

Bioengineering Day Poster Addendum

Biological Joint Resurfacing: Bioreactor Validation

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1. Desired Needs

- Use tolerance values from MicroCT (32um) to dimension the double-diffusion bioreactor, so it can support controlled hydroxyapatite formation at the cartilage–bone interface.
- Define the main geometric and transport variables that affect mineralization, including chamber dimensions, flow rate, concentration gradients, and interface location.
- Confirm that the topographical mold geometry with permeable, synthetic, and sterile polymer is compatible with a rabbit-scale osteochondral graft.
- Create a clearer framework for future teams to test, troubleshoot, and improve bioreactor-based mineralization experiments.

2. Major Constraints

- **Safety/Regulatory Affairs:** My work required PPE, chemical safety, sterile handling, and careful use of calcium/phosphate solutions, oCPC assay reagents, and resin-printed or machined bioreactor parts.
- **Risks:** Main risks included hydrogel shrinkage, side-wall hydroxyapatite formation, nonuniform mineralization, dimensional mismatch, and uncertainty in how flow affects the reaction front.
- **Global Impact:** A reliable bioreactor could help produce more biologically realistic osteochondral grafts, which may reduce dependence on invasive or limited-lifespan joint replacement procedures.
- **Manufacturability:** The bioreactor parts had to be compatible with resin printing, machining, assembly, microCT scanning, and repeatable lab-scale testing.
- **Quality Control/Marketability:** Quality control depended on dimensional validation, repeatable assembly, clear assay protocols, and consistent tracking of where hydroxyapatite formed.

3. Major Engineering Standards

- CAD drawings and microCT scans were used to compare the fabricated graft chamber, mold, and assembly dimensions against the intended design.
- Transport analysis was guided by diffusion, flow rate, residence time, concentration gradients, and placement of the hydrogel–bone interface.
- Assay standards, especially oCPC calcium standards, were used to support calcium quantification and evaluate mineralization results.
- Future standards could define acceptable ranges for chamber dimensions, graft diameter, surface contour accuracy, hydroxyapatite interface thickness, and calcium content.

4. Ethical, Environmental, and Societal Concerns

- Ethical concerns include responsible use of animal-derived tissues, future animal studies, and patient safety if the graft platform eventually moves toward clinical testing.
- Environmental concerns include proper disposal of calcium/phosphate solutions, assay reagents, resin-printing waste, biological waste, and contaminated lab consumables.
- Societal concerns include whether advanced regenerative treatments would be affordable and accessible if translated into a clinical product.

5. Active Teamwork and Leadership

- My subproject focused on bioreactor validation, but it had to connect with the hydrogel and assay subprojects.
- I organized the main design and transport variables so the team could better understand what controls hydroxyapatite formation.
- I used feedback from mentors, prior teams, and lab members to refine the bioreactor aims, interpret dimensional results, and identify realistic future steps.
- I contributed to shared reports and presentations by translating the bioreactor work into clear aims, results, limitations, and future directions.

6. Motivating Factors

- This subproject pushed me to learn more about bio-transport, hydroxyapatite mineralization, microCT-based dimensional analysis, and bioreactor design.
- Challenges such as unclear reaction-front behavior, possible side-wall mineralization, hydrogel deformation, and dimensional variation forced me to think critically rather than just accept the existing design.
- The clinical goal of building a more functional osteochondral graft made the work feel meaningful beyond a class assignment.

7. Innovative and Entrepreneurial Ideas

- The key innovation is using a controlled double-diffusion bioreactor to localize hydroxyapatite formation at the interface between engineered cartilage and trabecular bone.
- The bioreactor validation framework could become a quality-control pipeline for future graft production, combining microCT, assay data, and transport analysis.
- Future development could use computational fluid dynamics to predict flow paths, reduce unwanted side-wall mineralization, and improve experimental consistency.