



Development of an Antimicrobial 3D Bioprinted Rat Bladder

Capstone Team: Sean Aagard, Jose Onate, Angela Tungpalan, Munise Yilmaz

Faculty Advisor: Dr. Zhengwei Li
University of Houston, Houston, TX



Objective

Develop a non-toxic, antimicrobial chitosan hydrogel and test its safety and effectiveness in a rat bladder model for potential human urinary tract applications.

Background

Spinal cord injuries can cause permanent bladder dysfunction, significantly affecting an individual's quality of life. Current treatments rely on donor tissues that carry risks, and no synthetic implant alternative currently exists.

Chitosan is a naturally derived biopolymer that is both biocompatible and antimicrobial, making it a strong candidate for use in urinary scaffolds.

Crosslinking chitosan with genipin forms a stable hydrogel suitable for synthetic bladder mold casting, with safety validated through live/dead cell staining.

Methods

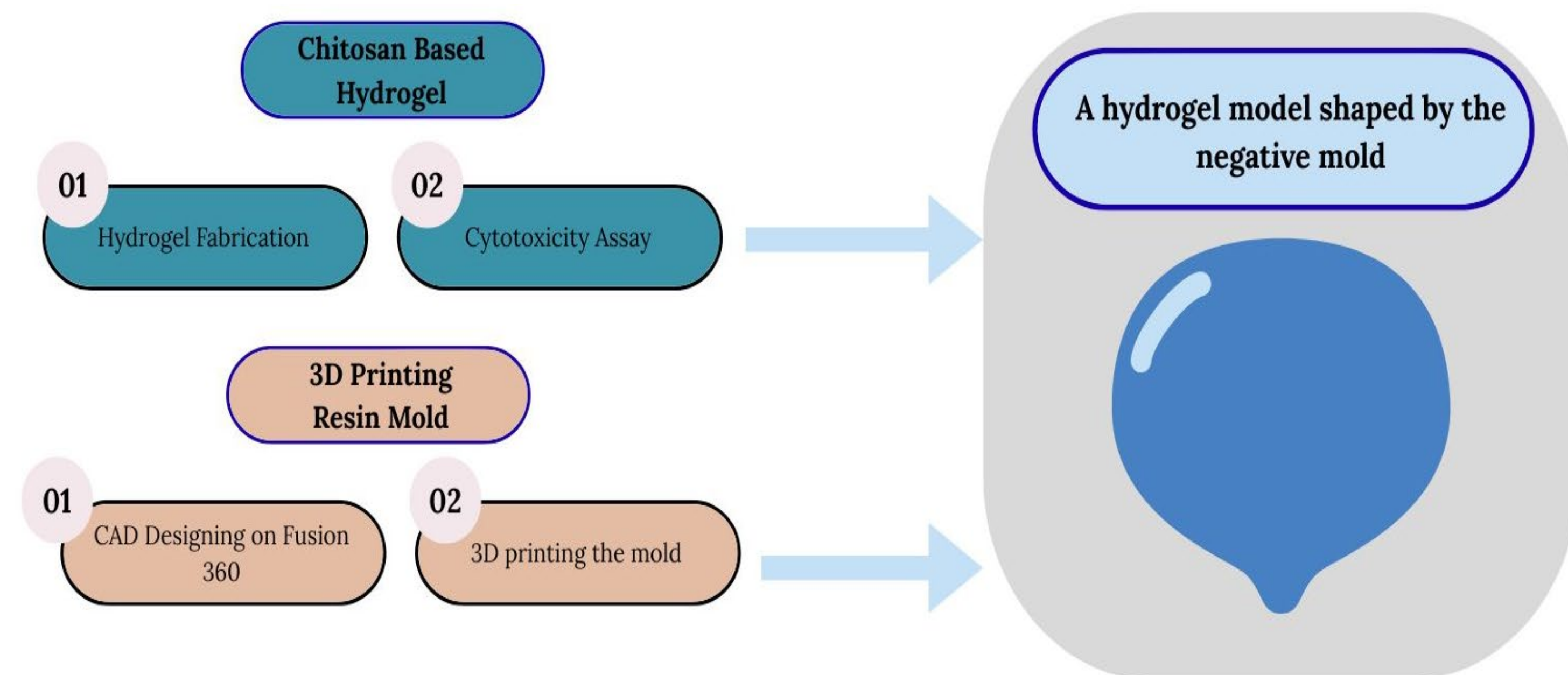


Figure 1. Overview of two-part protocols for developing the 3D antimicrobial rat bladder.

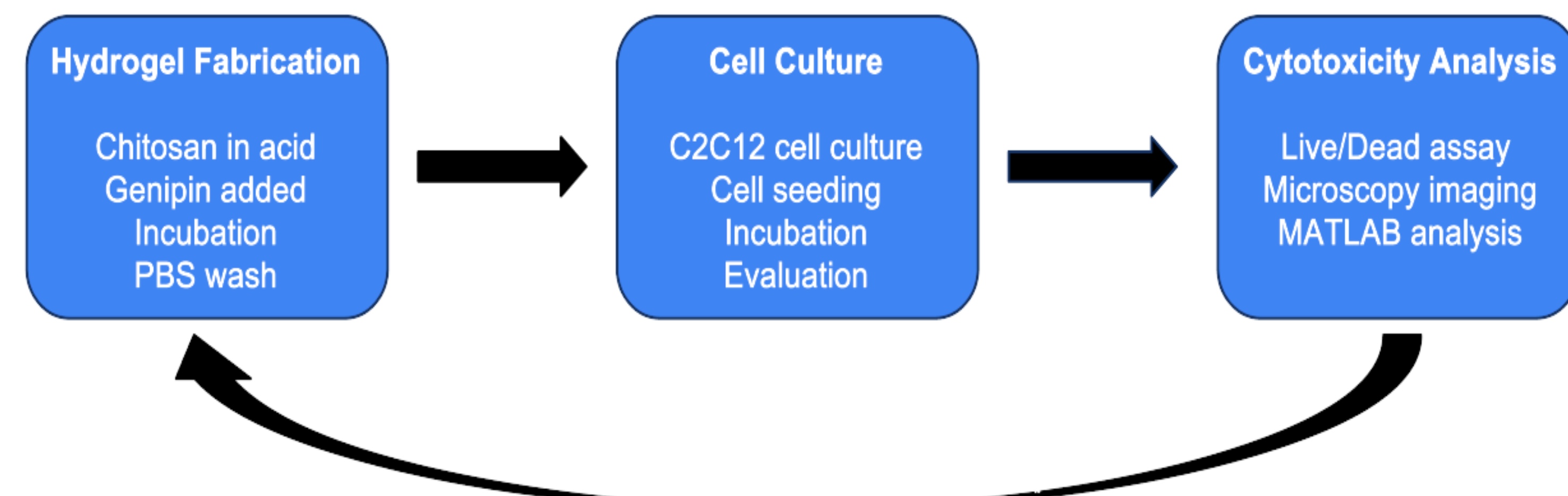


Figure 2. Overview of chitosan hydrogel production along with cytotoxicity workflow.

