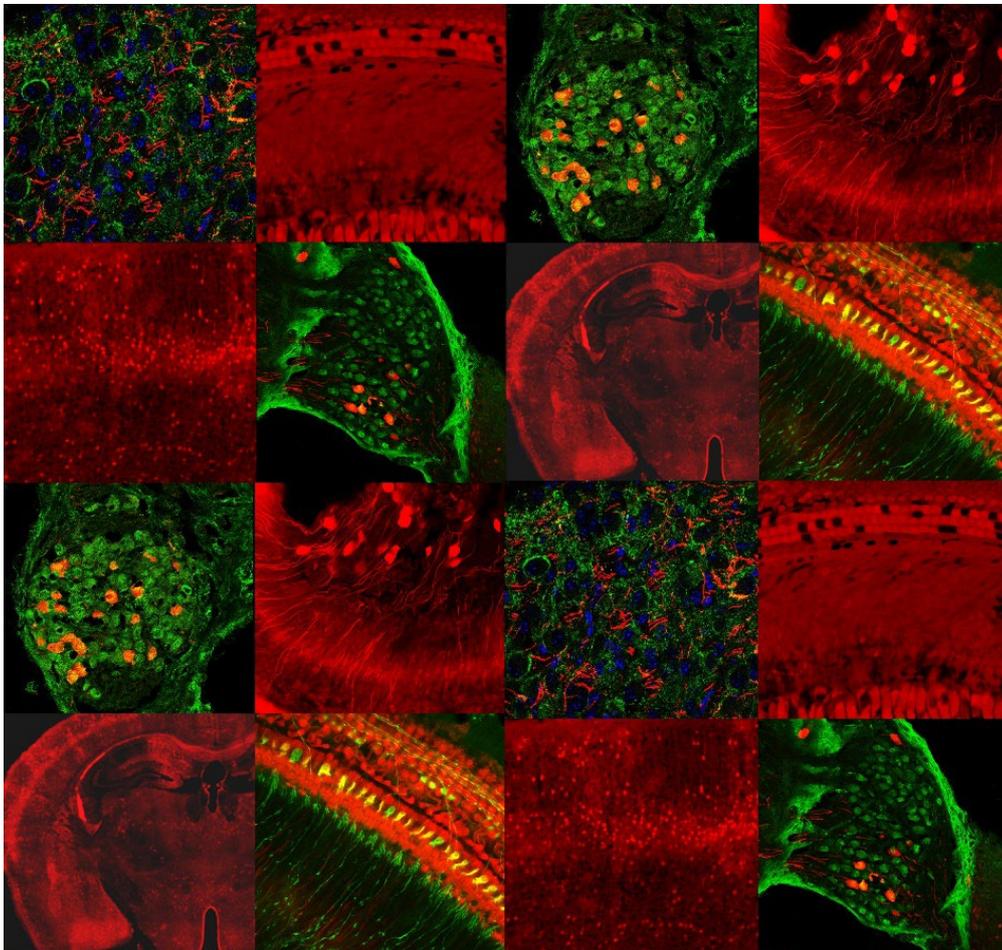


# PASTEUR COURSE

## HEARING: FROM MECHANISMS TO RESTORATION TECHNOLOGIES (HEAR)



*Credit: N. Michalski, M. Gagliardini.*

**PROGRAM**  
**FROM 5 TO 21 JUNE, 2023**



## **HEARING COURSE 2022-2023**

**JUNE 5-21, 2023**

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## Course locations

Day 1, 05/06	Day 2, 06/06	Day 3, 07/06	Day 4, 08/06	Day 5, 09/06
<b>IdA</b>	<b>IdA</b>	<b>IdA</b>	<b>IdA</b>	<b>IdA</b>
Day 6, 12/06	Day 7, 13/06	Day 8, 14/06	Day 9, 15/06	Day 10, 16/06
<b>Institut Pasteur</b>	<b>IP (am) / IdA (pm)</b>	<b>IdA</b>	<b>IdA</b>	<b>IdA</b>
Day 11, 19/06	Day 12, 20/06	Day 13, 21/06		
<b>IdA</b>	<b>IdA</b>	<b>IdA</b>		

**IdA:** Institut de l’Audition, 63 rue de Charenton, 75012 Paris

Mornings: Ground floor, Auditorium. Afternoons: Ground floor, Teaching room (salle modulable)

**Institut Pasteur:** 28 rue du Dr Roux, 75015 Paris. Education Center Classroom 2 (Pavillon Emile Roux) and Practicals (Pavillon Louis Martin).

