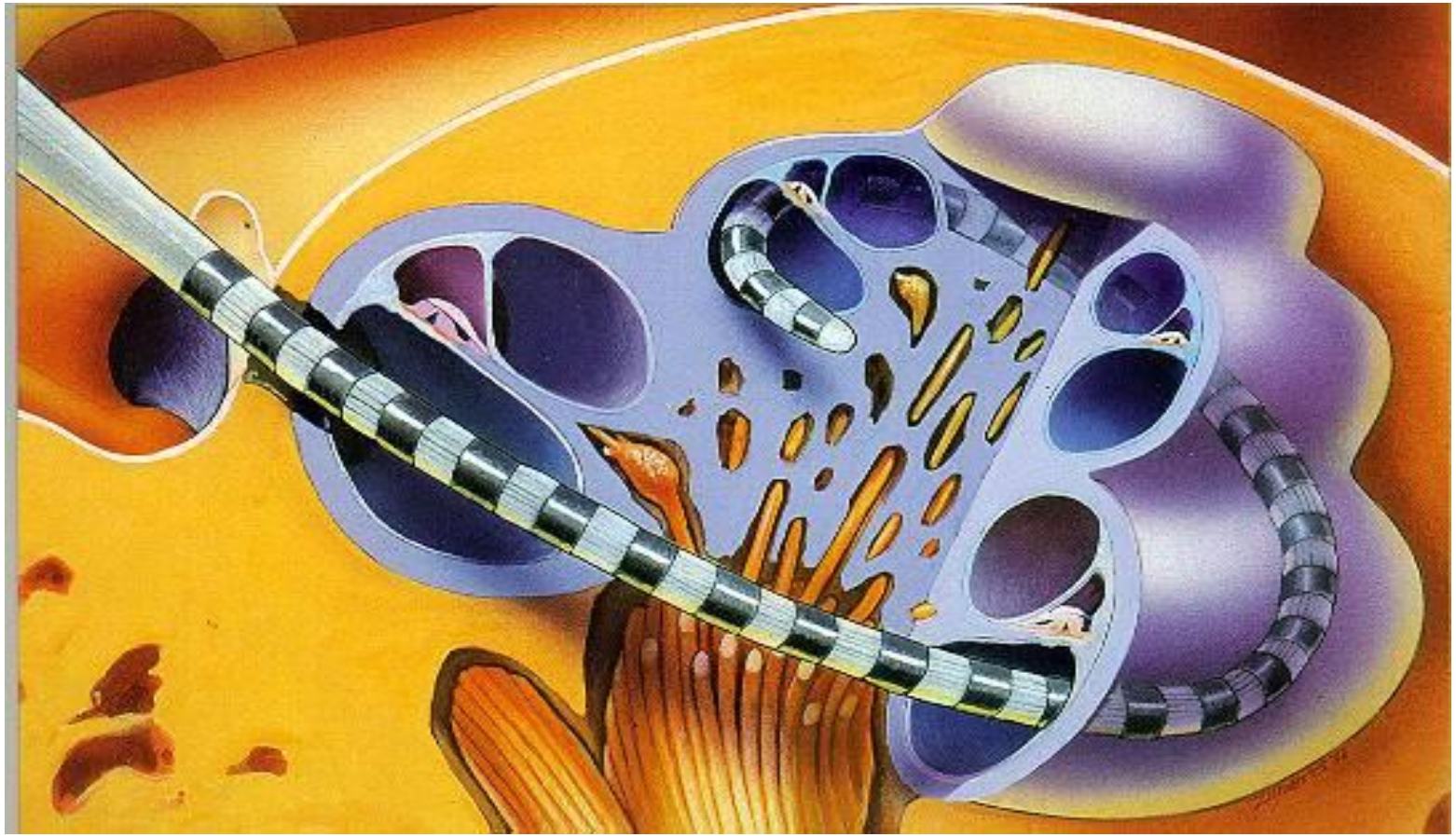
How Does a Cochlear Implant Work?

1. Sound is detected by an external microphone.
2. This signal is directed to an external sound processor.
3. Once processed, a digital electronic code is sent by a transmitting coil situated over the receiver-stimulator via radiofrequency through the skin.
4. The receiver-stimulator delivers electronic impulses to electrodes on a coil located within the cochlea according to selected strategy.
5. Electrodes electrically stimulate spiral ganglion cells and auditory nerve axons.



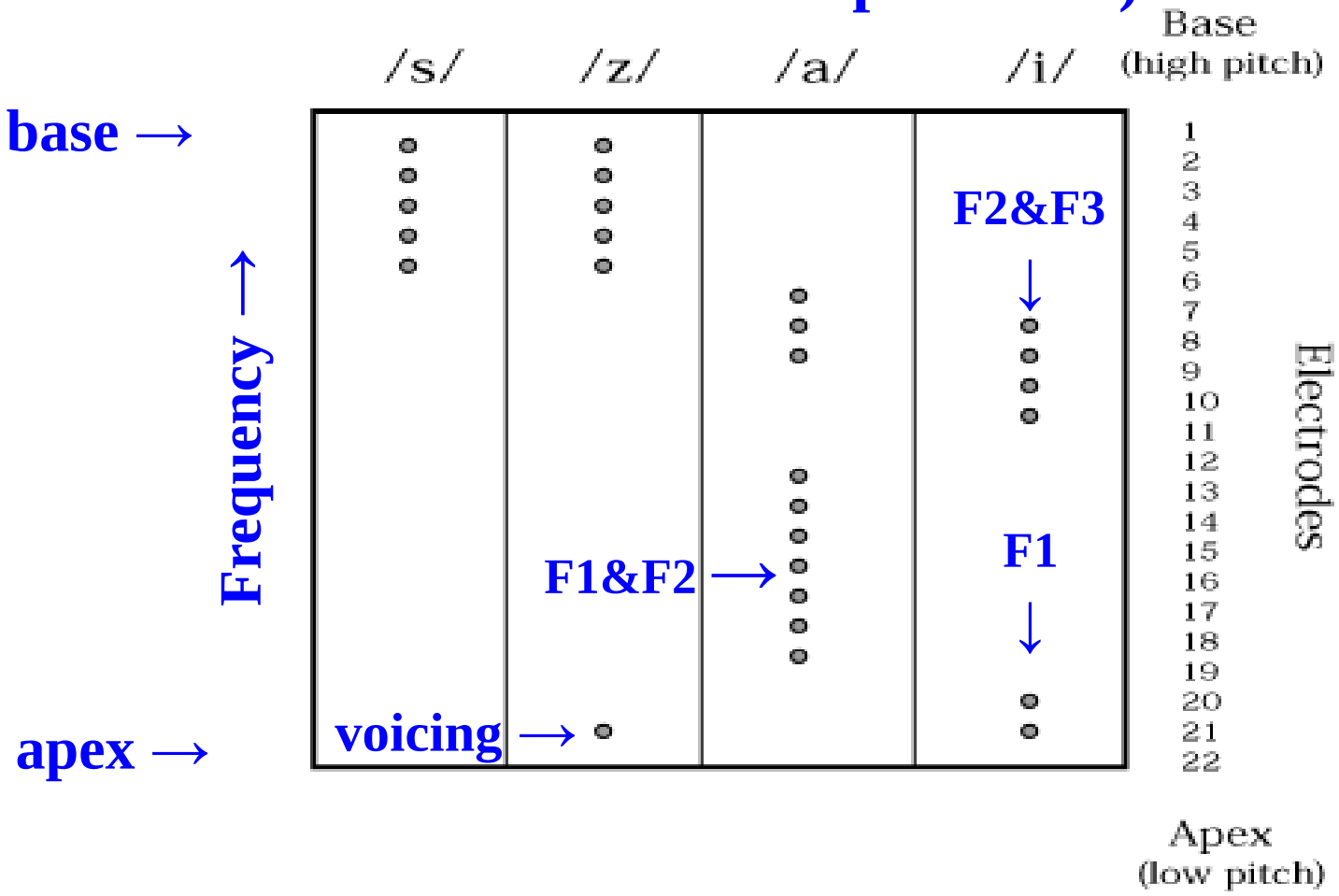


Electrode Array Placement Within the Cochlea



This figure shows *which electrodes are receiving the most electrical current* for some sample speech sounds for a 22-electrode implant.

(Note that electrode 1 stimulates the basal end and electrode 22 stimulates the apical end.)



