Centrifugal Cell Separation and Blood Mimic Development

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Background
Maximizing throughput of the centrifuge will provide patients with better treatments for a wide range of blood diseases. Increasing rotational speeds and centrifuge radius will increase the throughput but will in-turn increase the stresses and strains being induced on the cell fluid.

Purpose:
- Alter centrifuge chamber geometry to increase cell throughput while maintaining cellular viability
- Create a non-biohazardous blood mimic that matches the viscosity of whole blood

Project Goals
- Elutriation Centrifuge Chamber Design
  - 3D printed Chamber Key Features:
    - Shelf deflector
    - Spigot
    - Each feature was included to improve throughput of cell solution in chamber and limit cells crossing midline
- Blood Mimic Development
  - Measured the viscosity of the sucrose & xanthan gum mixture at different shear rates
  - Whole blood is a non-newtonian shear thinning fluid
  - Shear rate is inversely proportional to the dynamic viscosity

Elutriation Centrifuge Chamber Design

CFD Validation
- Velocity Pathlines
- Velocity Distribution with Rotation
- Velocity at Cell Inlet
- Velocity at Wash Inlet

Results
- Centrifuge Chamber
  - Printed chamber was unable to be tested at the Lakewood, CO Terumo BCT facility with blood or non-biohazard blood mimic for comparison with CFD simulation results
- Blood Mimic
  - The blood mimic follows the power law of a shear thinning fluid
  - The power law of the blood mimic closely matches that of whole blood at varying hematocrits

Conclusions
- Increasing the xanthan gum concentration increases the consistency and behavior index of the blood mimic
- Testing the new chamber prototype using blood will provide insight into the effectiveness that the design improvements have made
- The CFD simulations show a general inefficiency of flow direction from the cell inlet and could greatly benefit from a change in geometry

Future Work
- Create a 3D CFD simulation of the chamber to properly add centrifugal forces along the correct axis
- Test the new chamber design in the centrifuge with whole blood
- Create a graph of concentration vs viscosity after further iterations of the mimic have been made
- Test blood mimic in conjunction with a rheoscopic concentrate fluid to visualize flow patterns in the control chamber compared to whole blood runs
- Create a magnetic simulation of a hybrid array to design a cell flow path along a constant magnetic flux for cellular separation

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