## Day 1: Acoustics, signals and anatomy

Monday, June 5<sup>th</sup> 2023, Institut de l'Audition

*Principles of acoustics and wave signal processing:*

- *Sound pressure wave propagation.*
- *Effects of the physical environment : absorption, reflection, impedance*
- *Sound pressure measurement scales.*
- *Soundscapes and sound proofing.*
- *Spectral decomposition and spectrograms.*
- *Anatomical et biomechanical characteristics of the outer ear*

### MORNING

<b>09:00-09:30</b>	<b>Welcome, general information, student presentation</b>	
<b>9:30-10:30</b>	The auditory system – anatomy and principles of hearing	B. Bathellier
	BREAK	
<b>10:40-12:30</b>	Principles of acoustics	O. Warusfel
	<b>LUNCH BREAK: Buffet at Ida</b>	

### AFTERNOON

<b>13:30-18:00</b>	<b>PRACTICAL COURSE 1:</b> Anatomy, biomechanics and acoustic of the outer ear Introduction to programming of sound synthesis, delivery and recording (Matlab/Python) - Generation of pure tones and more complex sounds - Spectral decomposition - Calibration of sound delivery: intensity and equalisation	A. Coez B. Gourevitch
All students		

## Day 2: Auditory perception and psychoacoustics

Tuesday, June 6<sup>th</sup> 2023, Institut de l'Audition

- *Perceptual features in auditory perception: tonality, sonie, sound localisation, rugosity*
- *Measurement methods in psychoacoustics*
- *Temporal sequences and predictions*

### MORNING

<b>09:30-11:15</b>	Perception and psychoacoustics	D. Pressnitzer
<b>11:30-12:30</b>	A broadoverviewof threemain auditoryattributes:Loudness, Pitch and Timbre	O. Macherey
	<b>LUNCH BREAK</b>	

### AFTERNOON

<b>13:30-18:00</b>	<b>PRACTICAL COURSE 2:</b> Using Matlab/Python for generating and quantifying experiments auditory perception experiments. Psychoacoustic protocols: - Sound localization - Measuring intensity perception - Simple auditory illusions	B. Gourevitch O. Macherey
All students		

## Day 3: Mechano-electric transduction and amplification

Wednesday, June 7<sup>th</sup> 2023, Institut de l'Audition

- *Physical principles governing the mechano-electric transduction and sound amplification.*
- *Molecules, cells and structures involved in sound detection and spectral analysis.*

### MORNING

<b>09:00-09:55</b>	Sound amplification and distortions by hair cells	P. Martin
<b>10:00-10:55</b>	Genetics of mechano-electrical transduction	N. Michalski
<b>11:00-11:55</b>	Cochlear physiology and mechanics	J. Barral
<b>LUNCH BREAK</b>		

### AFTERNOON

<b>13:30-18:00</b> Group 1	<b>PRACTICAL COURSE 3:</b> Otoacoustic emissions and distortion products. - Better understand the meaning of otoacoustic emissions and their link to normal and impaired cochlea performances - Electrocochleography	Paul Avan, CERIAH staff
<b>13:30-18:00</b> Group 2	<b>PRACTICAL COURSE 8:</b> Functional exploration of the audiovestibular deficits in transgenic mice: - ABR recordings and interpretation in Shaker mutant and WT mice, including masking conditions - behavioral tests for locomotion swimming and occulo-vestibular reflex	S. Vitry and IdA/CERIAH staff

## Day 4: Auditory impairments and cochlear implant

Thursday, June 8<sup>th</sup> 2023, Institut de l'Audition

- *Clinical survey of middle and inner ear pathologies (presbycusis, ototoxicity, sound trauma)*
- *Inner and middle ear surgery*
- *Cochlear implants and hearing aids*

### MORNING

<b>09:00-10:00</b>	Clinical survey of middle and inner ear pathologies	E. Ferrary D. Dulon
<b>10:00-10:30</b>	Inner and middle ear surgery	Y. Nguyen
<b>10:30-11:15</b>	Hearing aids	C. Coudert
<b>11:15-12:00</b>	Electrical stimulation and coding strategies for cochlear implants	M. Cosnard
<b>LUNCH BREAK</b>		

### AFTERNOON

<b>14:00-18:00</b> All students	<b>PRACTICAL COURSE 5:</b> - Simulation of a surgery with a robot or a virtual simulator - Analysis of scanner images from post-surgery patients	Y. Nguyen E. Ferrary
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## Day 5: Synaptic transmission in the auditory system

Friday, June 9<sup>th</sup> 2023, Institut de l'Audition

- *Synaptic exocytosis, neurotransmitters and the molecular specificities of the auditory system from hair cells to brainstem*

