

Bioengineered Tissue Patches for Dynamic Organ Mimicry using Silk Fibroin

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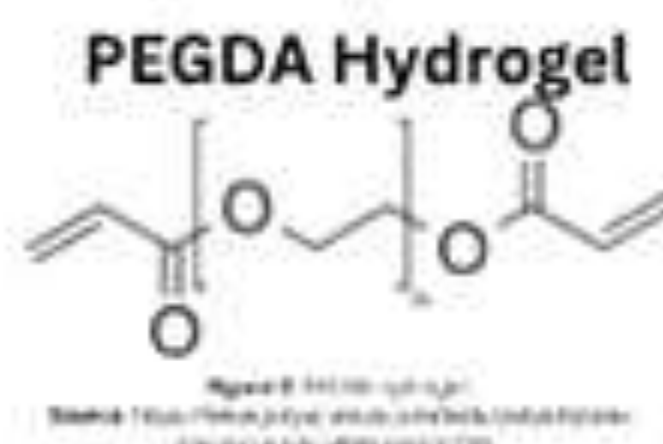


Problem

Current Therapeutic Patches Are Not Biocompatible

Contemporary therapeutic patches fail to compensate for the **anisotropic deformation** of organs that are intrinsically anisotropic or auxetic (negative Poisson's ratio) (Chansoria et al., 2022).

In addition, patches made from **synthetic polymers** often lack biocompatibility, which may cause a negative immune response in the body (Fernandez-Yague et al., 2022).



Research Goal

Engineering Goal

Develop a **therapeutic patch** that accounts for the anisotropic deformation of organs, such as that heart, through use of **biocompatible non-synthetic materials**.

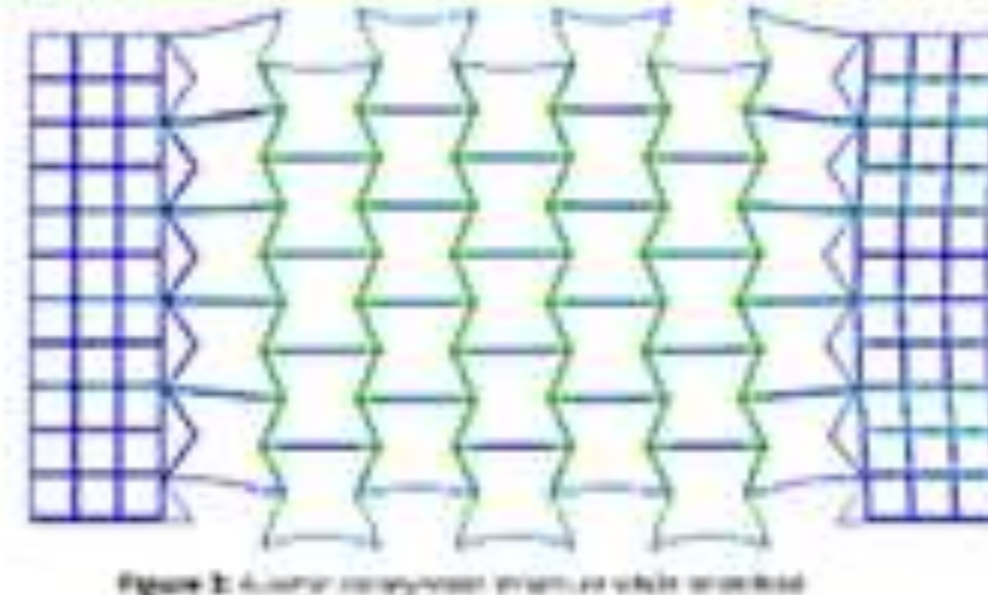
Materials

- InkRedible3D Printer
- Lithium Bromide
- Silk Cocoons
- Dialysis Tubing
- Ultra Pure Water
- Enrichment Cassette
- PDMS
- Salt bath

Approach

Accounting For anisotropic deformation

Auxetic patch design, such as the one seen to the right, has demonstrated the ability to account for the **anisotropic deformation** of organs.

