# ELECTROPHYSIOLOGY AND PSYCHOACOUSTICS WITH AUDITORY IMPLANTS

Waldo Nogueira

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Auditory Prosthetic Group

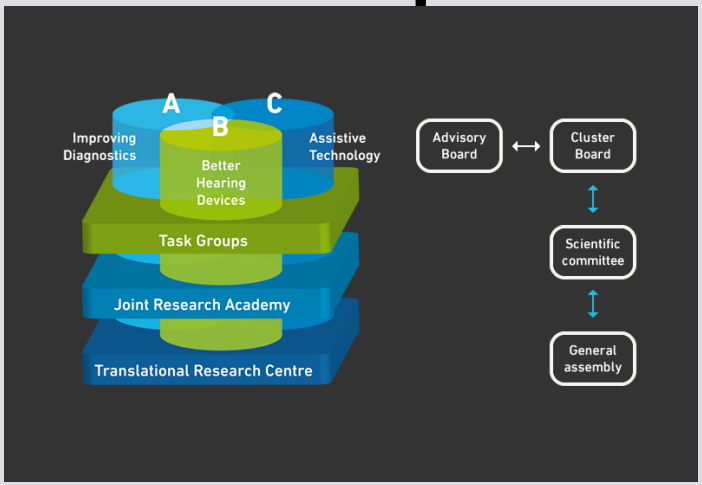



# Introduction

- 2002 Dipl-Ing: Electrical Engineering (UPC, Barcelona, Spain)
- 2002 Master Thesis: Erasmus at the TNT, LUH, Prof. Bernd Edler
- 2003 Dr.-Ing: TNT, LUH, Prof. Musmann, Prof. Osterman and Prof. Bernd Edler
- 2007 Research Engineer Advanced Bionics ERC (Belgium)
- 2009 Principal Research Engineer Advanced Bionics ERC (Hannover)
- 2011 Post-Doc, Visiting Professor, Music Technology Group (UPF, Barcelona, Spain)
- Since 2013 W1-Prof. Dr.-Ing Auditory Prosthetic Group (MHH)
- Since 2020 W2-Prof. Dr.-Ing Auditory Prosthetic Group (MHH)

# APG:
# Auditory Prosthetic Group

- Research (H4A, Auditory Prosthetic Group)
  - The group started in September 2013 as part of Excellence Cluster Hearing4all
  - Covering fields
    - Signal processing
    - Auditory modelling applied to implanted hearing protheses
      - Cochlear Implants and hybrid electroacoustic stimulation
    - Psychophysics
    - Electrophysiology