Results

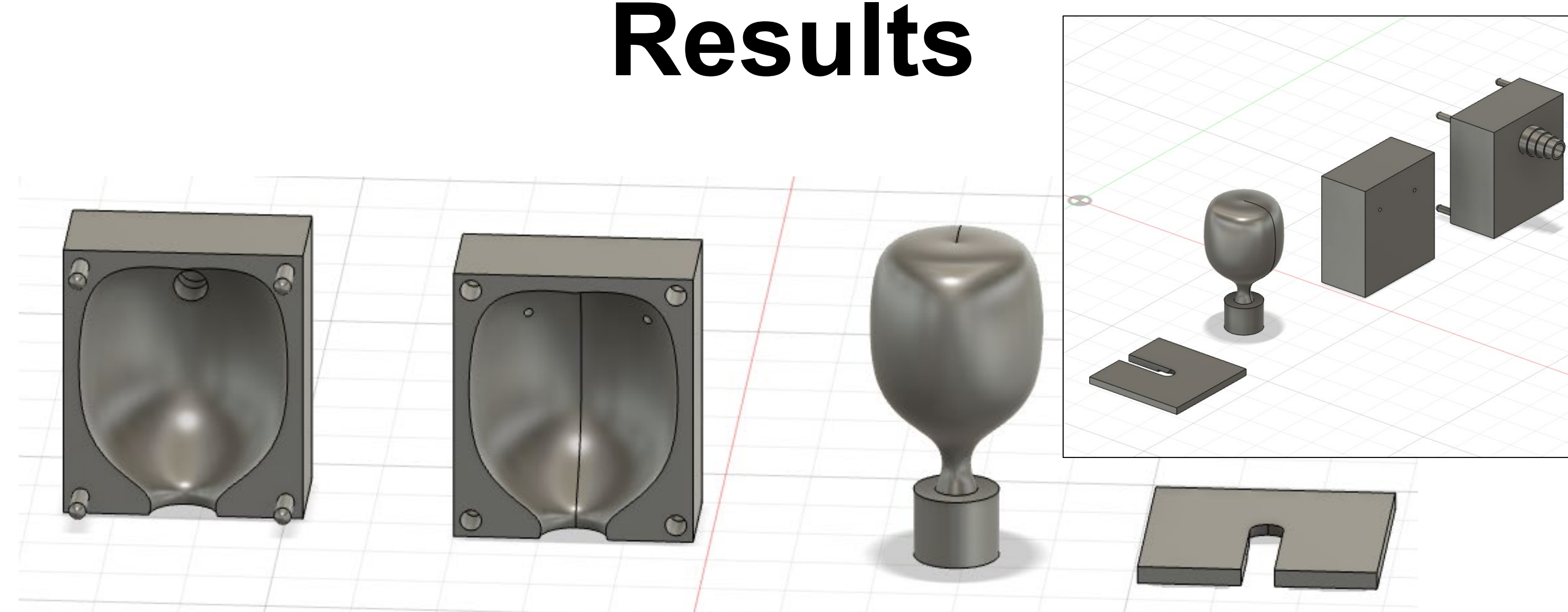


Figure 4. Finalized Fusion 360 AutoCAD design for the negative 3D rat bladder mold. Mold consists of small vent holes, alignment pins with respective holes, bulb shape wand-like structure, and cover to hold the wand in place. The image on the corner displays the back of the design.