### MORNING

<b>09:00-09:45</b>	Molecular anatomy of auditory synapses	S. Safieddine
<b>09:50-11:05</b>	Synaptic transmission of the ribbon synapse	D. Dulon
<b>11:10-12:00</b>	Auditory nerve processing and giant synapses	N. Michalski
<b>12:00-12:15</b>	<b>Feedback session 1</b>	
	<b>LUNCH BREAK</b>	

### AFTERNOON

<b>13:30-18:00</b> Group 2	<b>PRACTICAL COURSE 4:</b> Access the temporal aspects of auditory processing through field recordings electrophysiology in humans, by in depth dissection of ABR signals to extract the following concepts: - responding sub-populations - synchrony - stability of unitary responses - associated psychoacoustics	P.Avan and CERIAH staff
<b>13:30 - 18:00</b> Group 1	<b>PRACTICAL COURSE 8:</b> Functional exploration of the audiovestibular deficits in transgenic mice: - ABR recordings and interpretation in Shaker mutant and WT mice, including masking conditions - behavioral tests for locomotion swimming and occulo-vestibular reflex	S. Vitry and IdA/CERIAH staff

## Day 6: Inner ear: development, evolution and genetics of associated disorders

Monday, June 12<sup>th</sup> 2023, Institut Pasteur

- *Development and evolution of the cochlea.*
- *Functional interpretations in the light of the major genes involved.*

### MORNING

<b>09:00-10:00</b>	From inner ear development to basic principles of inner-ear organoid generation	R. Etournay
<b>10:00-11:00</b>	Evolution of inner ear and hair cells : effects and consequences	A. El Amraoui
<b>11:00-12:00</b>	Hereditary auditory and vestibular defects : from genes to functions	C. Petit
	<b>LUNCH BREAK</b>	

### AFTERNOON

<b>13:30-18:00</b> All students	<b>PRACTICAL COURSE 6:</b> Dissection of the cochlea of mutant and wild type Shaker mice for staining and imaging in PRACTICAL COURSE 7 on on day 7	S. Vitry
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## Day 7: Full day practical courses

Tuesday, June 13<sup>th</sup> 2023, Institut Pasteur/ Institut de l'Audition

### MORNING (IP)

<b>09:00-12:00</b> All students	<b>PRACTICAL COURSE 6:</b> Immuno-staining <i>in toto</i> of the cochlea of mutant and wild type Shaker mice for imaging in PRACTICAL COURSE 7 Course on fluorescence microscopy	S. Vitry
<b>LUNCH BREAK</b>		

### AFTERNOON (IdA)

<b>14:30-18:30</b> Group 1	<b>PRACTICAL COURSE 7:</b> Confocal microscopy of mutant and wild type mice cochlea stained in PRACTICAL COURSE 5: Quantitative analysis for a comparative study of cochlear morphology in normal and hearing-impaired mutant mice	S. Vitry M. Brunstein
<b>14:30-18:30</b> Group 2	<b>PRACTICAL COURSE 3:</b> Otoacoustic emissions and distortion products. - Better understand the meaning of otoacoustic emissions and their link to normal and impaired cochlea performances - Electrocochleography	Paul Avan, CERIAH staff

## Day 8: Hearing restoration by gene therapy and genetically-driven audiology

Wednesday, June 14<sup>th</sup> 2023, Institut de l'Audition

- *Role of genes in auditory-vestibular defects*
- *Gene therapy approaches*
- *New directions in audiology exploration opened by genetic results*

### MORNING

<b>09:00-10:00</b>	Replacement Gene Therapy for Inner Ear Defect: from animal models to the clinic	S. Safieddine
<b>10:00-11:00</b>	Gene editing for hereditary deafness	C. Petit
<b>11:00-12:00</b>	How molecular physiology of the auditory system underpins a new audiology	P. Avan
<b>LUNCH BREAK</b>		

### AFTERNOON

<b>13:30-18:00</b> Group 2	<b>PRACTICAL COURSE 7:</b> Confocal microscopy of mutant and wild type mice cochlea stained in PRACTICAL COURSE 5: Quantitative analysis for a comparative study of cochlear morphology in normal and hearing-impaired mutant mice	S. Vitry M. Brunstein
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## Day 9: Central auditory system

Thursday, June 15<sup>th</sup> 2023, Institut de l'Audition

- *Anatomy and physiology of the central auditory system*
- *Main structures, connectivity, receptive fields, neural coding schemes*
- *Models of auditory processing*

### MORNING

<b>09:00-10:50</b>	Auditory system anatomy and main functions	J.M. Edeline
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<b>11:00-12:00</b>	Neural population imaging in the auditory system	B. Bathellier
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**LUNCH BREAK**