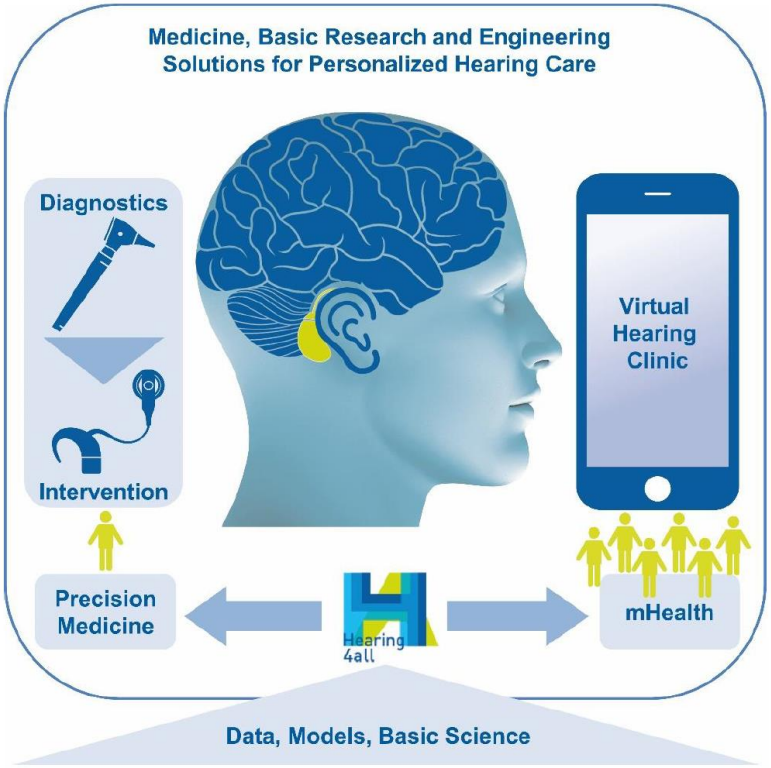


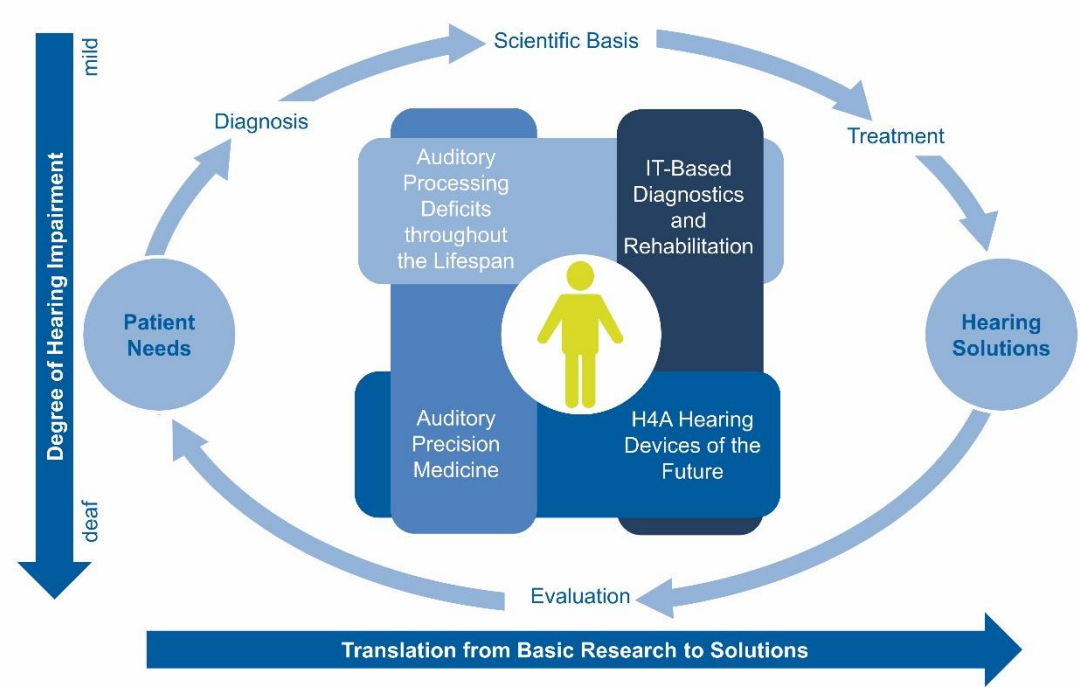

- Department Otoloringology/German Hearing Center
  - 30 years of cochlear implant experience
  - World largest cochlear implant programm (7000 Impl. 2013)
  - 500 patients are implanted every year
  - Large spectrum of Hearing Systems
    - Cochlear-Implants, Middle Ear Implants, Heraing Aids
    - ABI (auditory brainstem implant), AMI (auditory midbrain implant)

# Cluster of Excellence Hearing4all Largest Research Program in Hearing Worldwide (~40 mEuro – 2019-2026)

Medizinische Hochschule Hannover

PIs: Prof. Kollmeier (Oldenburg); Prof. Lenarz (Hannover)



# Medizinische Hochschule Hannover

# Contact Details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- http://auditoryprostheticgroup.weebly.com/
- Office: Karl-Wiechert Allee, 3, 30625, Hannover
- Deutsches Hörzentrum Hannover
- Telephone: +49 (0)511 532 8025

- Do you have questions? Send me an email and we will make an appointment!