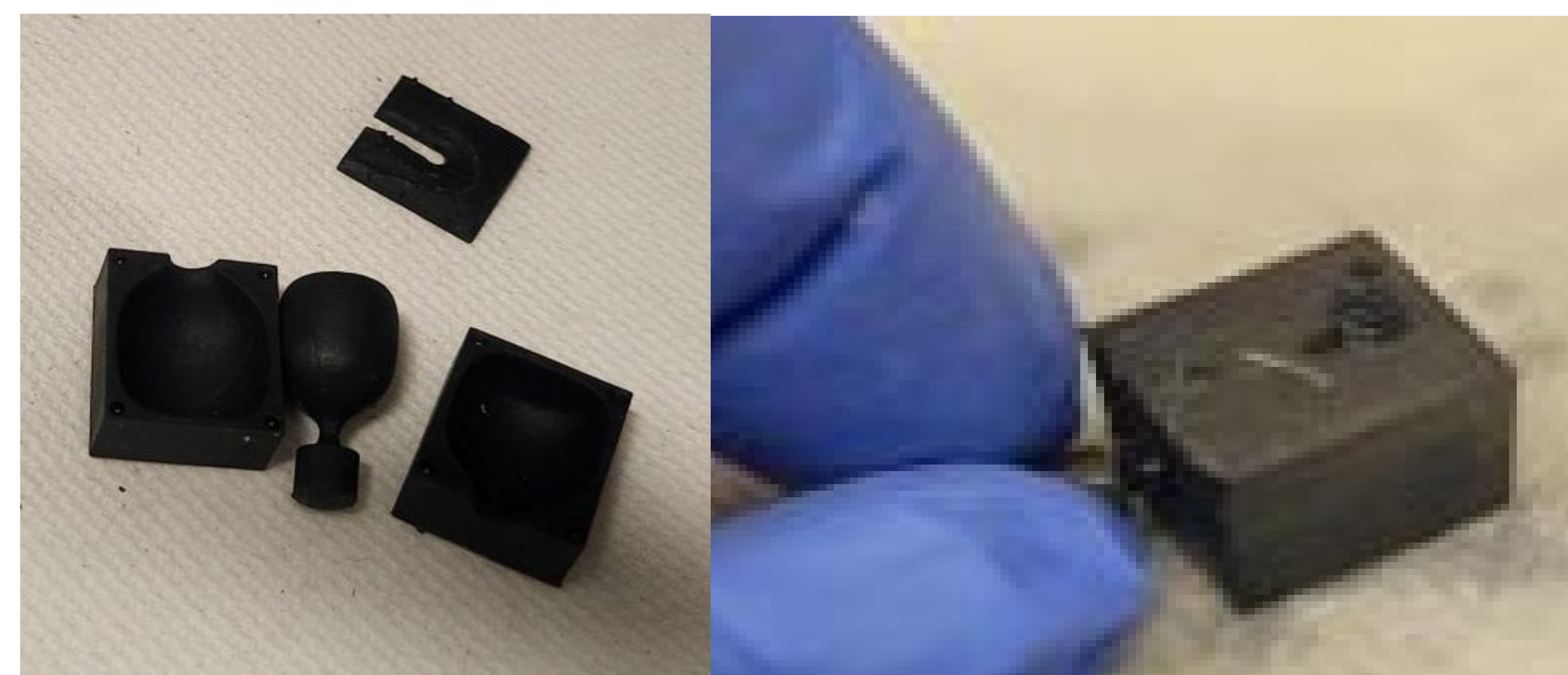


Figure 5. The figure on the left is the printed and assembled 3D negative rat bladder. The figure on the right depicts the leak test. The assembled print had undergone a leak test, using water, to ensure vent holes functioned properly.



Figure 6. Left hand side of image shows initial hydrogel fabrication that contains a light blue color. Right hand side of image shows final hydrogel fabrication which contains a dark rich blue color.