1 ch 

2 ch 

4 ch 

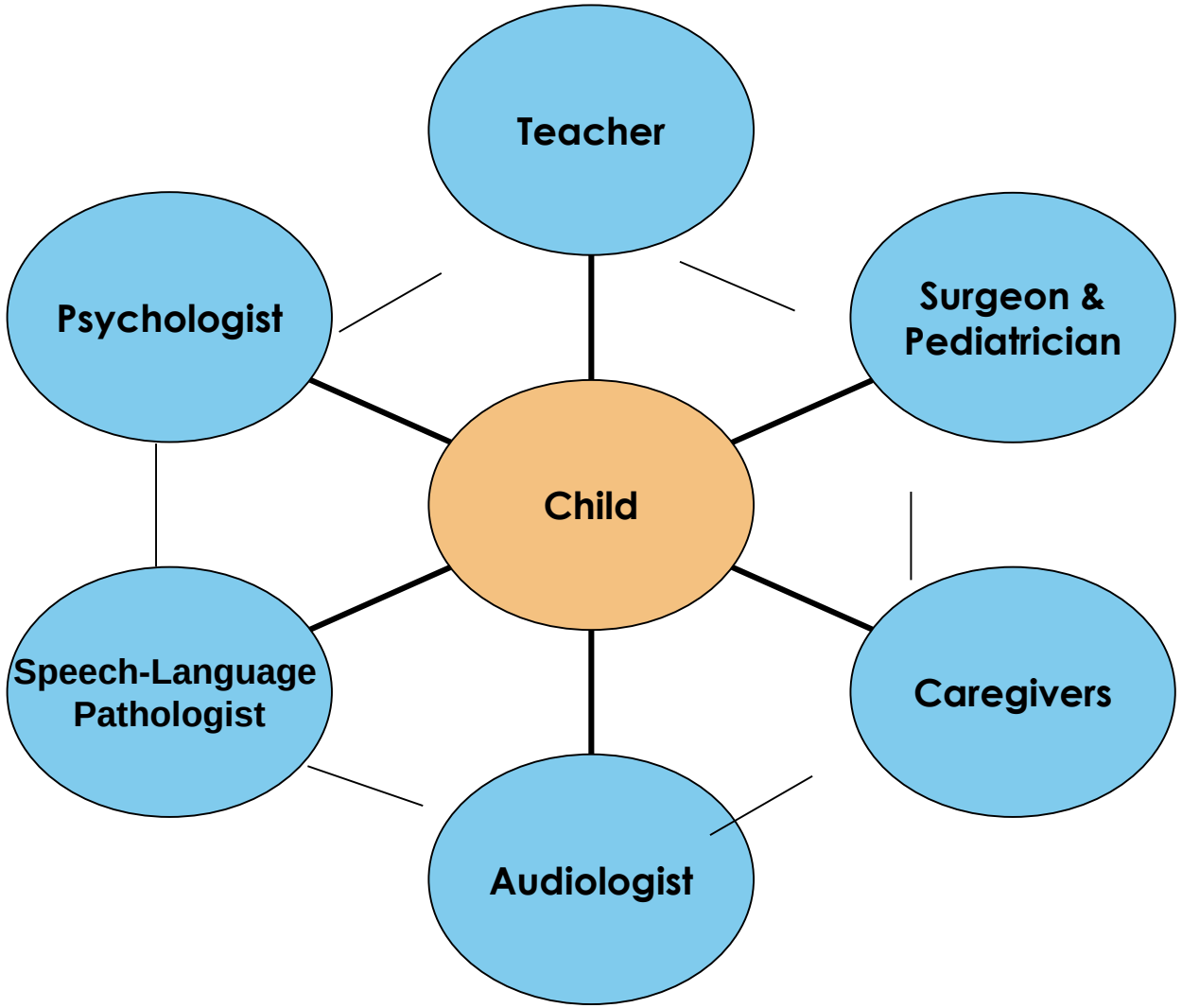
6 ch 

8 ch 

music 

(orig) 

Team Approach



SELECTION & EVALUATION OF PATIENTS

- AUDIOLOGIC ASSESSMENT
- OTOLOGIC ASSESSMENT
- RADIOLOGIC ASSESSMENT

AUDIOLOGIC ASSESSMENT

- Determine the type and degree of hearing loss
  - Air & bone conduction thresholds for each ear
  - ABR & OAEs
- Assess the child's current amplification system
  - Aided sound field testing
  - Aided speech perception testing
- Counseling
  - Address realistic expectations
  - Device selection
  - Post-operative follow-up

AUDIOLOGIC ASSESSMENT

- In adults, candidacy is based on sentence recognition test scores (eg, **Hearing-In-Noise Test**, or HINT) with properly fitted hearing aids. Scores of 40% in the ear to be implanted and 60% in the contralateral ear are generally needed to establish candidacy.
- In children, it is first necessary to establish a hearing threshold.

  A hearing aid trial can then be initiated and speech and language development assessed.

  Even children with a profound hearing loss undergo a hearing aid trial.

How is a Cochlear Implant Different From a Hearing Aid?

Hearing Aid	Cochlear Implant
Acoustically amplify sound.	Convert sound into electrical signals.
Rely on the responsiveness of healthy inner ear sensory cells.	Bypass the inner ear sensory cells and stimulate the hearing nerve directly.

OTOLOGIC ASSESSMENT

- **Assessment of Pediatric Patients:**
  - History of recurrent ear infections, pressure equalization (PE) tube placement, or other otologic surgeries.
  - Patients with acute otitis media should be treated prior to proceeding with surgery.
  - For patients with a chronic middle ear effusion or recurrent acute otitis media, myringotomy with PE tube placement may be considered.
  - Cochlear implants can coexist with PE tubes.

OTOLOGIC ASSESSMENT

- **Cochlear Patency**
  - When deafness is a result of meningitis, /the possibility of cochlear ossification.
  - (CT) scan or magnetic resonance imaging (MRI).
  - CT scanning should generally demonstrate cochlear ossification;
  - Obliteration due to fibrosis and the presence of soft tissue can be best assessed with a T2-weighted MRI.
  - When the cochlea appears to be undergoing obliteration, the surgeon may wish to implant .

OTOLOGIC ASSESSMENT

- **Vestibular Evaluation**
  - A vestibular evaluation, including at least electronystagmography (ENG) .
- **Other Otologic Conditions**
  - Otosclerosis and congenital cochlear dysplasia.
  - Patients with otosclerosis are likely to be at a higher risk of unwanted facial nerve stimulation due to coexistent demineralization of the surrounding bone.
  - For patients with known cochlear dysplasia, unusual surgical anatomy and a higher incidence of CSF leak should be anticipated.

RADIOLOGIC ASSESSMENT

- Fine-cut CT scanning of the temporal bone.
- High-resolution MRI with and without gadolinium plus high-resolution T2-weighted images may prove to be valuable.
- Particularly noteworthy is the fact that both the Michel deformity (ie, congenital cochlear agenesis) and an absence of the auditory nerve, which may be present with the narrow internal auditory canal syndrome, comprise the two absolute contraindications to cochlear implantation that may be found on radiologic assessment.

Children Candidacy

1. Severe to profound sensorineural hearing loss in both ears
2. Lack of benefit from hearing aids and therapy
3. No medical contraindications
4. High motivation and appropriate expectations for child and family
5. 12 months and up; may be indicated earlier for special cases

Patients with Other Disorders

- A unique group of individuals requiring careful consideration are those with hearing loss and other developmental and cognitive deficits.
- In fact, if a hearing disability can be reduced with a cochlear implant, other disabilities (eg, a learning disability) may become less pronounced or more manageable.

Timing of Implantation

- Earlier implantation in children generally yields more favorable results.
- Current devices are FDA approved for implantation in children 12 months and older, with no upper age restrictions.
- The more the child works with and depends upon the implant, the better the eventual outcome.

Contraindications

- Deafness due to lesions of the eighth cranial nerve or brain stem.
- Chronic infections of the middle ear and mastoid cavity or tympanic membrane perforation.
- The absence of cochlear development as demonstrated on CT scans remains an absolute contraindication.
- Certain medical conditions that preclude cochlear implant surgery (eg, specific hematologic, pulmonary, and cardiac conditions) also may be contraindications.
- The lack of realistic expectations regarding the benefits of cochlear implantation and/or a lack of strong desire to develop enhanced oral communication skills poses a strong contraindication for implant surgery.

INTRAOPERATIVE & POSTOPERATIVE COMPLICATIONS

- **Wound Infection**
- **Facial Nerve Injury**
- **Tinnitus**
  - Cochlear trauma from device insertion not only results in a loss of hearing, but it also may lead to or exacerbate tinnitus.
- **Vestibular Dysfunction**
- **Electronic Malfunction**
- **Risk of Meningitis.**
  - Patients with inner ear malformations have a higher risk of meningitis pre- and postoperatively unrelated to the cochlear implantation.