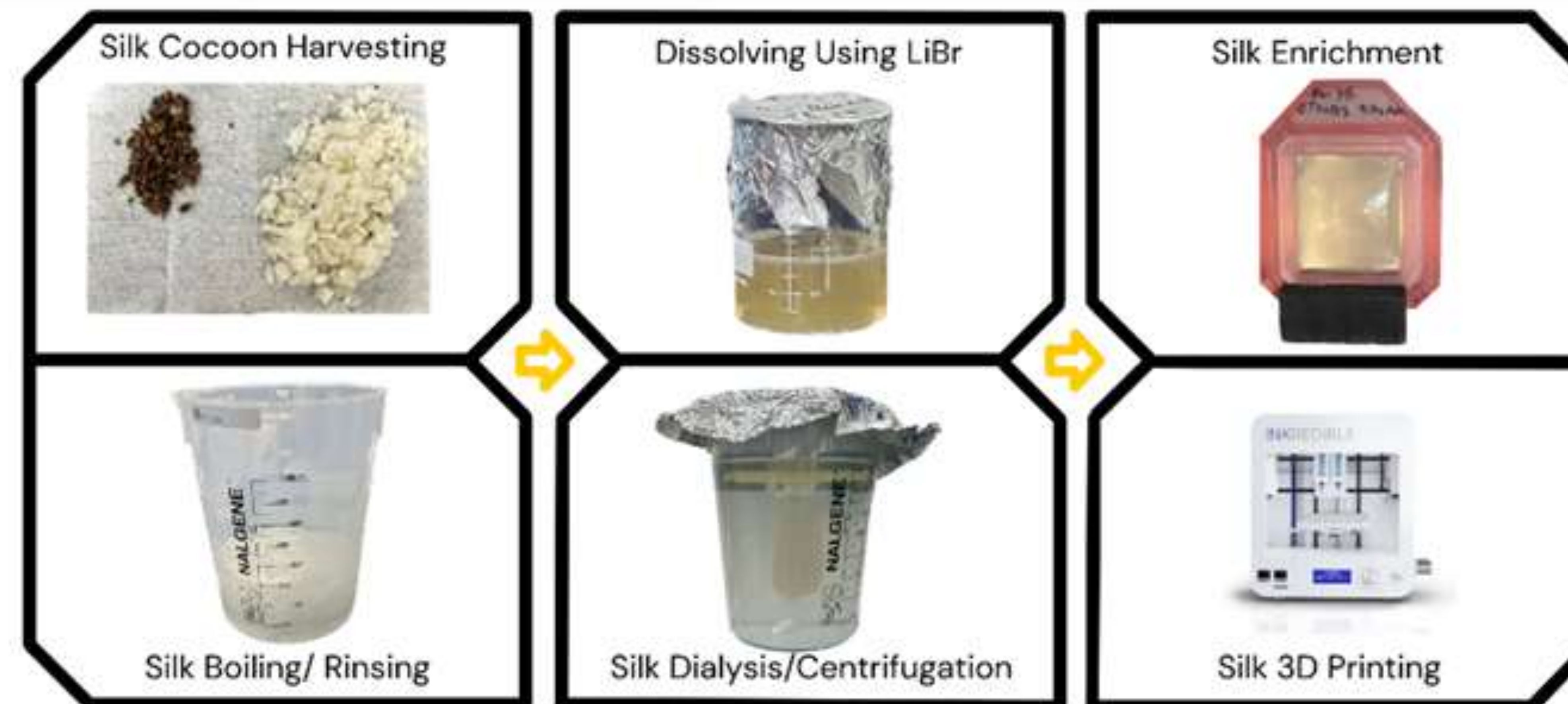


Biocompatible Materials

To account for the lack of biocompatible hydrogels, **silk fibroin** was developed inside the Mu lab. This silk fibroin is **capable of being 3D-printed** to create the therapeutic patches in this project.



