Call identifier and title: HORIZON-HLTH-2025-03-ENVHLTH-01-two-stage: The impact of pollution on the development and progression of brain diseases and disorders

Introduction

The **Faculty of Information Technology and Bionics** at Pázmány Péter Catholic University (PPKE ITK), is a top-tier Hungarian research hub at the intersection of IT, bionics, and life sciences. Known for its strong theoretical foundations and cutting-edge applied research, ITK is home to the **Ányos Jedlik Laboratories**, encompassing over 30 interdisciplinary research groups driving breakthroughs in **bioinformatics, artificial intelligence, neurotechnology, nanodevices, and human-machine interfaces**.

The Faculty's researchers publish regularly in Q1 journals, contribute to major international projects (Horizon Europe, DARPA, EUREKA), and foster innovation through student-led spin-offs. Notable outcomes include **award-winning assistive technologies** like EyeRider in the Cybathlon, and novel lab-on-a-chip systems for diagnostics and drug delivery.

Education at ITK is closely integrated with research, training the next generation of scientists and engineers through **hands-on, research-driven programs** in computer science, electrical engineering, and bionics. Doctoral degrees are awarded in biology, information technology, and electrical engineering, reinforcing the institution's role as a key contributor to the European Research Area.

The Integrative Neuroscience Research Group

Our lab offers a powerful, **integrated multi-species translational platform** to dissect the complex mechanisms by which **environmental pollution impacts brain development and contributes to neurological/neuropsychiatric disorders**, directly addressing the core goals of **HORIZON-HLTH-2025-03-ENVHLTH-01-two-stage**. We provide a unique capability to move from identifying cellular targets of pollutants to understanding their effects on complex brain function and behavior across species, including humans.

Our Core Value: A Multi-Tiered Approach to Unravel Pollution's Neurotoxicity

Understanding pollution's insidious effects requires a sophisticated, tiered approach. Our platform is designed to:

1. **Pinpoint Mechanisms in Controlled Models (Rodents: Mouse & Rat):**
    - Ideal for **controlled exposure studies** to specific pollutants (or mixtures) at defined developmental stages.
    - Rapidly assess fundamental cellular/molecular neurotoxic mechanisms (e.g., oxidative stress, neuroinflammation, synaptic dysfunction) using our advanced neuro-biotechnology.
    - Screen for initial behavioral and neurophysiological alterations indicative of pollutant impact.

2. **Assess Impact on Specialized Systems & Higher Translational Relevance (Cat & Marmoset NHP):**
    - **Cat Models – Investigating Sensory System Vulnerability:** Leverage the cat's well-characterized sensory systems (visual, auditory), known for their human homology, to understand how specific pollutants disrupt sensory processing and development – a key area of concern for neurodevelopmental disorders.
    - **Marmoset NHP Platform – Advanced Insights into Neurodevelopment & Cognition:** Our institution has **approved facilities, permissions, and preliminary AAV delivery & behavioral data for marmosets**, enabling **rapid study initiation**. This NHP platform is critical for studying how developmental or chronic pollutant exposure affects:
        - Complex social behaviors and cognitive functions relevant to human disorders.
        - Primate-specific neurodevelopmental trajectories and vulnerability windows.
3. **Technology Validation Hub for Detecting Subtle Neurotoxic Effects – Our Amblyopia Cross-Species Platform:**
    - We have an **established cross-species pipeline (rodent, cat, NHP, human links) investigating neurodevelopmental plasticity in amblyopia.** This highly controlled system serves as an **ideal reference platform to validate and deploy the modern neurobiology toolset for detecting subtle, pollution-induced disruptions.**
    - **Benefit to You:** We can use this platform to test how pollutants affect critical period plasticity, sensory system maturation, or exacerbate underlying neurodevelopmental vulnerabilities. It also allows us to validate novel biomarkers or imaging techniques for early detection of pollutant-induced neurotoxicity before applying them to broader exposure models.
4. **Human Clinical Alignment & Biomarker Translation:**
    - We have ongoing collaborations with clinics that could correlate environmental exposure data (from epidemiological partners) with human electrophysiological/imaging data and can serve as a site for assessing neurological outcomes in exposed cohorts.

Key Capabilities to Uncover Pollution's Impact:

- **Mechanistic Neurotoxicology & Advanced Modeling:**
    - **Gene Vector Expertise:** Applying viral vectors (AAVs, LVs) in our multi-species platform to probe genetic susceptibility to pollutants, deliver biosensors for cellular stress, or model specific pathway disruptions.
    - **Immune Response & Neuroinflammation Quantification:** Directly assessing how pollutants trigger inflammatory cascades and glial activation in the brain – key mechanisms of neurotoxicity.

- **High-Resolution *In Vivo* Assessment:** Advanced neurotransmitter imaging, multimodal electrophysiology, 3D two-photon microscopy to visualize pollutant effects at cellular and circuit levels.
- **Multi-Species Transcriptomics:** Identifying conserved molecular signatures of pollutant exposure and neurotoxicity across species.

- **Biomarker Discovery for Exposure & Effect:**
  - Employing AI/Machine Learning on our rich multi-modal datasets (neurophysiology, behavior, molecular) to identify robust, translatable biomarkers of pollutant exposure, susceptibility, and early signs of neurodegeneration or developmental disruption.
- **Understanding Vulnerable Periods:**
  - Our platform is ideal for studying the impact of pollutant exposure during critical neurodevelopmental windows (pre-natal, early post-natal) in rodents and NHPs.

Why Partner With Us for the Pollution & Brain Health Challenge?

- **Deep Mechanistic Insight:** We move beyond correlation to causation, dissecting *how* pollutants damage brain cells and circuits.
- **Translational Power:** Our multi-species approach, culminating in NHP and human-aligned data, increases the relevance of findings for human risk assessment.
- **Technology-Driven Detection:** We validate and deploy cutting-edge tools to detect early and subtle neurotoxic effects.
- **Ready-to-Deploy NHP & Validation Platforms:** Our marmoset capabilities and amblyopia system offer immediate value and de-risk novel approaches.

We seek partners with expertise in toxicology, epidemiology, environmental sciences, human cohort studies, and pollutant characterization. We are prepared to integrate our unique platform to make your consortium's proposal exceptionally strong in elucidating the impact of pollution on brain health.

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