Factors Generally Associated with Better Outcomes in Cochlear Implantation

Adults and Children

Shorter duration of deafness

Better preoperative word or sentence recognition (or both)

Lip-reading ability

Higher intelligence quotient (I.Q.)

Better preoperative residual hearing

Optimized implant technology and processing strategy

Cause of deafness (eg, meningitis associated with poor outcomes)

Intact, nonossified cochlea

Additional Factors in Children

Younger age at implantation

Motivated family assistance

Oral preoperative education

Oral education rehabilitation program as opposed to total communication

Auditory Brain Stem Implants

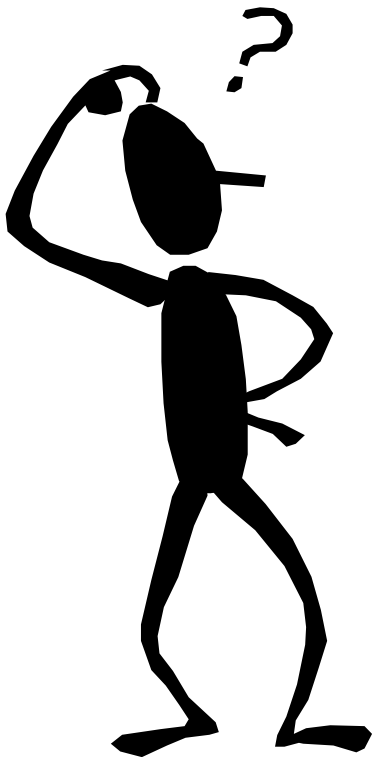
- Designed to stimulate cochlear nuclear complex in the brainstem directly by placing the implant in the lateral recess of the fourth ventricle.
- Such implant is needed when CN VIII has been severed in surgery of vestibular schwannoma.
- ABI help in communication, awareness and recognition of environmental sounds; however they are not efficient as multichannel cochlear implants.

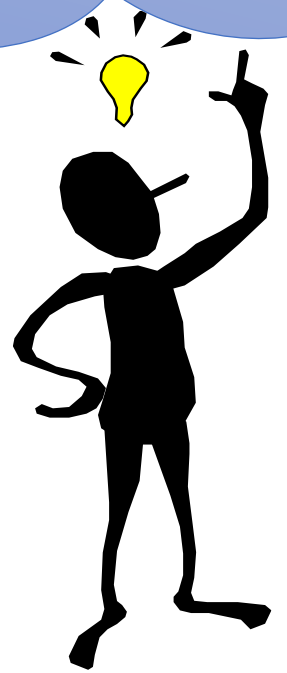
الأجهزة المساعدة على السمع
Listening assistive devices (ALDs)

HOME	COMMUNITY	WORKPLACE	TRAVEL AND RECREATION	SCHOOL
One-on-one conversation	Medical treatment (visiting a physician, dentist, hospital)	Office conversation	One-on-one conversation, e.g., in the car	Communication with the teacher
Group conversation	Volunteer activities	Lectures	Television reception	Communication with classmates
Television reception	Religious services	Telephone communication	Public spaces	Speech-language therapy
Radio reception	Post office and other community service centers	Conferences and group meetings	Restaurants	
Reception of environmental signals such as the doorbell		One-on-one meetings	Hotel rooms	

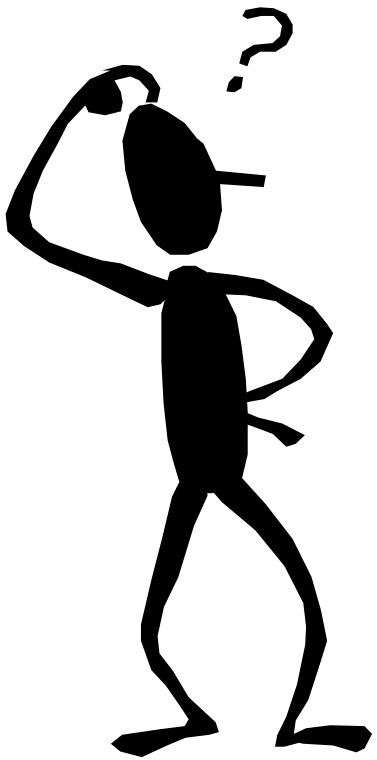
What we mean by ALDS
??

Assistive Listening Devices work by collecting sound from the sound source and delivering it to the user's ear

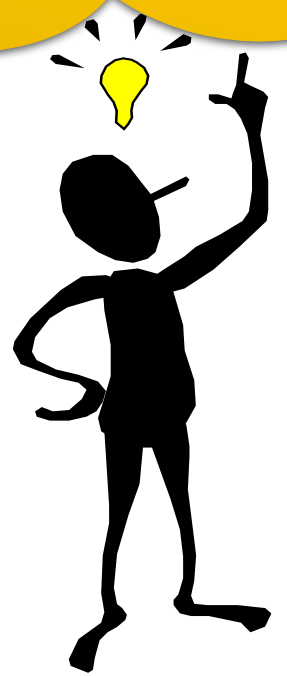




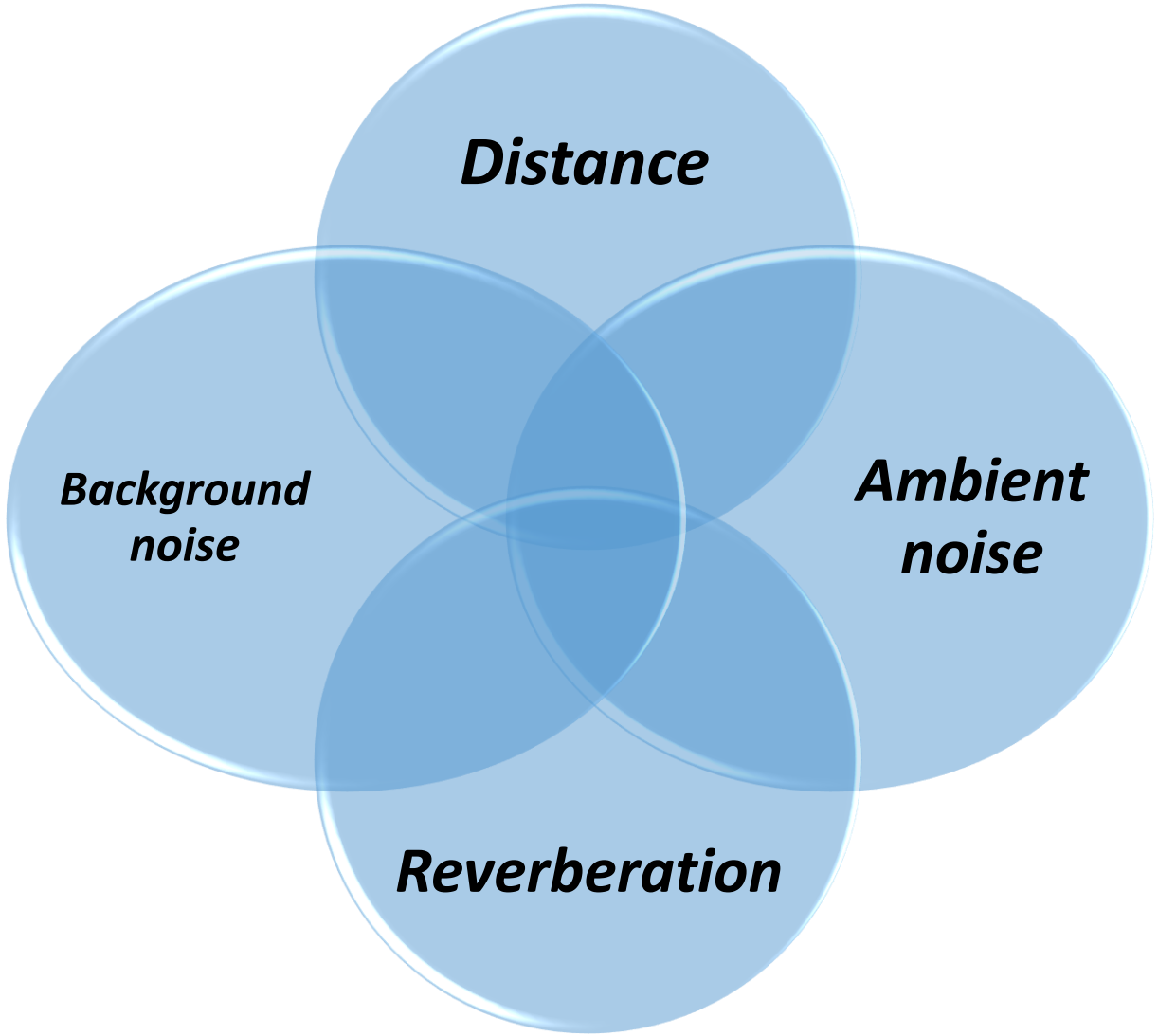
When we use ALDS??