# Ressources

- All ressource will be made publicly available throguh the following web-sites
  - https://auditoryprostheticgroup.weebly.com/blog
  - https://www.vianna.de/01_workgroups/nogueira/teaching.html

# Content Blocks (I)

- **Session 1:** Introduction to the course
- **Session 2:** Introduction to the Hannover Medical School; Hearing loss; Indications and Strategies for medical and audiological therapy (Prof. Lesinski-Schiedat)
- **Session 3:** Fundamentals: Signal processing, acoustics, speech signals
- **Session 4:** Psychoacoustics I: Loudness, Pitch, Spatial hearing
- **Session 5a:** Physiology of the Human Auditory System
- **Session 5b:** Electrophysiology: OAEs, ECochG, ABRs, ASSRs, CAEPs

# Content Blocks (II)

- **Session 6a:**
  - Intro EEG  (Hanna Dolhopiatenko)
  - Intro ASSRs, CAEPs (Nina Aldag)
  - Practical part: Introduction to Matlab speech and EEG processing EEG recording
- **Session 6B:**
  - Neural Tracking and Bimodal stimulation
  - ACCs + ASSRs + intracochlear recordings
- **Session 7:**  Sofia Bonfatti, Cochlear Italia, Fitting and Sound Coding Strategies
- **Session 8:** DISCCO lecture: Prof. Nogueira, Advances research strategies and new technologies for improving hearing healthcare: learning, living, working and music listening with a cochlear implant.
- **Session 9:**
  - Evaluation of Outcomes with Auditory Implants (CI, ABI, ANI, AMI)
  - Summary and relation between medical and audiological aspects

