Master Thesis Project (60 hp)
1 student
Ultrasound-based staging of mouse embryos for automated developmental classification

Project overview
Andersson lab has established in utero nano-injection approaches that enable precise targeting of mouse embryos at early developmental stages. This method relies on accurate stage identification to ensure reproducibility and targeting specificity. The development of a validated ultrasound-based staging framework will therefore directly support and enhance the precision and scalability of these nano-injection experiments.
Mouse embryogenesis is classically categorized using the Theiler stages, which define morphological progression independent of embryonic age. However, current ultrasound-based approaches of mouse work lack precise annotation to these stages. This project addresses this gap by combining ultrasound imaging with embryo collection, fixation, sectioning, and staining to accurately assign developmental stages.

Scientific aim
This project aims to generate a validated reference atlas of ultrasound images of mouse embryos mapped to precise Theiler stages through ex vivo histological confirmation. In addition to establishing an ultrasound based staging pipeline, the project will address the biological question of developmental heterogeneity within individual pregnancies at defined embryonic ages. It will further identify anatomical landmarks that can be reliably recognized by ultrasound and validated by histology, thereby informing stage specific strategies for precise in utero embryonic manipulation. The resulting dataset will also serve as a standardized resource for future machine learning based automated stage classification.

Research questions
1. What is the range of developmental stages present within individual pregnancies at the same nominal embryonic day and time?
2. Which anatomical structures can be reliably identified by ultrasound at different developmental stages and confirmed by histological analysis?

Expected outcomes
The resulting dataset will be used to train machine learning models that enable automated stage recognition, ultimately supporting real-time decision-making for applications such as automated embryo injection systems.

Methods and training
- Wet lab
    - In utero ultrasound imaging of mouse embryos
    - Embryo dissection and collection
    - Fixation and tissue processing
    - Paraffin or cryo-sectioning
    - Histological staining (e.g., H&E)
    - Microscopy and image acquisition
    - Developmental staging using morphological criteria

- Computational analysis
    - Image annotation and dataset curation
    - Basic image processing and feature extraction

Key references

1. Mangold K, He J, Stokman S, Andersson ER. *Murine Neural Plate Targeting by In Utero Nano-Injection (NEPTUNE) at Embryonic Day 7.5*. J Vis Exp. 2022 Feb 14;(180). doi: 10.3791/63148. PMID: 35225287.
2. de Haan S, He J, Corbat AA, Belicova L, Ratz M, Vinsland E, Frisén J, Kelley MW, Andersson ER. *Ectoderm barcoding reveals neural and cochlear compartmentalization*. Science. 2025 Apr 4;388(6742):60-68. doi: 10.1126/science.adq9248. Epub 2025 Apr 3. PMID: 40179197.
3. Kaufman, M. H. (1992). *The atlas of mouse development*. Academic Press.