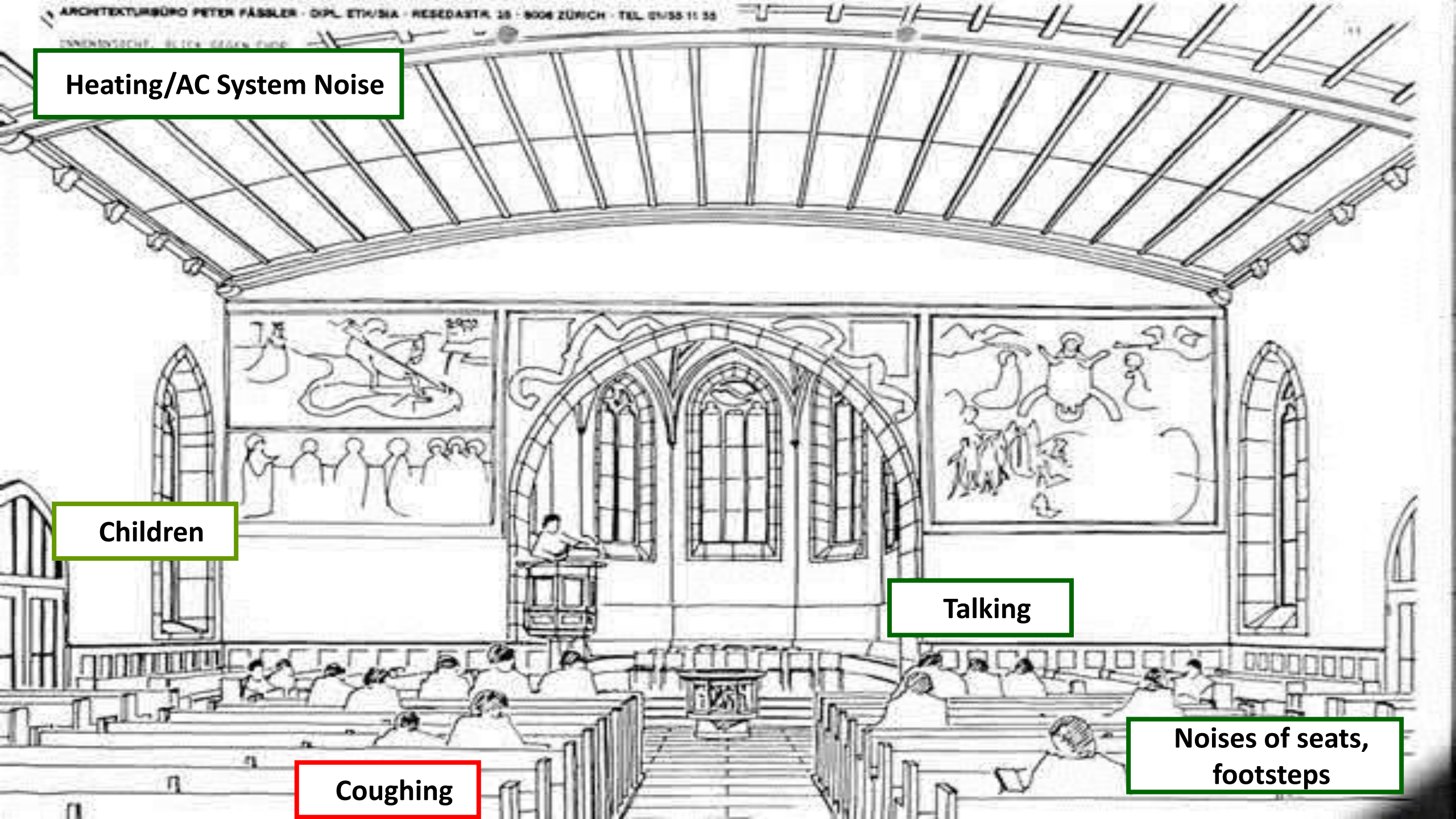


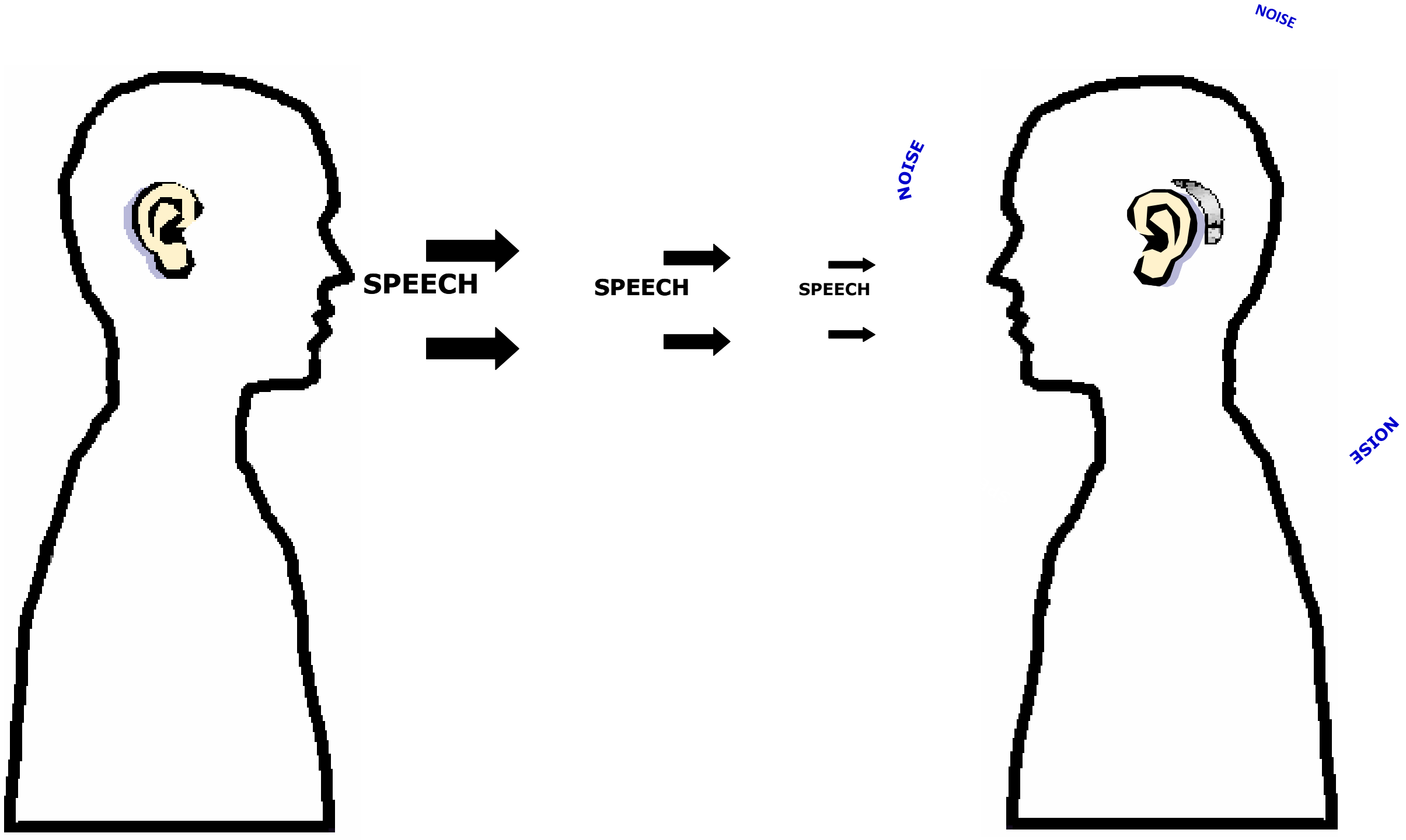
ALDS are especially useful when the audio signal is presented at a distance or when the listening conditions are less than ideal, In such conditions, a hearing aids or cochlear implant may not be adequate.