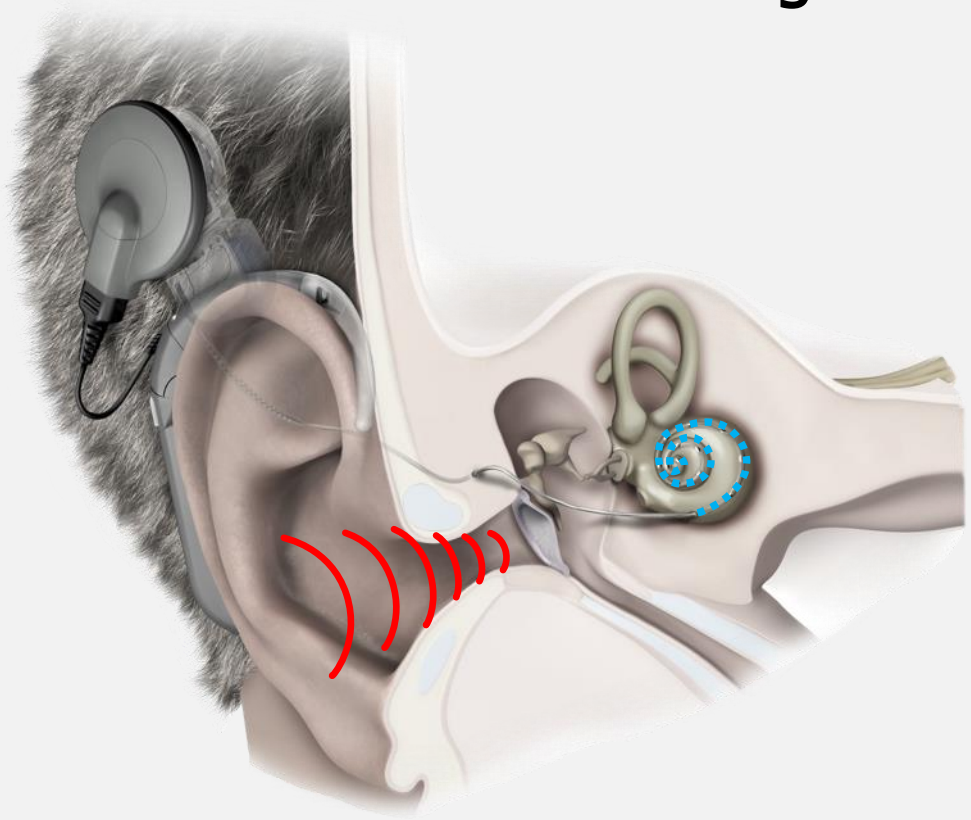
# Attendees

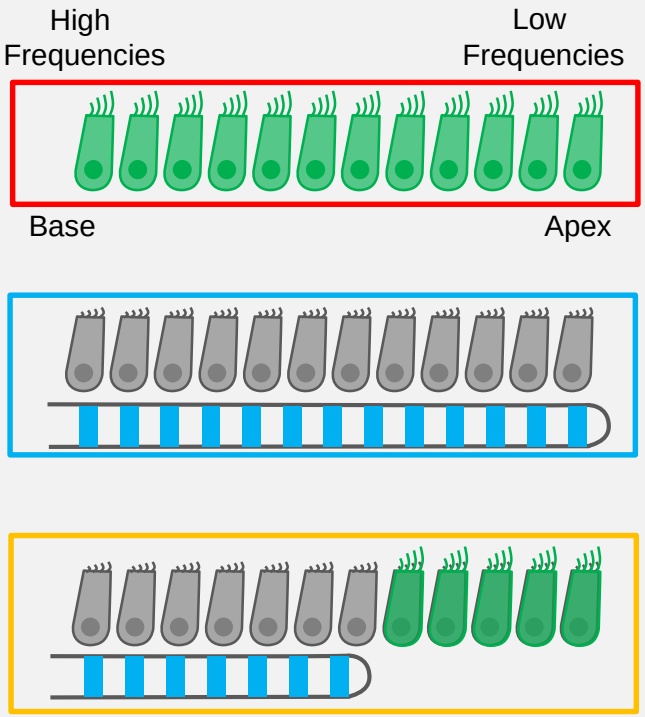
- Interdisciplinary audience with different backgrounds:
  - Students from the Postgraduate School of Audiology and Phoniatrics.
  - Students from the Undergraduate Programs in Audiometric Techniques and Audioprosthetic Techniques.
  - Medical doctors and technical personnel from the ENT department

# Introduction

- Course operation.
- Approach and objectives of the course.
- Introduction to Audiology.
- History of Audiology.
- The relationship of Audiology with other disciplines and with this course.

# Current Hearing Devices






- Electric acoustic stimulation provides large benefits
- Cochlear implantation is an invasive procedure

