Developing a Printability Characterization Protocol for 3D Bioprinting

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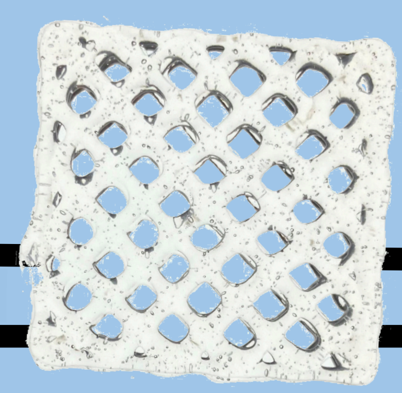
What is 3D Bioprinting?

3D Bioprinting is a novel technology that leverages additive manufacturing techniques to create custom shaped living tissues. The technology is already being used for drug and treatment testing, but future development in tissue implantations may lead to cures for currently incurable diseases such as Type 1 Diabetes.

Characterizing Printability

Printability broadly speaking is the ability of a biomaterial to assume its desired form once extruded from a 3D bioprinter. Quantifying printability requires printing constructs and imaging them to determine the physical deviation from the intended form.



Preparing Bioinks

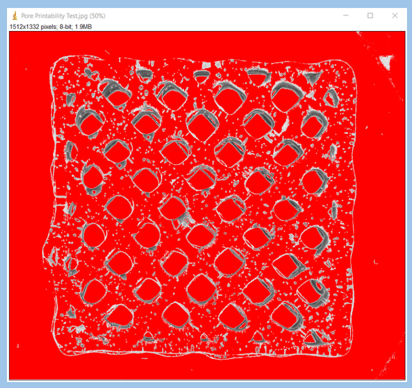
Bioprinting requires bioink, a substance that is simultaneously able to be extruded from a 3D printer and support healthy living cells. Bioinks are primarily made of water and appear transparent. This poses a challenge for image analysis as the bioink does not naturally contrast with a given background.

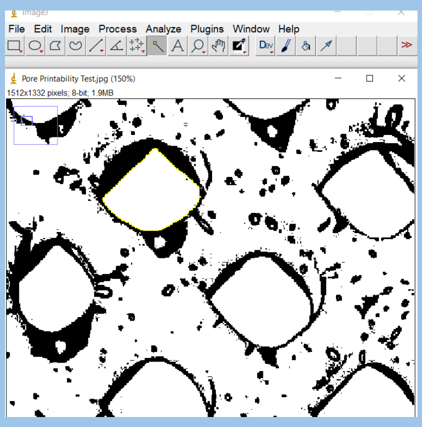
Printing Process

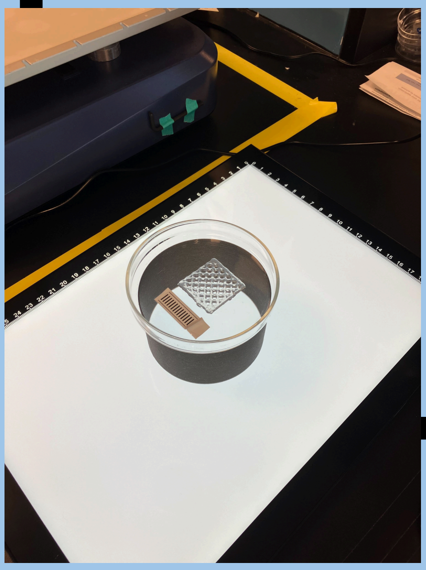
Various types of bioprinters exist, some techniques used are microfluidics, pneumatics, and light curing. The type of printer used will affect the bioink's printability. The protocol I designed was performed on a CELLINK Bio X (pictured left) which uses pneumatically driven syringes.

Imaging Bioinks

To take photos of the bioinks that were amenable to computer recognition, I proposed the use of a light pad and a dark cylinder in order to create shadows within the construct over a high-contrast background. This technique proved effective and allowed for printability to be measured with significantly greater efficiency.







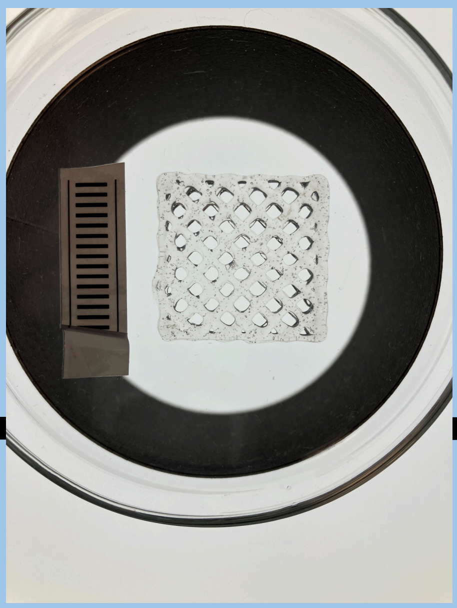


Image Analysis

Since the light pad and cylinder created a suitable high-contrast image, images of the bioprinted constructs could be binarized and a simple edge detection tool could quickly select the perimeter of the construct's pores. By eliminating the need for manual selection, the accuracy and speed of image analysis was greatly increased. Once results were obtained, statistical analysis could be completed as necessary.

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}}$$

	Area	Mean	Min	Max	Perim.	Circ.	AR	Round	S
1	16533	254.954	0	255	680.843	0.448	1.336	0.749	
2	27706	254.365	0	255	813.453	0.526	1.266	0.79	
3	25421	253.776	0	255	975.117	0.336	1.275	0.785	
4	36149	253.258	0	255	869.578	0.601	1.321	0.757	
5	25036	255	255	255	965.335	0.338	1.187	0.842	
6	19388	252.856	0	255	792.808	0.388	1.296	0.772	

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