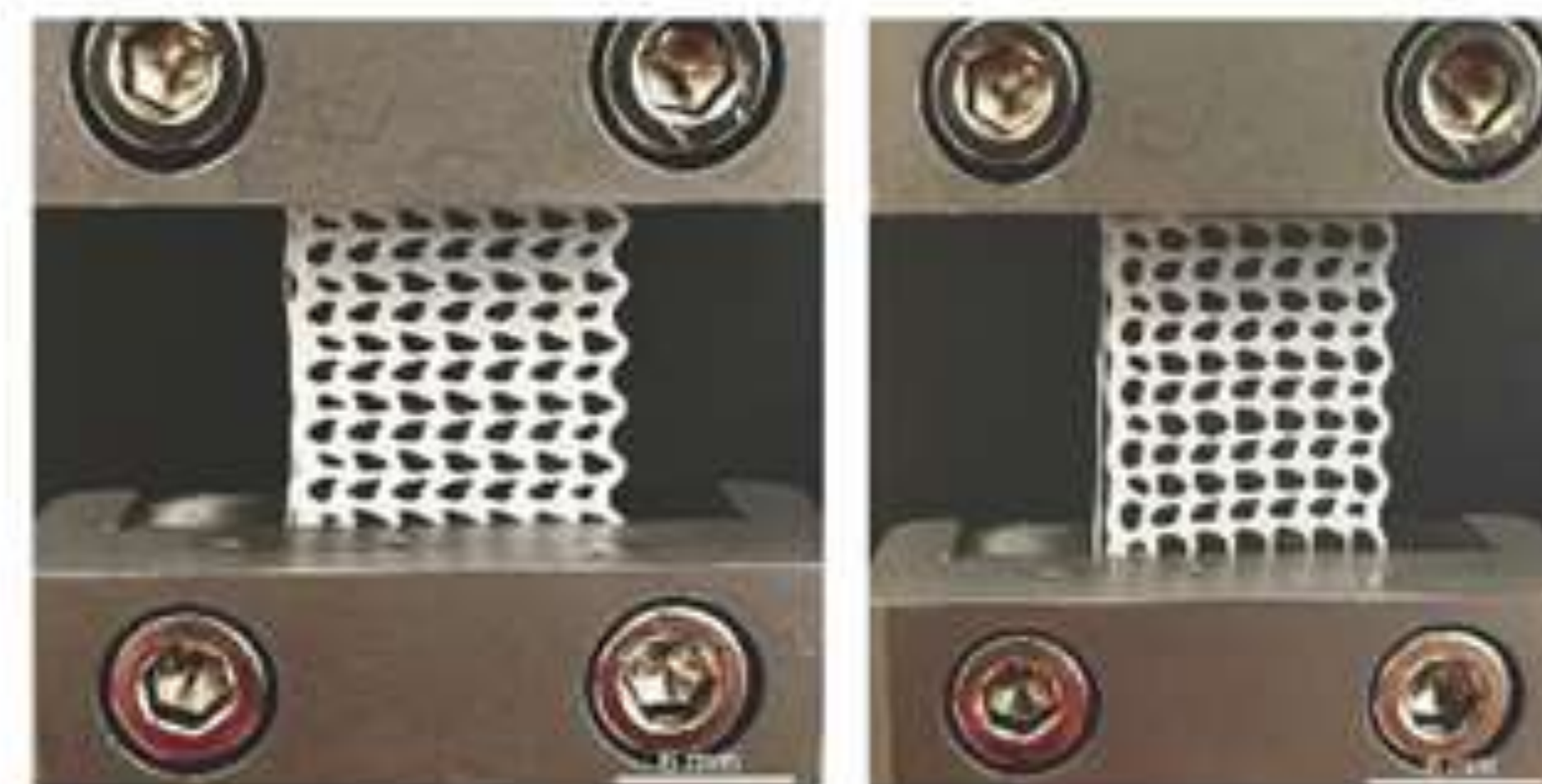
Methodology



Results

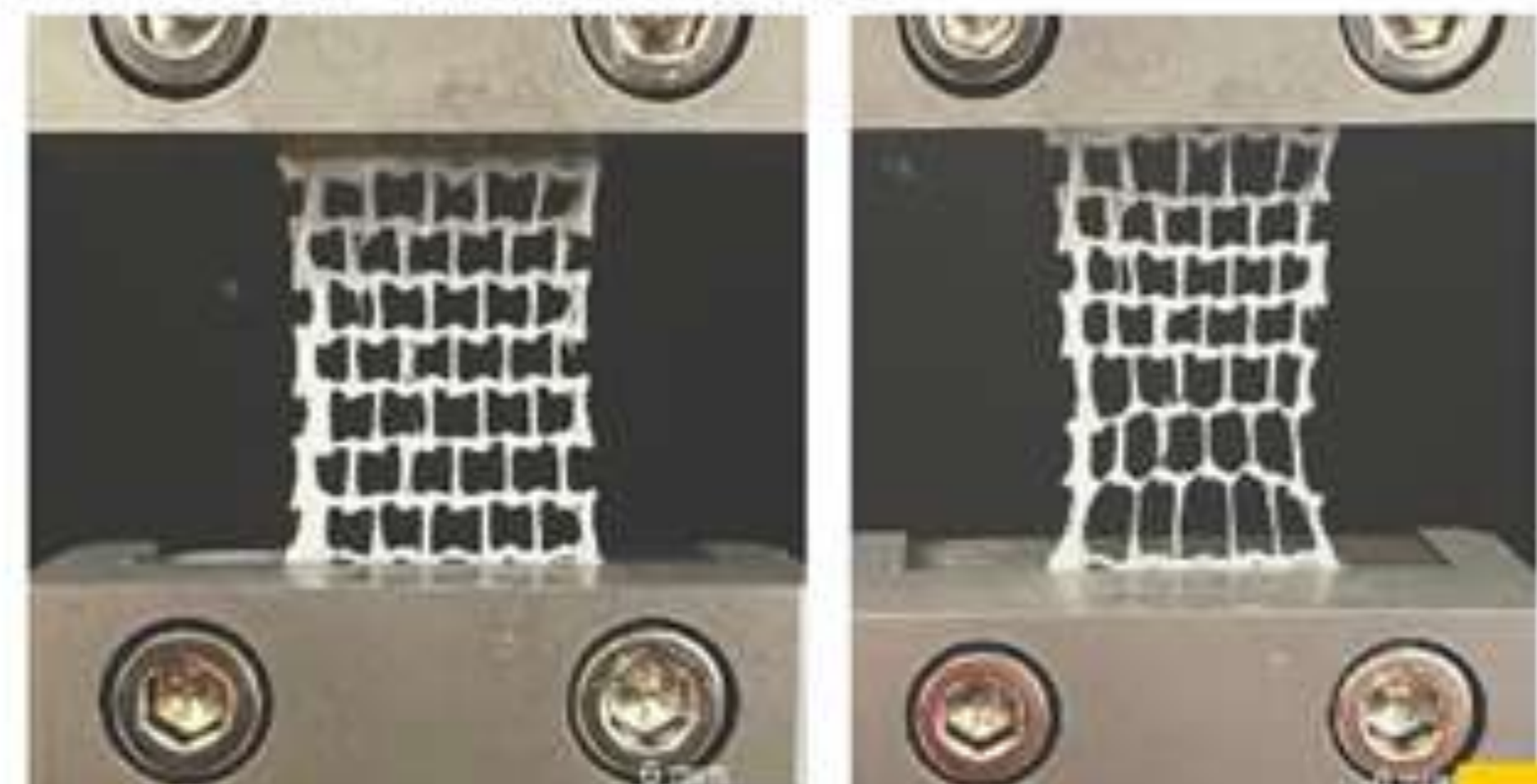
Arrowhead

Poisson's Ration: .024



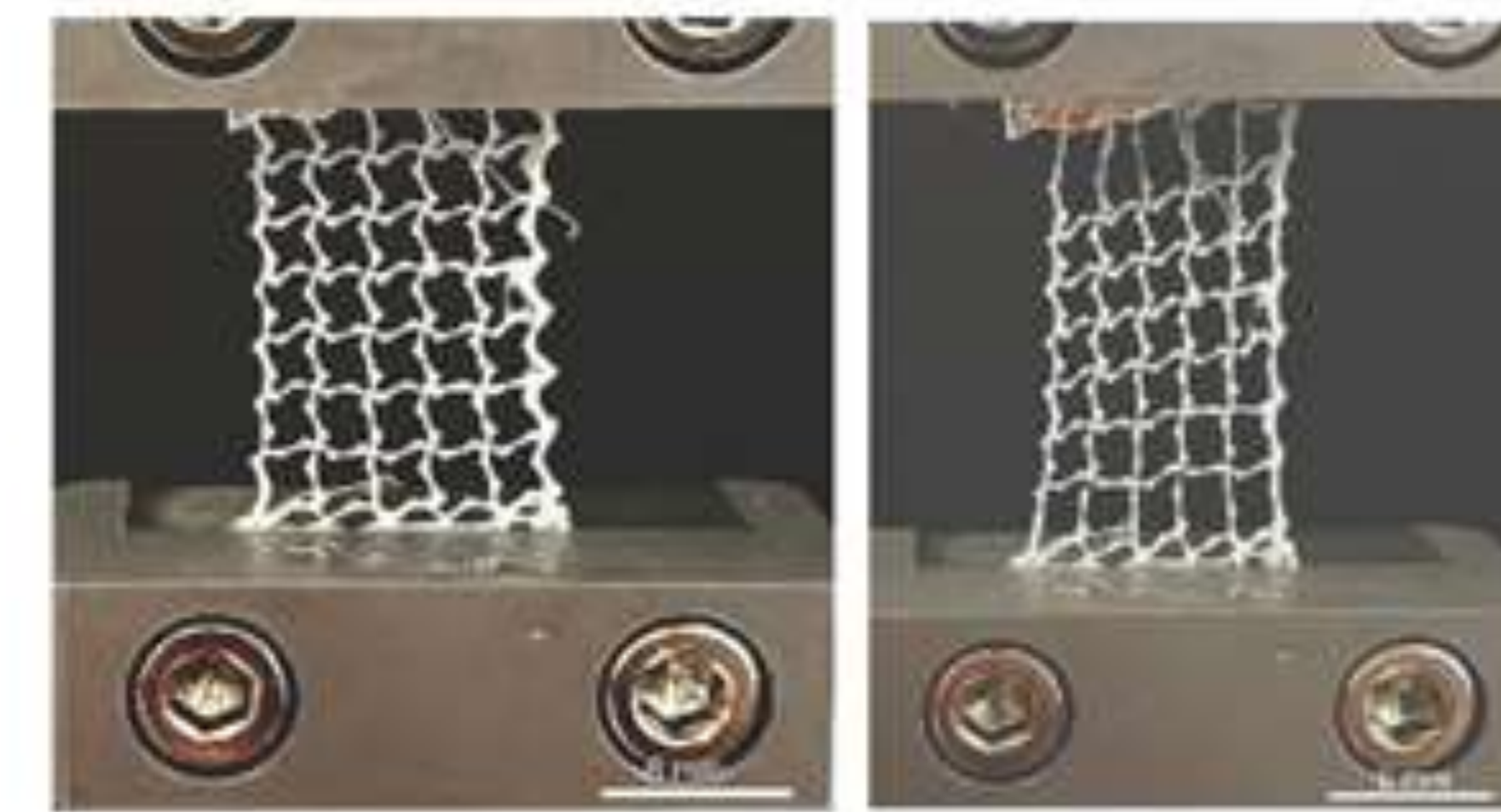
Re-entrant Honeycomb

Poisson's Ration: .98



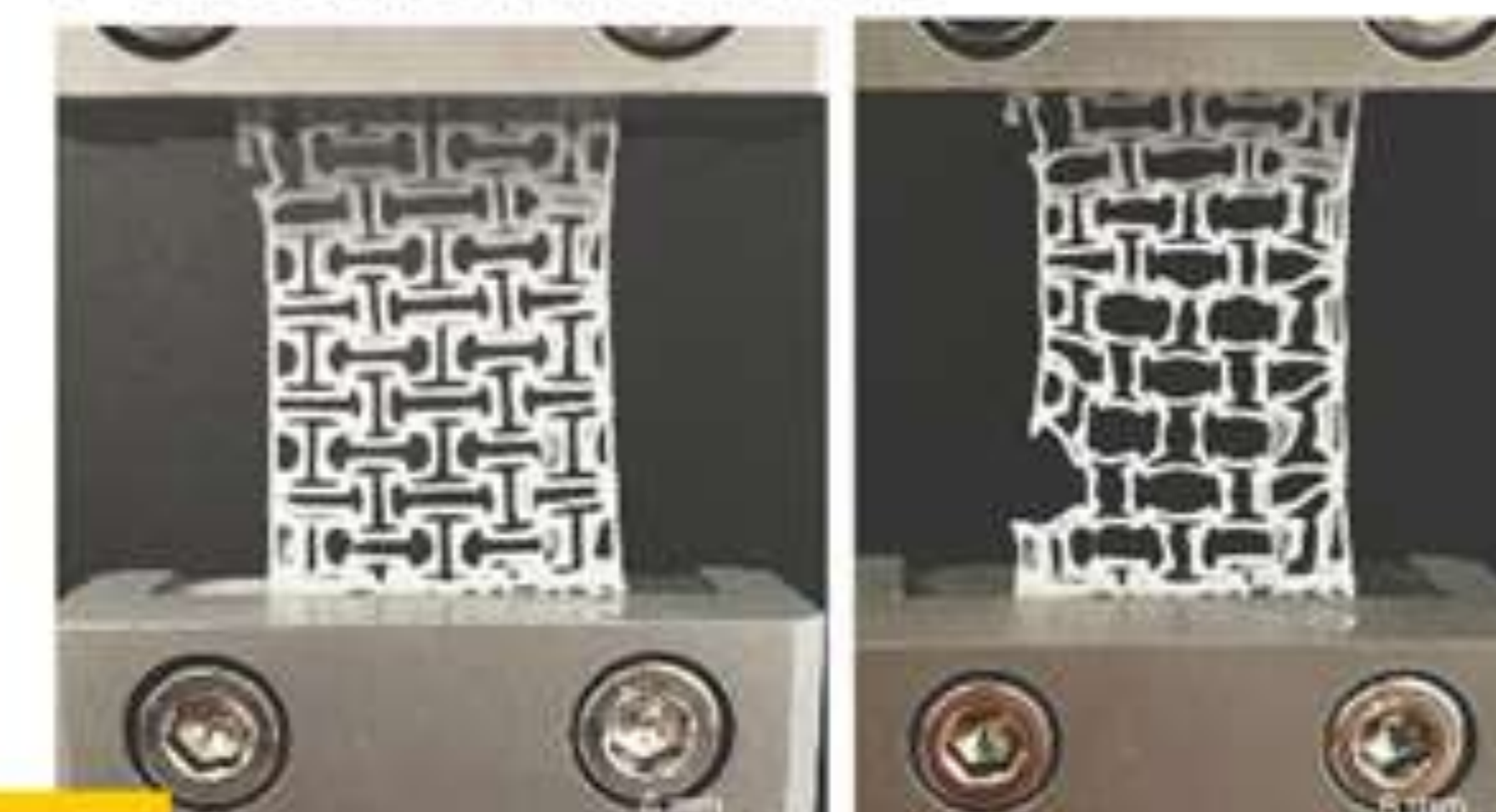
Chiral Truss

Poisson's Ration: .22



Lozenge Truss

Poisson's Ration: .48



Discussion

Auxetic Design Implications

The results indicate that the **project goal has not yet been reached**, and the patches are not yet ready to be produced. The stretching of the designs often led to tearing, indicating that more layers are needed so that the patch can reach its fully stretched auxetic state.