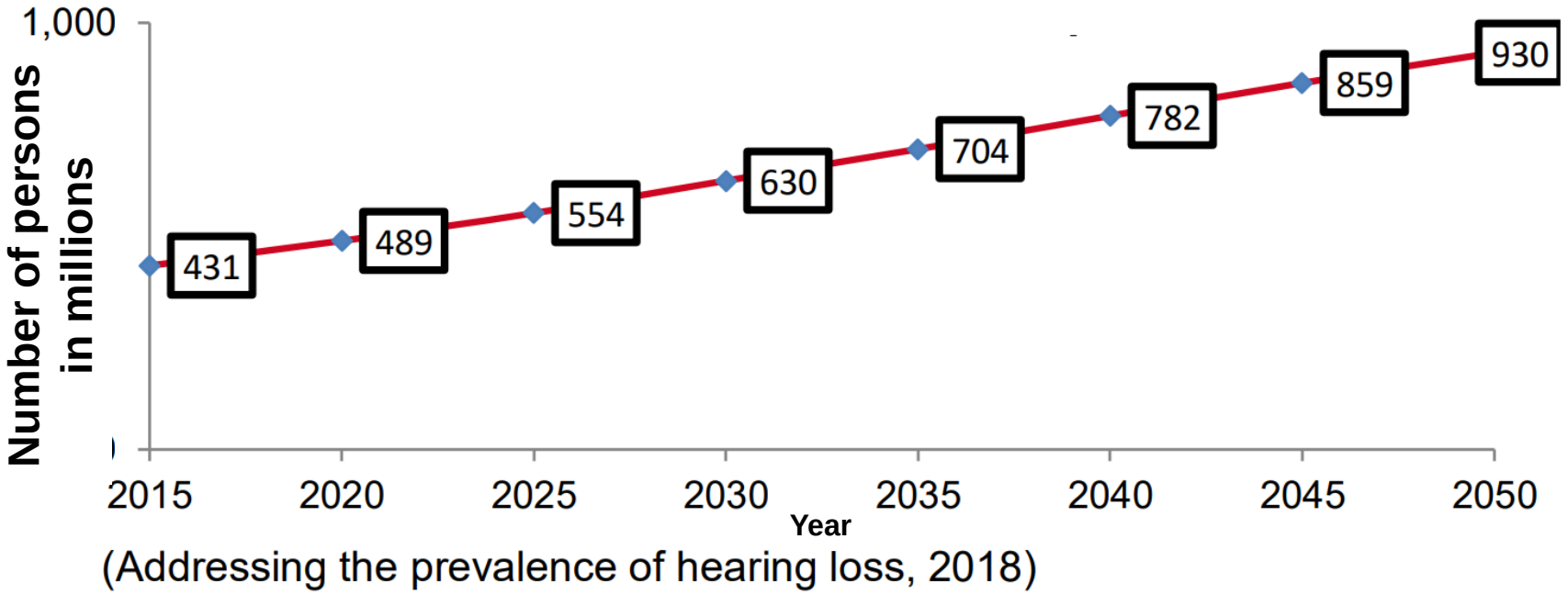
ReadiHear

# The WHO predicts that by 2050 one in every ten people will have disabling hearing loss.

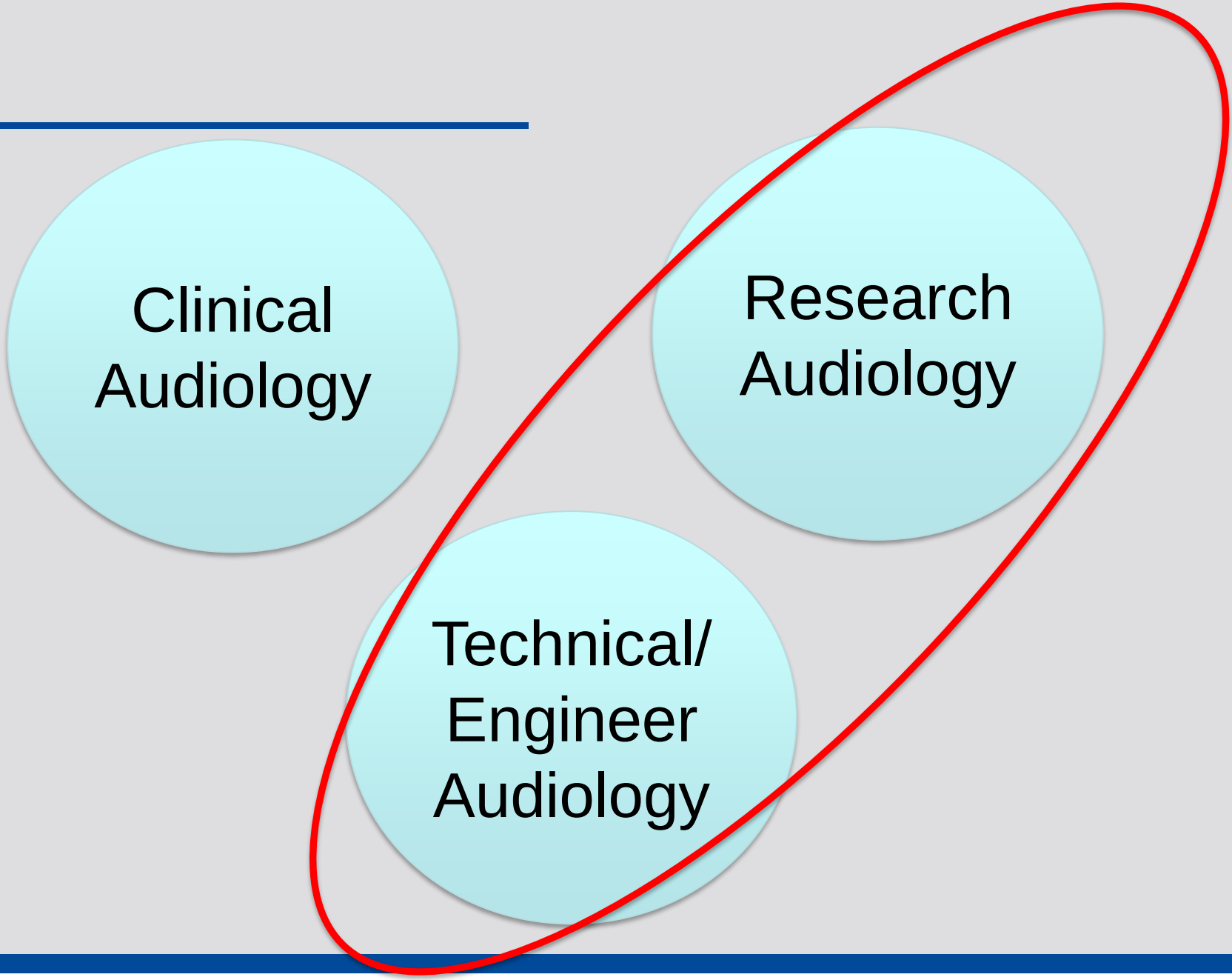
Delayed diagnostic of hearing loss has a negative impact on brain development and learning (Kral et al., Lancet, 2016)