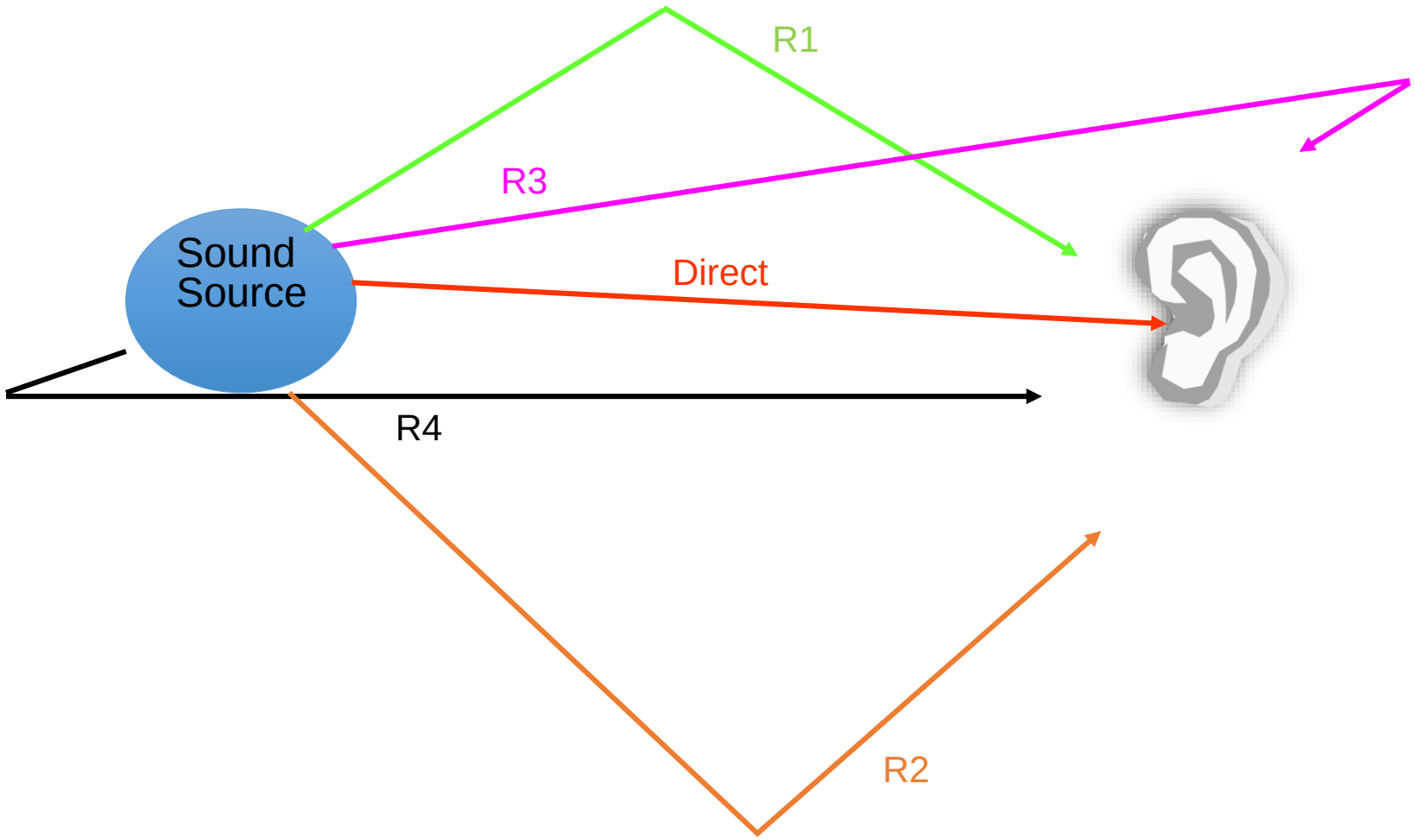
Factors affecting the acoustic medium




Heating/AC System Noise
Children
Talking
Noises of seats, footsteps
Coughing


NOISE
SPEECH
SPEECH
SPEECH
NOISE
NOISE

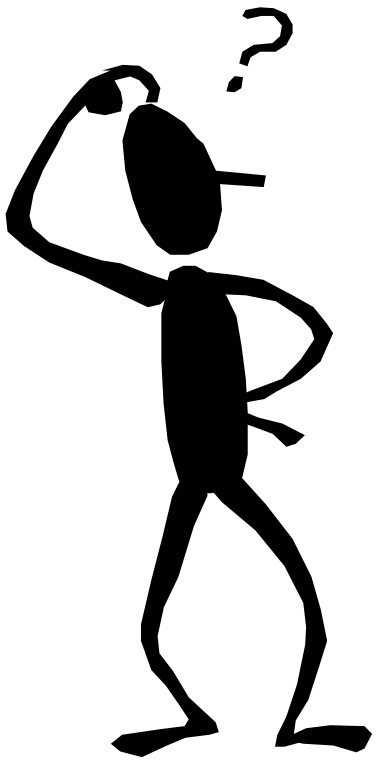
Reverberation

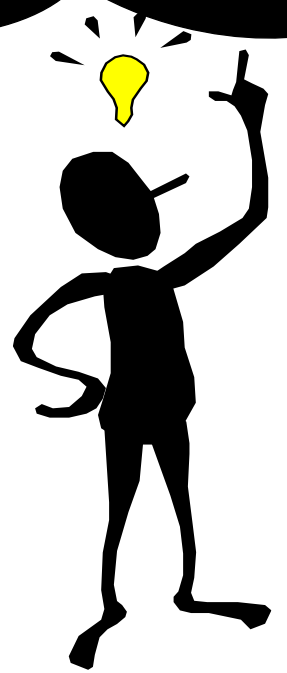


Reverberation is caused by sound bouncing off ceilings, floors, walls and other surfaces and objects in the room before it arrives at the listener's ears.

Why we need ADLS ??

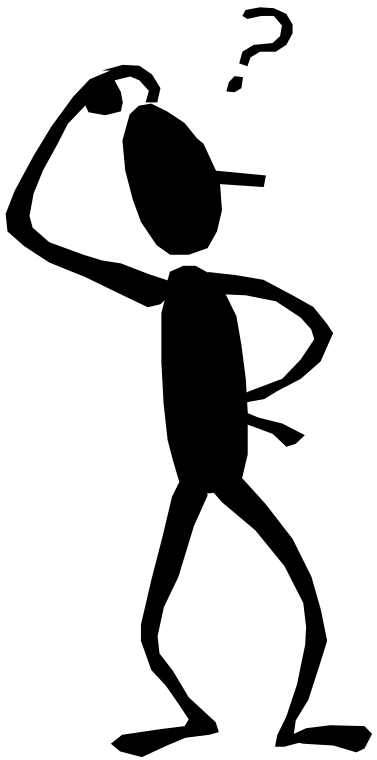
To get present the audio signal at an audible level, with a favorable SNR, with minimal ambient noise , without the effect of reverberation and with little background noise.

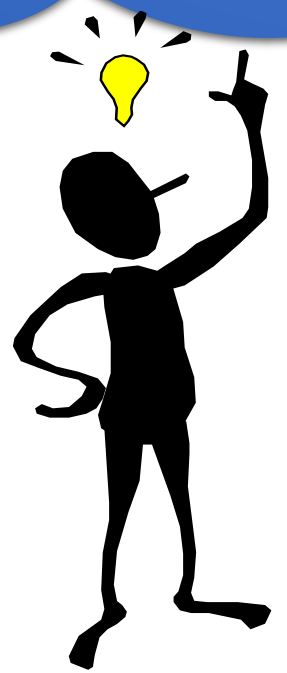




Where we use ADLS ??

Religious services or when attending a theater play or when several people must attend to a talker, as students do when listening to their teacher .





