Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

# MIE498H1: Research Thesis 2025-2026

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| **Supervisor** | Axel Guenther |
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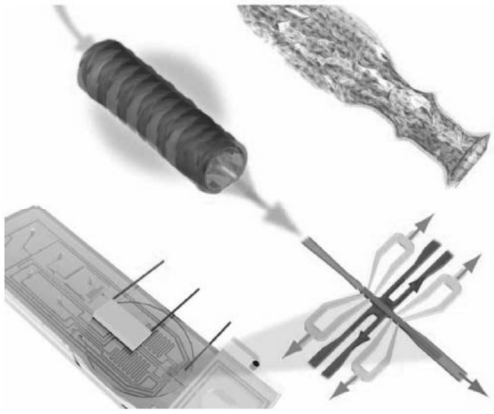
| **Number of Positions** | 1 |
| **Open to** | Mechanical Engineering Students |
| **Term Offered** | Full-year |
| **Research Area** | Mechanics & Design |
| **Research Topic** | Automated Measurement of Pressure-Diameter Relationships for Cannulated Collagen Tubes |

**Project Description**

**Objective:**
Semi-automated evaluation of pressure-diameter (P‑D) relationship for chip hosted, millimeter-scale collagen-based tubular biomaterials and arterial tissue structures under physiological conditions.

**Background & Motivation:**
Our laboratory has introduced the worldwide first microfluidic platform for the functional assessment of contractile arterial structures [1,2]. While this technology has been promising, the investigated arteries were animal derived. In the meantime, advances in stem cell technology and biofabrication [3,4] promise the bottom-up fabrication of patient specific human arterial structures to accelerate the development of new medicines.

In this project, at least ten tubular biomaterials or cardiovascular tissues will be biofabricated from ultrathin aligned collagen sheets [4], chip hosted [1,2,5,6] and subjected to near physiological conditions (e.g., temperature, transmural pressure, nutrient supply). Pressure-diameter relationships of passive tubular biomaterials and functional (contractile or dilating) tubular tissues will be obtained using a combination of bright-field microscopic imaging of the tube inner and outer tube



contours and image processing.

**Goals:**

- Establish scalable setup for subjecting at least 10 tubular biomaterial or tissue structures to physiological temperature and transmural pressure.
- Provide for independent perfusion through the lumen (physiological shear stress) and superfusion on the outside (ablumen) using computer-controlled syringe pumps.
- On the abluminal side, a drug should be added at controlled concentrations.
- Control all pumps, pressure sensors, camera, stage positions, and temperature using a single MATLAB program.
- Develop a real-time image processing pipeline (using OpenCV or MATLAB) to extract inner and outer diameters under varying transmural pressure based on microscope cameras.

**Expected Outcomes:**

- Real-time P–D curves under physiologic temperature and pressure.
- Platform can later be extended to test drug response or matrix remodeling over time.

**Prerequisites:**

- MATLAB knowledge required.
- Interest in robotics, mechatronics, organ on chip technology and asset
- No prior knowledge in organs on chips, cell biology or biofabrication required

[1] Guenther A., Yasotharan S., Vagaon A., Lochovsky C., Pinto S., Yang J.L., Lau C., Voigtlaender-Bolz J., Bolz S.S., "A microfluidic platform for probing small artery structure and function" *Lab Chip* 10 (18), 2341-2349, 2010.
[2] Yasotharan, S.; Pinto, S.; Sled, J.G.; Bolz, S.S.; Guenther, A. "Artery-on-a-chip platform for automated, multimodal assessment of cerebral blood vessel structure and function", *Lab Chip* 15, 2660-2669, 2015.
[3] Leng L.; McAllister A.; Zhang B.; Radisic M.; Guenther A., "Mosaic hydrogels: one-step formation of multiscale soft materials" *Adv. Mat*, 24(27), 3650-3658, 2012
[4] Malladi, S.*; Miranda-Nieves, D.*; Leng, L.; Grainger, S.J.; Tarabanis, C.; Nesmith, A.P.; Kosaraju, R.; Haller, C.A.; Parker, K.K.; Chaikof, E.L.**, Guenther, A.** "Continuous formation of ultrathin, strong collagen sheets with tunable anisotropy and compaction" *ACS Biomater. Sci. Eng.*, 6, 4236–4246, 2020.
[5] Gao, W.; Kanagarajah, K.R.; Graham, E.; Soon, K.; Veres, T.; Moraes, T.J.; Bear, C.E.; Veldhuizen, R.A.; Wong, A.P.; Guenther, A. "Collagen Tubular Airway-on-Chip for Extended Epithelial Culture and Investigation of Ventilation Dynamics", *Small* 2024, 2309270.
[6] Gao, W.; Vaezzadeh, N.; Chow, K.; Chen, H.; Lavender, P.; Jeronimo, M.D.; McAllister, A.; Laselva, O.; Jiang, J.; Gage, B.; Ogawa, S.; Ramchandran, A.; Bear, C.E.; Keller, G.M.; Guenther, A. "One-step formation of protein-based tubular structures for functional devices and tissues", *Adv. Healthc. Mater.,* 10(8)*,* 2021.

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| **Additional Information** | N/A |
| **Application Instructions** | Please submit CV, unofficial transcript, to Prof. Axel Guenther, e-mail: axel.guenther@utoronto.ca |