Hearing loss is the largest modifiable factor influencing dementia (Nichols et al., Lancet, 2022)

# Evolution in number of people with hearing loss worldwide




(Addressing the prevalence of hearing loss, 2018)


Clinical Audiology
Research Audiology
Technical/ Engineer Audiology

# Number of Cochlear Implantations

- Number of cochlear implantations approaching 1 million (Zeng, 2022)

- Expansion of implantation criteria
  - Residual hearing

  → Need to train professionals in auditory implants

# Audiology

- Audiology is a generalist discipline that studies hearing (Katz, 2002; Roeser, Valente & Hosford Dunn, 2000).
- Clinical audiology encompasses the study of hearing as part of the human communicative system (Kidd, Cox & Matthies, 2003).
- The discipline brings together a series of very broad, general, structural and basic knowledge to be able to understand the mechanisms of hearing:
  - **Knowledge of physics**
  - **Anatomical knowledge**
  - **Knowledge of the physiology of the auditory system, from the ear to the cerebral cortex**
  - Prevention of hearing damage
  - Knowledge of the genetics of hearing loss
  - Epigenetics of hypoacusis
  - Sound as an auditory toxicant
  - **Rehabilitation of hearing loss**
  - Rehabilitation of neurological deficits through sound
  - Functional examination of the hearing aid

# Approach and Objectives

- Focus on Research Audiology and Technology
- Focus on Auditory Imlplants
- Focus on Fundamentals of:
  - Sound perception with acoustic and electric stimulation
  - fitting of CIs, EAS and Bimodal
  - Speech Audiometry with Cis
  - Objective Assessment of CI through:
    - eCAPs, ASSRs, ACCs Neutral Tracking
- Combination of Theory, Practical Sessions and Clinical Experience

# History of Audiology

- Audiology was born of interdisciplinary collaboration.
- The substantial prevalence of hearing loss observed in the veteran population after World War II inspired the creation of the field as it is known today.
- The International Society of Audiology (ISA) was founded in 1952 to "…facilitate the knowledge, protection and rehabilitation of human hearing" and to "…serve as an advocate for the profession and for the hearing impaired throughout the world.“
  - It promotes interactions among national societies, associations and organizations that have similar missions
  - Organization of a biannual world congresses
  - Publication of the scientific peer-reviewed International Journal of Audiology
  - Offers support to the World Health Organization's efforts towards addressing the needs of the hearing impaired and deaf community.