CATCH

CARRY

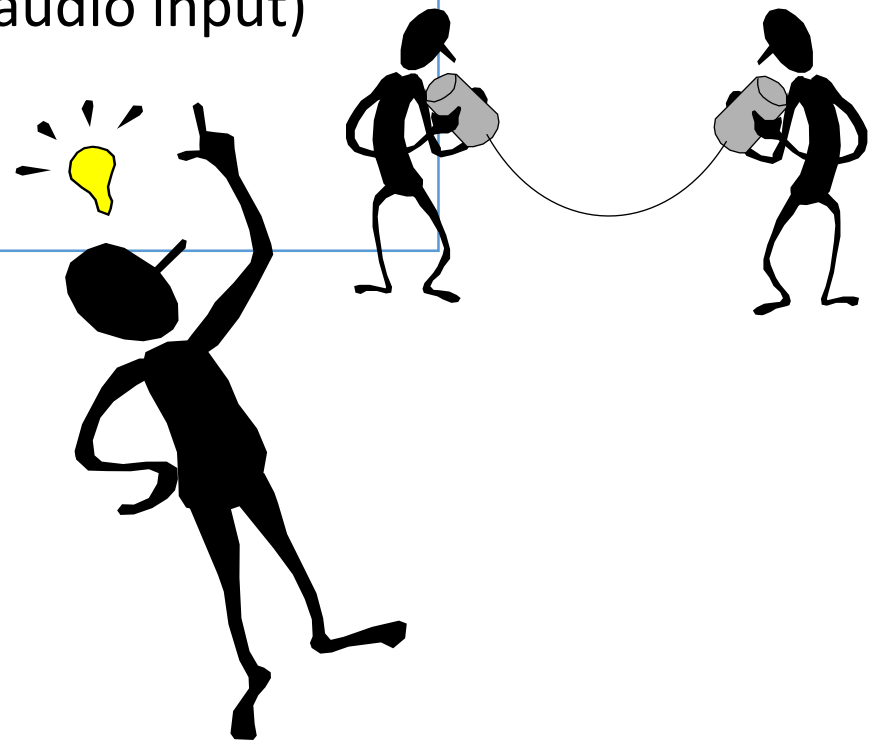
COUPLE

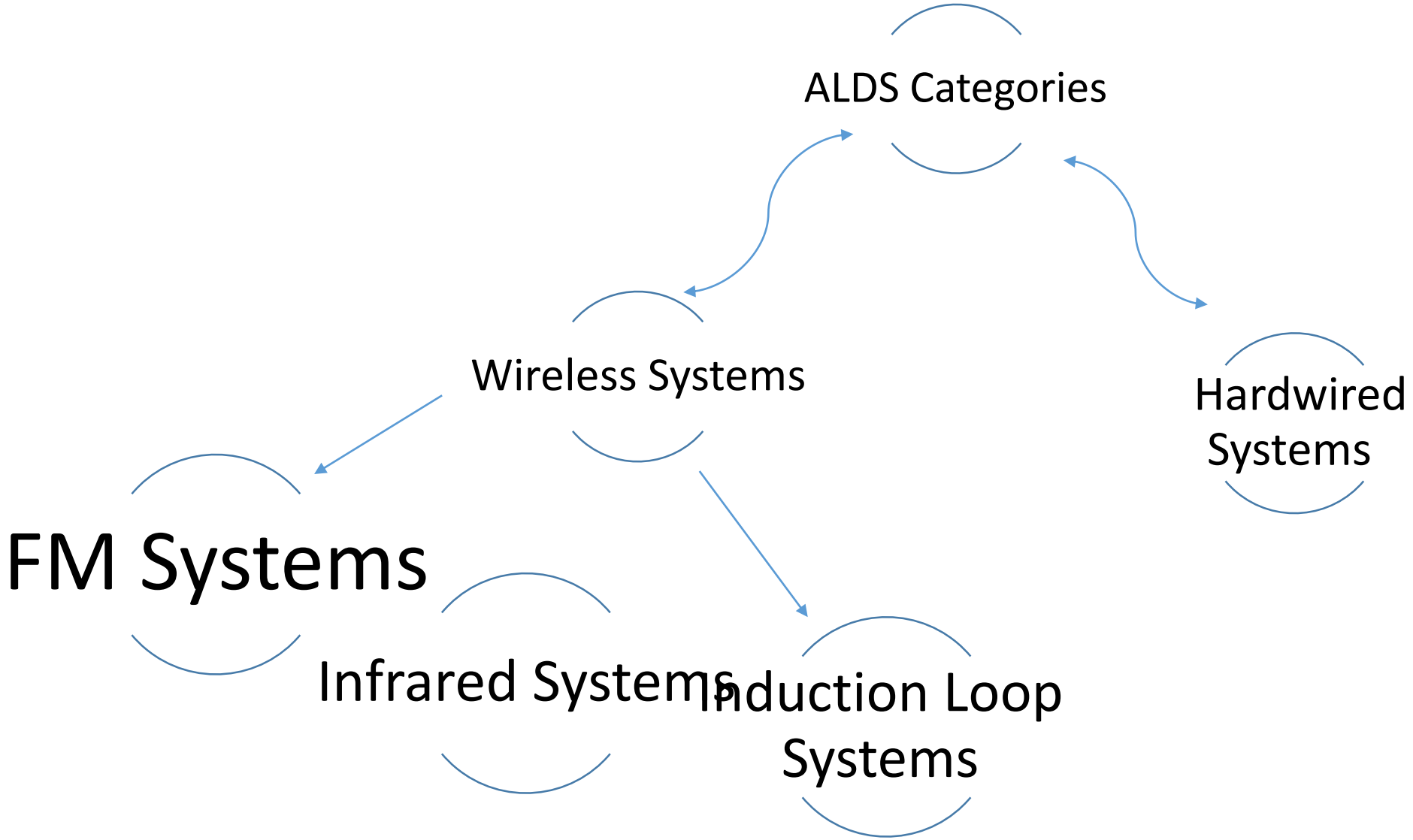
the signal (microphone or direct connection)

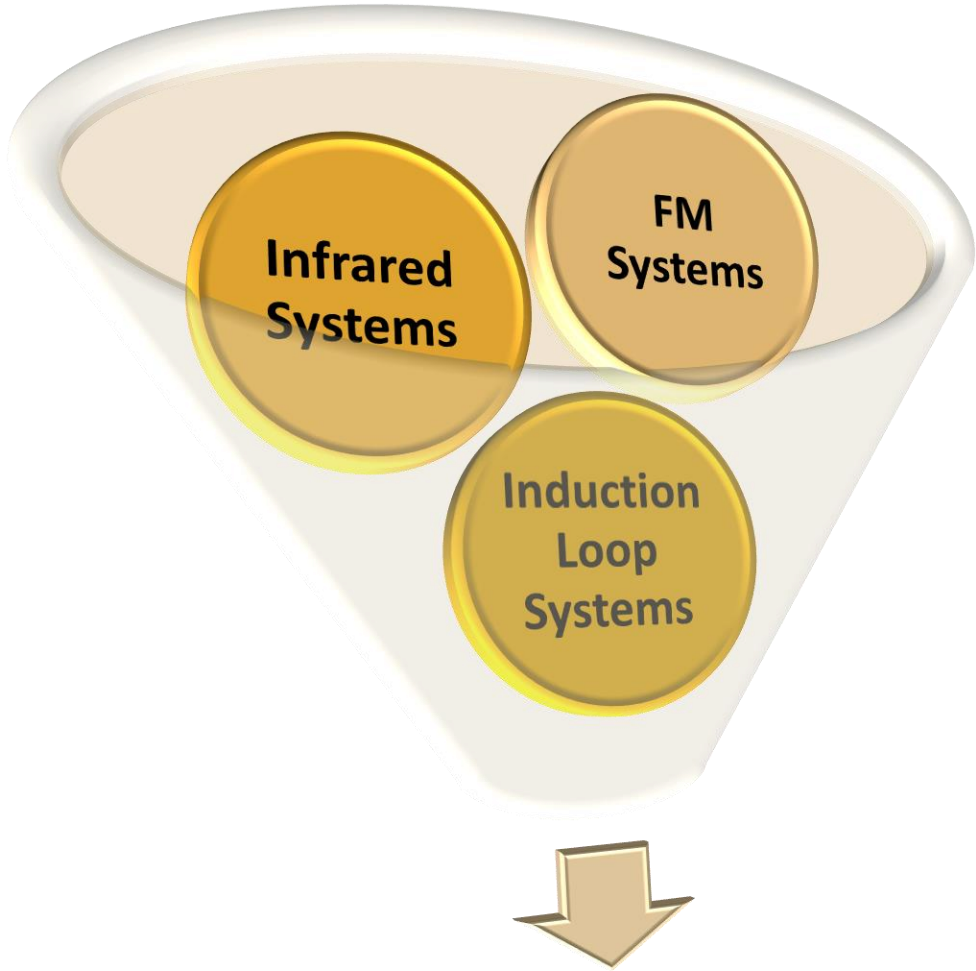
the signal (bypassing effects of distance)

the signal to the ears (via air, the telecoil, or direct audio input)