### AFTERNOON

<b>13:30-18:00</b> All students split in two halves (Analysis / Imaging)	<b>PRACTICAL COURSE 9:</b> Two-photon imaging <i>in vivo</i> <ul style="list-style-type: none"><li>- Theory of two-photon microscopy and calcium imaging</li><li>- Training on commercial two-photon microscope</li><li>- Imaging in auditory and other sensory cortex <i>in vivo</i> in mice during stimulus presentation</li><li>- Data analysis using state of the art pipelines</li></ul>	B. Bathellier M. Brunstein
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## Day 10: Cortical circuits and plasticity

Friday, June 16<sup>th</sup> 2023, Institut de l'Audition

- *Functional architecture of the cortical circuits*
- *Plasticity of the auditory system and critical periods*

### MORNING

<b>09:00-10:30</b>	The forefront of central auditory system research	A. King
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<b>10:30-12:00</b>	Experience dependent plasticity in the auditory cortex	T. Barkat
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<b>12:00-12:30</b>	<b>Feedback session 2</b>	
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**LUNCH BREAK**

### AFTERNOON

<b>14:00-18:00</b> All students split in two halves (Analysis / Imaging)	<b>PRACTICAL COURSE 10:</b> Two-photon imaging <i>in vivo</i> <ul style="list-style-type: none"><li>- Theory of two-photon microscopy and calcium imaging</li><li>- Training on commercial two-photon microscope</li><li>- Imaging in auditory and other sensory cortex <i>in vivo</i> in mice during stimulus presentation</li><li>- Data analysis using state of the art pipelines</li></ul>	B. Bathellier M. Brunstein
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## Day 11: Auditory cognition and communication: predictive and emotional processing

Monday, June 19<sup>st</sup> 2023, Institut de l'Audition

The lectures will present the neural bases of auditory perception and communication with an emphasis on vocal, musical and emotional processing. In particular, they will focus on:

- recent cognitive and neurophysiological models of auditory processing that emphasize the hierarchical and predictive nature of perception.
- the neural pathways and mechanisms involved in the processing of ecologically relevant sounds, with a particular focus on vocal communication signals, whether verbal or non-verbal.

### MORNING

<b>09:00-10:25</b>	Auditory perception and predictions	K. Doelling
	BREAK	
<b>10:35-12:00</b>	Vocal communication and auditory emotions	L. Arnal
	<b>LUNCH BREAK</b>	

### AFTERNOON

<b>13:30-18:00</b>  Half-group	<b>PRACTICAL COURSE 11:</b> Acquisition and analysis of EEG data using classical paradigms and applying the signal processing techniques acquired at the beginning of the course - data preprocessing and filtering - Evoked potentials (oddball paradigm) - Spectro-temporal analysis (auditory steady-state responses)	L. Arnal
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## Day 12: Language processing and deep neural networks

Tuesday, June 20<sup>nd</sup> 2023, Institut de l'Audition

- Language processing.
- Automated speech recognition, voice synthesis.
- Deep networks and artificial intelligence: principles, comparisons with brain circuit computations and potential for restoration approaches.

### MORNING

<b>09:00-10:50</b>	Introduction to deep networks and automated speech processing	R. Serizel
<b>11:00-12:00</b>	Analogies and differences between deep neural networks and sensory systems	B. Bathellier
	<b>LUNCH BREAK</b>	

### AFTERNOON

<b>13:30 - 18:00</b> Half-group	<b>PRACTICAL COURSE 12:</b> Introduction to the tools used in artificial intelligence in Python - Classification of sensory object (images and sounds) - Classification of musical genres	S. Bagur
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## Day 13: Vestibular function and disorders. Complex auditory deficits

Wednesday, June 21<sup>st</sup> 2023, Institut de l'Audition

- *Supraliminal deficits and new pathologies of hearing.*
- *Partial auditory disorders, central distortions, tinnitus, hyperacusia, neuropathies and synaptopathies.*
- *Vestibular physiology and disorders, multisensory integration and conflicts, static and dynamics balance.*
- *Vestibular aging*

### MORNING

<b>09:00 - 9:55</b>	Diagnosing complex auditory disorders with speech-in-noise and objective measures	H. Thai Van
<b>10:00 - 10:55</b>	The molecular and cellular bases of auditory synaptopathies	D. Dulon
<b>11:00 - 12:00</b>	TBA	S. Wiener-Vacher
	<b>LUNCH BREAK</b>	

### AFTERNOON

<b>13:30 - 14:00</b>	<b>Feedback session 2</b>	
<b>14:00 - 16:00</b>	Course exam. Format of the examen: written exam with questions on most theoretical parts of the course (except day 13)	