# History of Audiology

- 1946: use of the terms audiology and audiologist by Mayer BA Schier, Willard B Hargrave, Stanley Nowak, Norman Canfield, or Raymond Carhart

- Robert Galambos, Hallowell Davis is credited with coining the term in the 1940s, saying the then-prevalent term "auricular training" sounded like a method of teaching people how to wiggle their ears

- The first US university course for audiologists was offered by Carhart at Northwestern University, in 1946.

# Audiolgy Internationally

- USA:
  - Currently more than 74 universities offer Audiology (Doctoral Degree in Audiology, Au.D.) (ADA (Academy of Doctors of Audiology), 2019)
  - 656 students graduated In the academic year 2017-2018 (ASHA (American Speech-Language-Hearing Association), 2018).
  - The educational model used by the USA is becoming the most popular in several countries, although the length and nomenclature of the degree differs between countries. Some of these countries are the United Kingdom, Ireland, Australia, South Africa, Canada, Belgium, Sweden or Portugal.

- In Europe, work is being done along the same lines to alleviate this deficiency. The European Federation of Audiology Associations (EFAS) has been committed to advancing audiology in university education for years and is currently one of the three priorities of its president, Dr. Biger Kollmeier (Kollmeier, 2019).
  - Germany: Audiology is an engineering study
  - Spain: Audiology does not exist. Currently being established → Clinical Audiology
  - Italy: Medical study?

# Audiologist skills (I)

- Competencies of audiology professionals, ASHA classifies them as follows (ASHA, 2019)
- Assessment and identification:
  - Identify, **test**, diagnose and monitor disorders of **human hearing**, balance and tinnitus; **interpret test results of behavioral and objective measures**.
  - Consult the patient about their hearing health and the possible need for treatment.
  - **Assess the best solution for patients with hearing loss with hearing aids and cochlear implants and fit, schedule and rehabilitate to ensure the best possible results.**
  - Supervise and conduct newborn hearing screening programs.
  - Assessing and managing children and adults with central auditory processing disorders.

# Audiologist skills(II)

- Management and treatment:
  - Carry out otoscopies of the ear canals and eardrum.
  - Recommend and provide the selection, **fitting and programming of hearing aids.**
  - **Recommend and provide hearing aid technology systems.**
  - Recommend and provide audiological rehabilitation (including speech reading, communication management, language development and auditory skills development).
  - Assess and treat tinnitus non-medically.
  - Advise and educate patients and family members/caregivers on psychosocial adjustments to hearing loss

# Audiologist skills (III)

- Prevention and education:
  - Collaborate with educators in communication management, educational implications of hearing loss, educational programming, classroom acoustics and large area amplification systems for children with hearing loss.
  - Educate society on the prevention of hearing loss, tinnitus and falls.
  - Consult accessibility for people with hearing loss in public and private buildings, programs and services.
  - Implement and/or coordinate reviews and hearing conservation programs for the community, school or professional.
  - Participate in the development of professional and technical standards.
  - Demonstrate the value of audiological services by measuring functional outcomes, consumer satisfaction and treatment effectiveness.

# Needs for Cochlear Implants

- Complex device
  - Subjects in general understand speech in quiet but suffer in more difficult situations
    - Signal processing is similar to hearing aids
    - Fitting requires speific knowledge on
      - Basics of electric sitmulation
      - Basics of acoustics
      - Basics of physiology
      - Basics of psychoacoustics
      - Basics of electrophysiology
    - Fitting is subjective and very variable
- After care
  - Intensive training
  - Regular appointments
  - Track performance
  - Optimal fitting rquired for each individual