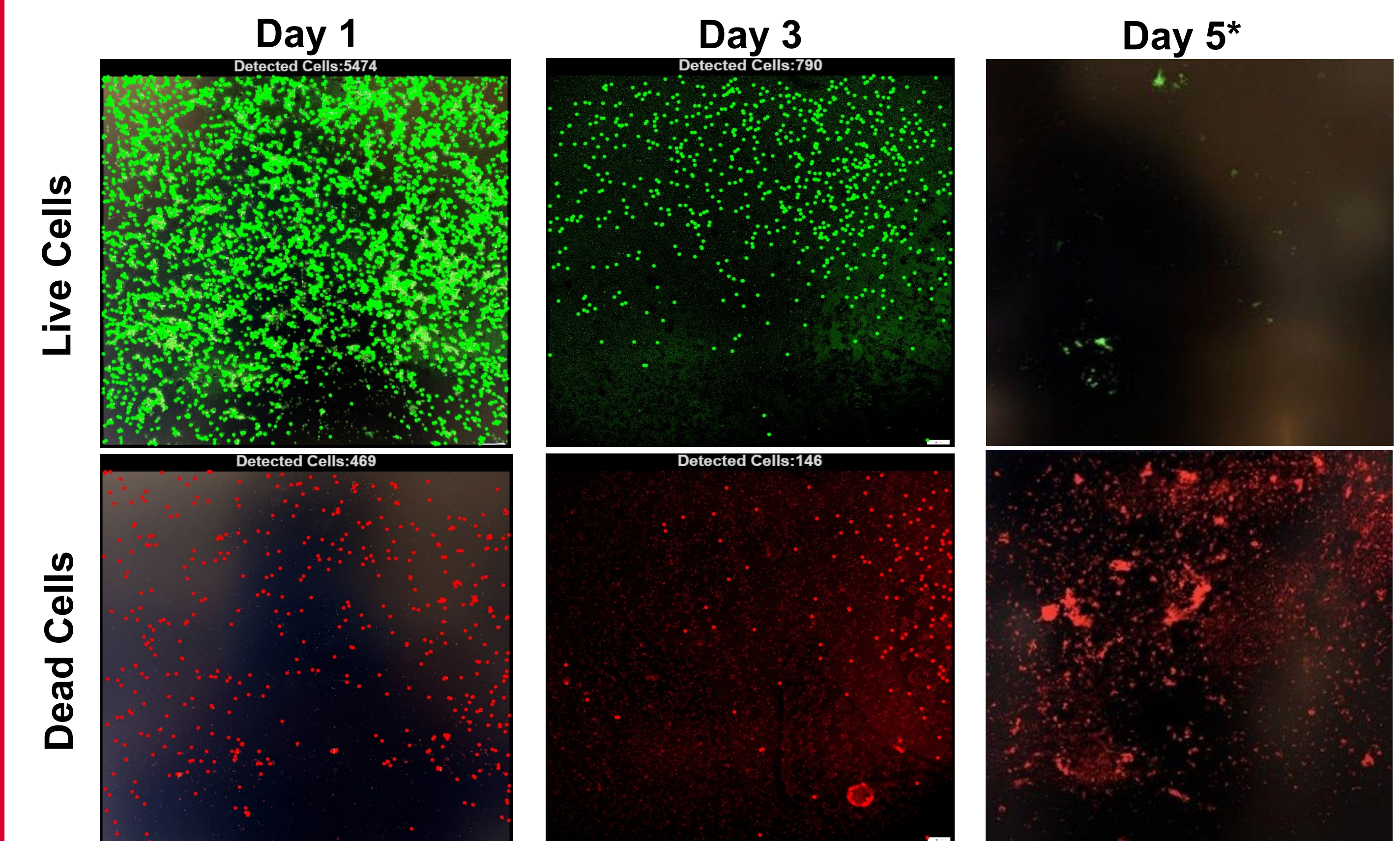
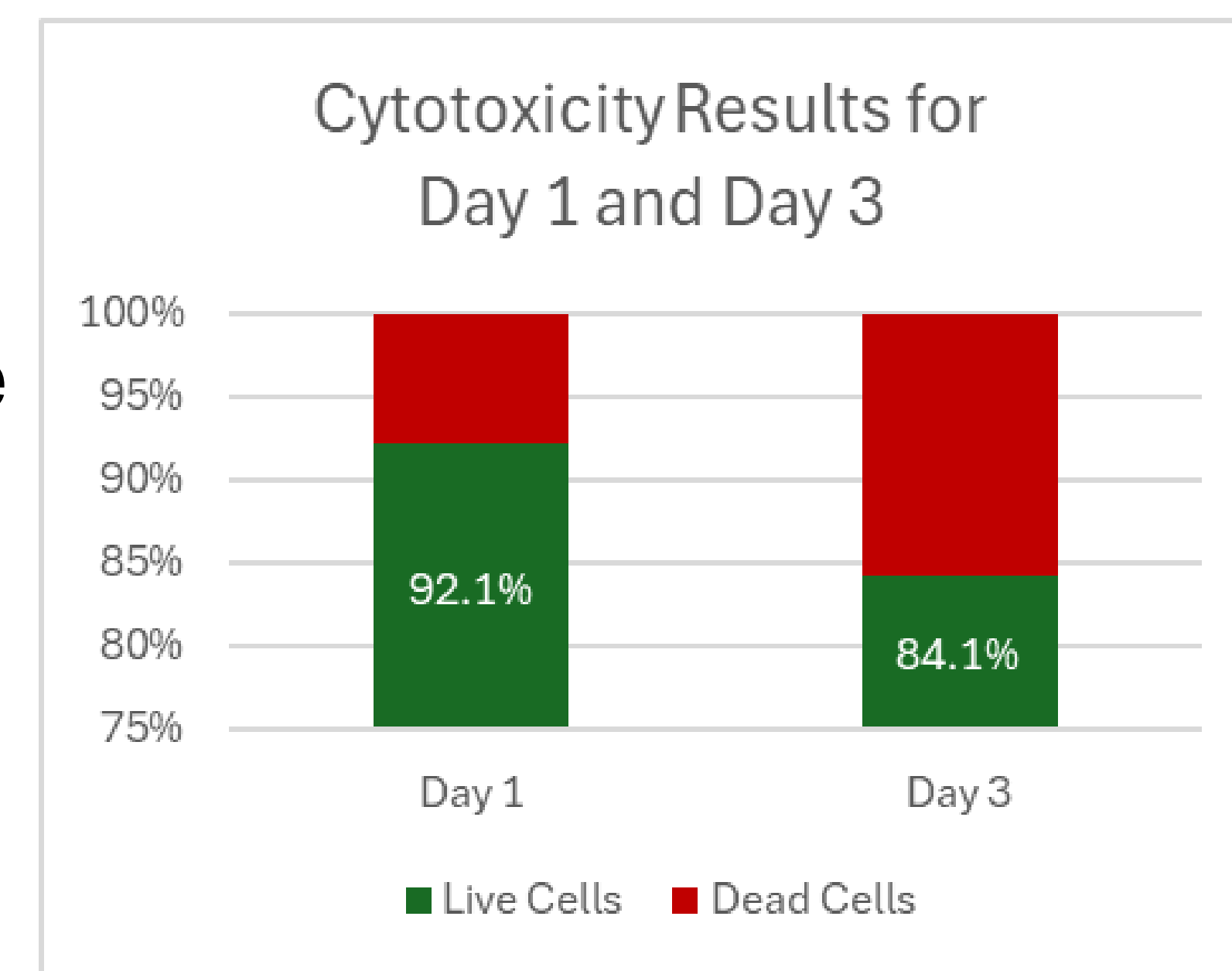


Figure 7. Cytotoxicity fluorescent image analyzed and amplified in MATLAB. Results include cell counts from cultured hydrogels from 1, 3, and 5 days.

*Day 5 results were inconclusive and no cells were detected. In addition, the control for Day 5 also resulted with no cells detected.

Figure 8. Bar graph displayed on the right depicts the percentage of live and dead cells. Data was recorded for days 1 and 3 of cells incubated with prepared hydrogels.



Conclusion

- The negative 3D rat bladder model successfully fit together along with proper function.
- A chitosan hydrogel was successfully fabricated using a chitosan base with a genipin cross-linker.
- The dark blue pigment indicates successful crosslinking, giving it a more robust structure.
- Cytotoxicity initially displayed limited toxicity, with 92.1% live cells on day 1.
- At the day 3 mark, the hydrogel had an 84.1% cell viability.

Acknowledgements

We would like to acknowledge our advisor, Dr. Zhengwei Li, his graduate students, Yifan Wang and Alejandro Munoz, and our Capstone Advisor, Dr. Yuncheng Du. Many thanks to all of them for guiding us!