

2026-27 HIVE Summer Internship Project

Immersive 3D Visualisation of Gut Immune Cell Trafficking After Mild and Moderate Brain Injury

Primary Academic Supervisor

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Project Background

Our laboratory studies traumatic brain injury, and particularly what happens in the body long after the impact itself. A knock to the head does not only affect the brain. In the days and weeks that follow, the immune system changes across the whole body, including in the gut.

We work with a rat model of closed head injury where we can control how severe the injury is and study the same animals months later. In recent work we found that immune cells become more numerous in the gut lining eleven days after repeated mild injury. A single mild injury produced a smaller change that was not statistically significant. The response appears to scale with how much injury an animal has sustained.

That leaves a question we cannot yet answer. Eleven days is a short interval. Nobody knows whether anything is still happening six months later, or whether the gut simply returns to normal. Nobody has looked at all after a moderate injury.

To answer it, counting cells is not enough. What matters is where each cell sits. A cell might still be inside a blood vessel, attached to the vessel wall, or crossed out into the surrounding tissue. That distinction tells us whether immune cells are actively moving into the gut wall. You cannot make it in a flat two-dimensional image. You need a three-dimensional reconstruction. We have prepared gut tissue so its natural tube shape is preserved rather than flattened, stained it so blood vessels and immune cells glow in different colours, and imaged it as stacks of layers on Curtin's Andor Dragonfly confocal microscope. The result is volumes of data that nobody has yet turned into something you can properly look at.

That is where this project starts. The images exist. What does not yet exist is the means to explore them in three dimensions, and to show them at scale on the HIVE displays. That is what you will build.

Project Description, Expected Outputs, Possible Stretch Goals

Aim:

To build a visualisation pipeline that turns existing confocal microscope image stacks of gut tissue into interactive three-dimensional reconstructions, and to use those reconstructions to determine whether immune cell trafficking in the gut wall differs six months after mild or moderate brain injury compared with uninjured animals.

All tissue preparation and microscope imaging will be completed before the internship begins. The student's work is entirely visualisation, reconstruction and analysis.

Expected outputs:

- A documented, reusable pipeline that loads multichannel image stacks, denoises them, and segments blood vessels and immune cells as separate 3D objects
- Reconstructed and annotated 3D volumes from every animal imaged, minimum two per group, showing the vascular network as a continuous surface with individual immune cells as discrete objects
- A working method for classifying each immune cell by position, inside a vessel, attached to the vessel wall, or fully outside in the surrounding tissue
- A quantitative comparison across the three groups, reporting cell counts, position proportions and distance to nearest vessel
- A comparative stereoscopic 3D asset for the HIVE Wedge presenting the three groups side by side
- An immersive fly-through of the gut wall for the Cylinder, forming the Showcase demonstration
- A rendered animation suitable for publication and public engagement
- A written report and shared workflow documentation

Possible stretch goals:

- Apply the pipeline to matching brain tissue from the same animals, held for a separate study, demonstrating that the workflow transfers between tissue types
- Build an interactive version in Unity or Unreal allowing a viewer to navigate the volume and query individual cells
- Automate the segmentation using a trained model to reduce manual correction

Links to background reading and any relevant recent work in the field

- Gut-brain axis and immune cells after brain injury (plain-language review, open access): El Baassiri et al. 2024, Journal of Neuroinflammation.
<https://jneuroinflammation.biomedcentral.com/articles/10.1186/s12974-024-03118-3>
- The 3D gut-imaging method this project builds on Bernier-Latmani and Petrova 2016, Nature Protocols.
<https://www.nature.com/articles/nprot.2016.092>
- Why immersive 3D beats flat screens for microscopy: ConfocalVR, Stefani et al. 2018.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC6805139/>
- Optional software starting points, all free and open source: Fiji/ImageJ (<https://fiji.sc/>). Imaris (<https://imaris.oxinst.com/>) is commercial with a 10-day free trial.
- The Curtin HIVE displays you would create outputs for (Wedge, Cylinder, Tiled Display, Dome):
<https://hive.curtin.edu.au/visualisation-systems/>

What type of visualisation will the student develop or produce?

The student will produce 3D models, segmented surface reconstructions of gut blood vessels and individual immune cells built from confocal image stacks. These become stereoscopic 3D volume renders for the HIVE Wedge, showing three experimental groups side by side, an immersive fly-through of the gut wall for the Cylinder, high-resolution multichannel

montages for the Tiled Display, and a rendered animation for publication and outreach.

How will the visualisation contribute to your research outcomes?