Future Auxetic Designs

Future patch designs will incorporate two significant changes:

- First, the **layer count of the patches will increase** to prevent tearing when under significant strain of 20% or more
- Second, the **size of each unit in the design will increase**, which will decrease the overall number of units per patch. This will allow the strain and auxetic performance to be equally distributed across the structure.

Conclusion

Application of Tissue Patches

- **Rapid Recovery of Organ Based Surgeries**
 - Through using a biocompatible nonsynthetic material, cells are able regenerate and grow on the patches. This will allow for a speedy recovery from injury or surgery.
- **More Effective Small Scale Bandage**
 - Heighten cell regeneration.
 - The auxetic design can account for the stretching of smaller appendages such as the fingers and feet.

Summary

- Contemporary therapeutic patches are unable to account for the anisotropic deformation of organs and may cause negative immune responses due to the nonsynthetic materials used.
- Testing indicates that the therapeutic patches created from silk fibroin, while functional, would likely become stronger with **fewer units and more layers**.

Acknowledgement

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References

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- Fernandez-Yague, M. A., Hymel, L. A., Olingy, C. E., McClain, C., Ogle, M. E., Garcia, J. R., Minshew, D., Vyshnyak, S., Lim, H. S., Cui, P., Garcia, A. J., & Botchwey, E. A. (2022). Analyzing immune response to engineered hydrogels by hierarchical clustering of inflammatory cell subsets. *Science Advances*, 8(8). <http://doi.org/10.1126/sciadv.abd8066>