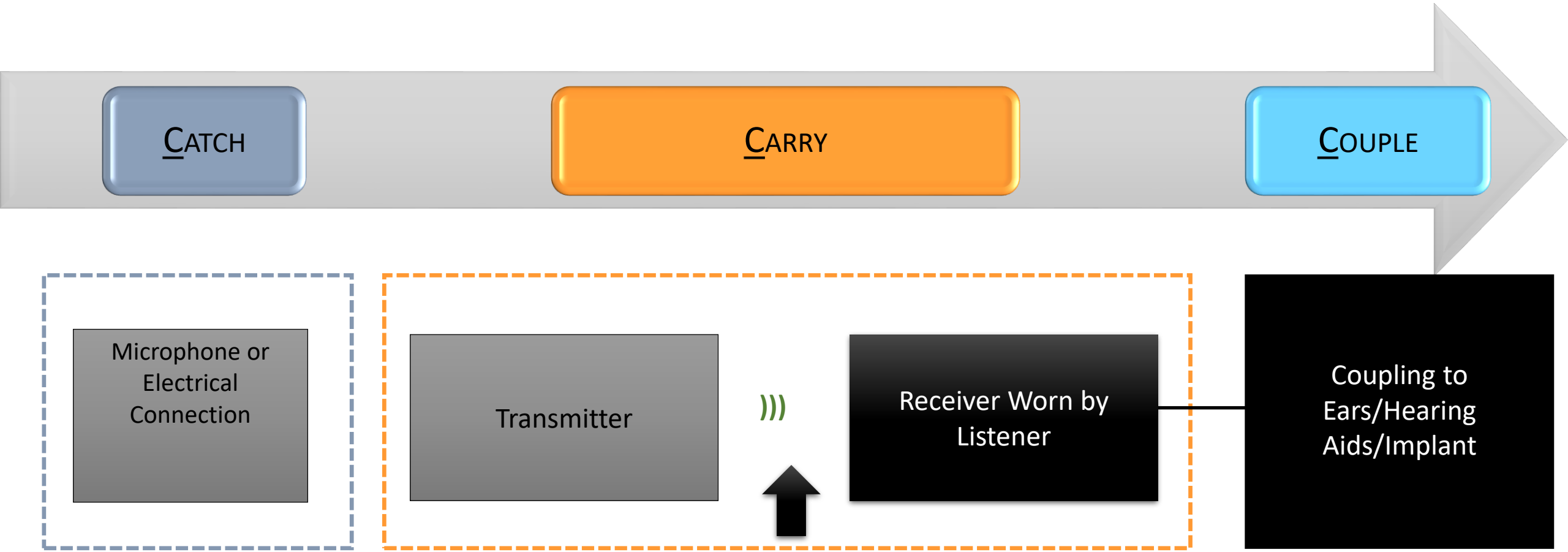
How ADLS Work ??




ALDS Categories
Wireless Systems
Hardwired Systems
FM Systems
Infrared Systems
Induction Loop Systems



Wireless Systems



Wireless broadcast

1. Frequency Modulation (FM)
2. Infrared (IR)
3. Audio Frequency Induction Loop (Room Loop)

FM Systems

Personal FM Trainer

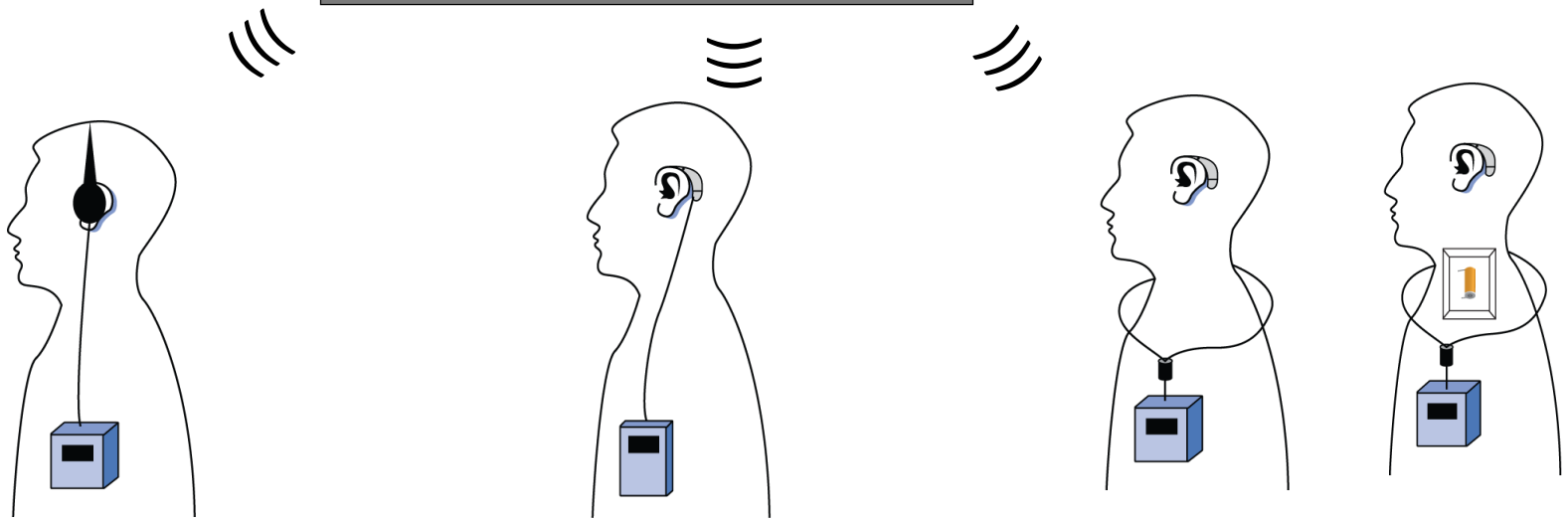
The hearing professional wears a microphone . Each child wears a receiver and may receive the teachers signals.

Sound-field FM

Differs from the personal system because the sound transmitted to loudspeakers that are throughout the room. Don’t require each one wear a special FM receiver.

Coupling to an FM System

FM Transmitter Connected to PA System Broadcasts to FM Receivers Worn by Listeners



1. Acoustic Coupling

Listener **borrows** receiver and uses **earphones** (no hearing aids) Called acoustic coupling because sound enters ear directly from earphone.

2. DAI (Direct Audio Input)

Listener **borrows** receiver and plugs personally-owned **electrical** cable into hearing aid or implant (venue not required to have cables on hand).

3. Inductive Coupling

Left: Listener with telecoil-equipped hearing aids/implants borrow FM receiver with an **inductive** neckloop.
Right: Listener with no telecoils but with telecoil-equipped streamer **borrows** FM receiver with neckloop.

Assistive Listening Devices

Personal FM System

- Delivers speech from a speaker's microphone to the ears of the person with a hearing loss

Soundfield FM System

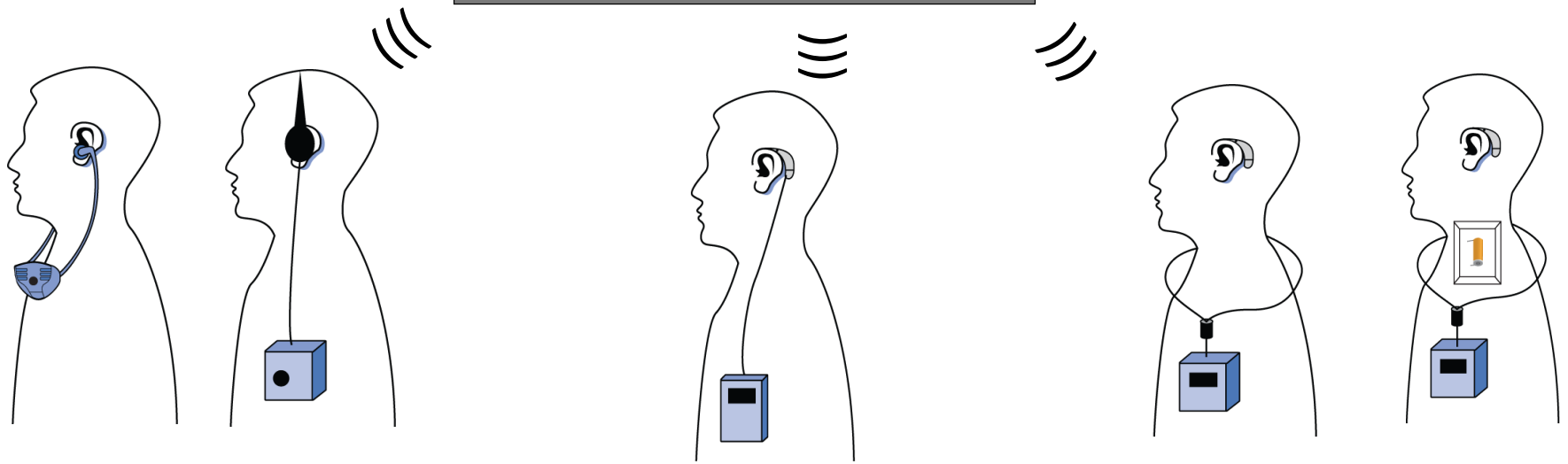
- Delivers speech from a speaker's microphone to speakers placed strategically throughout the room

Infrared Systems

Operate similarly to FM unites , but use infrared signals to transmit sounds. A transmitter/emitter sends the signal encoded in infrared light wave to a wireless receiver, which contain photo detector diode. The receiver picks up the infrared signal and convert it back to the audio signal and the LOS is required.

Coupling to an IR System

IR Transmitter Connected to PA System Broadcasts to IR Receivers Worn by Listeners



1. Acoustic Coupling

Listener **borrows** receiver and uses **earphones** (no hearing aids). Called acoustic coupling because sound enters ear directly from earphone. Left: Under-chin version; Right: Body worn version.