The core measurement is only possible in 3D. Whether an immune cell sits inside a vessel, on its wall, or fully outside it cannot be determined from a flat section, so the visualisation generates the finding rather than illustrating it. Outputs will support a manuscript on whether gut immune involvement persists six months after injury, provide figures for NHMRC grant applications, and establish a reusable confocal-to-HIVE pipeline that transfers to other tissues in the laboratory.

If the project is successful, where would you consider publishing the results?

The visualisation pipeline itself is separately publishable as a methods paper in STAR Protocols or Journal of Neuroscience Methods, offering the intern a realistic pathway to authorship. Reconstructions and animations will also be submitted to the HIVE Showcase and used in conference presentations and public engagement.

Draft Project Timeline:

Week 1

Nov 16 - Full day HIVE induction

Nov 17 - Area and Project Induction with Primary supervisor

Develop project plan with HIVE and academic team

Literature and relevant project review

Project Familiarisation

Week 2

Data access and Project Participation Agreement signed Introduction to the image archive, channels, voxel dimensions and file formats Load first z-stacks in ZEN Blue and Imaris, produce initial projections and orientation checks Plain-language briefing on study design and what each stain shows

Week 3

Build core visualisation pipeline, test denoising and deconvolution options Produce first segmented vascular surface render First session on the HIVE Wedge to review render quality at scale
Milestone 1: pipeline established and first 3D render produced

Week 4

Segment immune cells and vasculature in ZEN Blue Refine vessel surfaces and annotate gut wall layers in Imaris Develop and document the rule set for classifying cell position relative to vessels

Week 5

Complete first fully annotated reconstruction with position classification applied Validate ambiguous classification calls in VR using the Quest 3 Confirm reproducibility on a repeat run, document the workflow to date
Milestone 2: classification method validated and documented

Week 6

Checkpoint meeting with supervisor on return Apply the pipeline across the remaining groups, blinded to group allocation Consistency checks between animals

Week 7

Unblind and compare across the three groups Quantify cell counts, position proportions and distance to nearest vessel First stereoscopic 3D export, tested on the Wedge
Milestone 3: all groups reconstructed, quantified and comparable

Week 8

Build immersive fly-through for the Cylinder with HIVE technical staff Begin report and presentation preparation Produce high-resolution montages for the Tiled Display

Week 9

Focus on report writing and presentation (including demo) preparation

Week 10

Focus on report writing and presentation (including demo) preparation

5th Feb Final Showcase Day and final report due

Student Experience and Supervision:

How often will you meet with the student over the 10-week period?

Once per week minimum, as a scheduled formal meeting with a fixed day and time agreed in week 1. In practice contact will be more frequent, as the intern will be desked adjacent to the supervisor and informal daily availability is expected.

Your work desk location and the location of student desk

Supervisor and student desks are co-located in the Curtin Neurotrauma Laboratory, Sarich Neuroscience Research Institute Building, 8 Verdun Street, Nedlands (Perron Institute), Room 3.3.4. The student desk is in the same room as the supervisor, alongside.

Student Attributes:**Please indicate any preference for student's academic discipline or field of study**

Computer Science, Data Science, Software Engineering, Games and Interactive Media, Design, Biomedical Science, Health Sciences.

No single discipline is required and no biology background is needed, as all data and training will be provided. Applicants from computing, data science or design backgrounds are equally welcome as those from health sciences. What matters most is comfort learning new software quickly and an interest in 3D graphics or image analysis. Experience with any of image processing, 3D rendering, Python or scientific computing is a bonus rather than a prerequisite.

What competencies are required to start this project

Beginner - 2D art/editing

Beginner - Video production/editing

Beginner - 3D modelling software (Blender, 3ds Max)

Beginner - Scientific image analysis. Comfort working with multichannel image stacks and volumetric data, or willingness to learn quickly.

Intermediate - Data structures, analytics, statistical modelling

Do you have any other student attributes you think are important to the project?

Self-direction is the most important attribute. The university shutdown falls mid-internship, so the student will spend a fortnight working through tutorials and running batch renders without daily supervision. Someone comfortable making progress independently and bringing questions to a weekly meeting will do well.

A tolerance for iteration matters. Segmentation is rarely right first time, and the student should be prepared to refine parameters, inspect results critically and try again rather than accepting the first output the software produces.

Attention to detail in judgement calls. Deciding whether a cell sits inside a vessel, on its wall, or fully outside it will sometimes be genuinely ambiguous, and we want someone who will flag the uncertainty rather than force a decision.

Willingness to work across two sites, as the supervising laboratory is at Nedlands and the HIVE is at Bentley.

Curiosity about the biology is welcome but not required. The best outcome would be a student from a computing or design background who becomes interested in what the images actually show.