Background:

Drug eluting implants can provide a convenient alternative to daily oral dosing regimens for patients on treatments requiring regular, continued dosing for extended periods of time (months to years) such as for contraception or for HIV treatment/prophylaxis. Drug eluting implants may utilize biodegradable polymers that erode over time or they may leverage non-degradable polymers that allow removal of the implant after the dosing is completed. The rate at which the implant releases the drug over time is a critical performance parameter and must be consistent from batch to batch. Additionally, the mechanical properties (ex. tensile, compression, bending moduli; hardness; strain to break) of the implant can affect the ability for it to be injected sub-dermally and may affect the patient comfort over the course of implantation.

Problem statement Options:

1. The release profile of a matrix-type, non-erodible drug-eluting implant is a function of both the drug particle size and the drug loading for an implant of fixed dimensions. The sensitivity of this release profile to these two parameters is not well established, especially considering that the drug particle shape is not isotropic and the drug particle size is not discrete but typically a unimodal distribution of sizes.

2. The mechanical properties of a drug eluting implant are a function of both the drug particle size and the drug loading. The sensitivity of the mechanical properties to these two parameters is not well established, especially considering that the drug particle’s shape is not isotropic and the drug particle size is not a singular value but typically a unimodal distribution about a mean.

Project Objective:

1. Develop a 3-dimensional model of a cylindrical implant with drug particles randomly distributed and randomly oriented in a non-degradable polymer matrix.
2. Simulate the release of the drug from the implant as drug loading, particle size and shape are varied.
3. Stretch Goal: Predict the mechanical properties of the implant as drug loading, particle size and shape are varied.

Modeling Parameters:

- Implant Size: 2mm diameter x 40 mm length
- Drug Particles: 3D rectangular prisms with aspect ratios from 1 to 10
- Particles may touch but not overlap in space.
- Drug load by weight will vary from 30% to 50%
- Drug Particle sizes $D_{50}$: varies from 1µm to 15µm (actual PSD by laser diffraction may be provided)
- Implant is placed in dissolution medium under sink conditions as in-vitro test.
- The drug has a solubility of 1mg/mL in the dissolution medium
- The drug has a molecular weight of 300 g/mol.
- Drug release occurs by dissolution and diffusion of the outermost particles first and then via the percolation of connected particles.
- The drug has no solubility in the polymer and can not diffuse through it.
- Water has no solubility in the polymer and can not diffuse through it.

Expected skills within the team tackling this problem

The team tackling this problem should have student(s) with computational skills, student(s) with familiarity with soft materials, particle technology, and some experience in molecular simulations.

![Example Drug Particle Images and Size Distribution by Laser Diffraction](image-url)