2. DAI (Direct Audio Input)

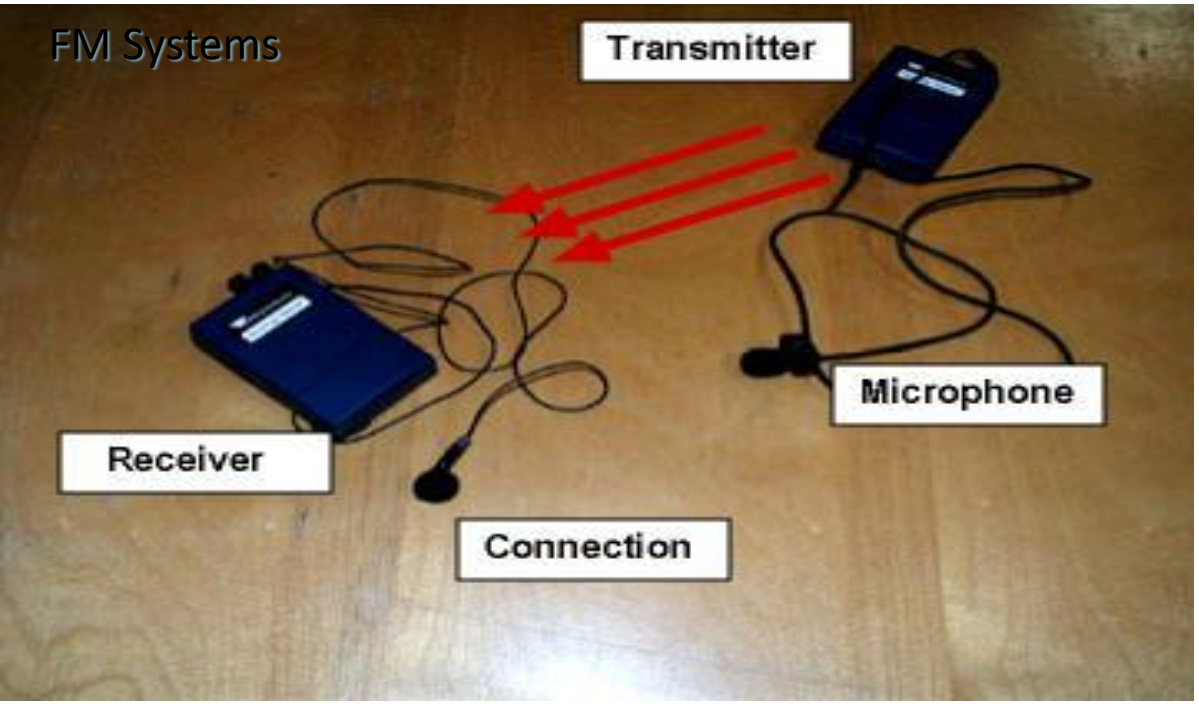
Listener **borrows** receiver and plugs personally-owned **electrical** cable into hearing aid or implant (venue not required to have cables on hand).

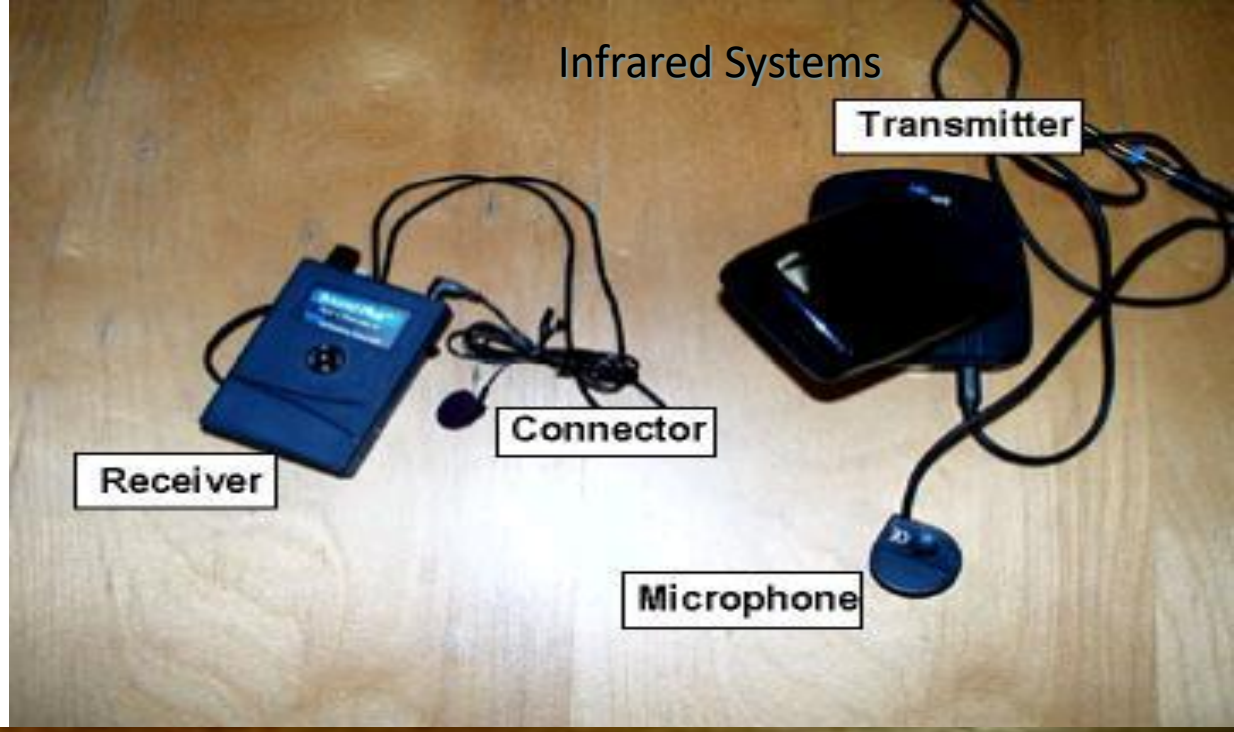
3. Inductive Coupling

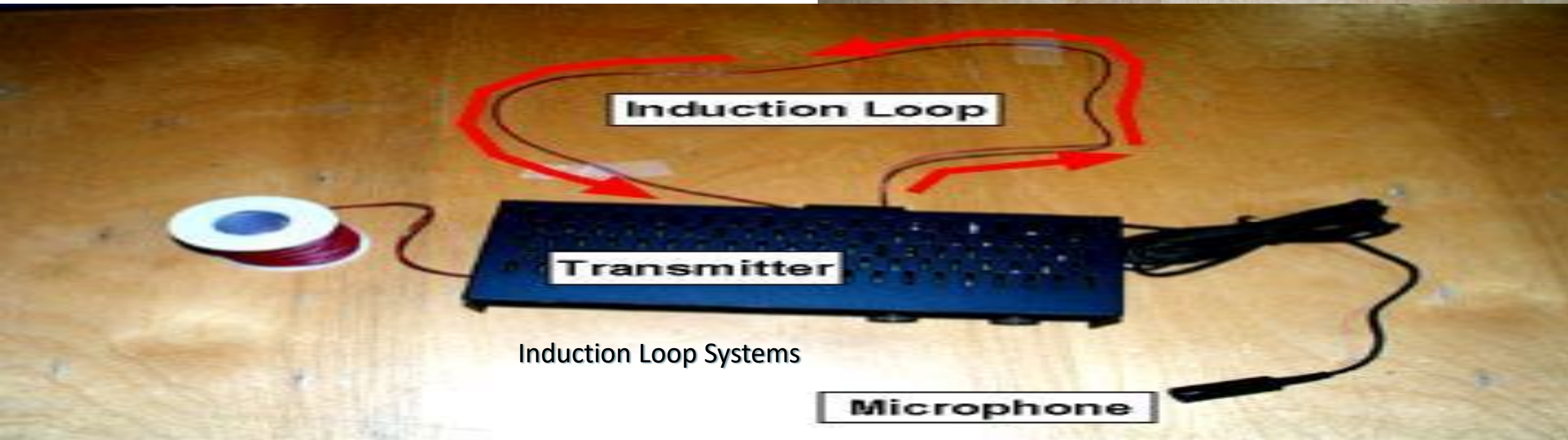
Left: Listener with telecoil-equipped hearing aids/implants borrow IR receiver with an **inductive** neckloop. Right: Listener with no telecoils but with telecoil-equipped streamer **borrows** IR receiver with neckloop.

Induction Loop Systems

Is a system that works by running a wire around the circumference of the room that conducts electrical energy from the amplifier and thus creates a magnetic field, which induces the telecoil in a hearing aid to provide amplified sound to the user.


FM Systems
Transmitter
Microphone
Receiver
Connection


Infrared Systems
Transmitter
Connector
Receiver
Microphone


Induction Loop
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