New Frontiers: Manufacturing a Protein-Based Artificial Retina in Low-Earth Orbit

Nicole L. Wagner, PhD, CEO

March 29, 2023

LAMBDAVISION OVERVIEW

Company Overview

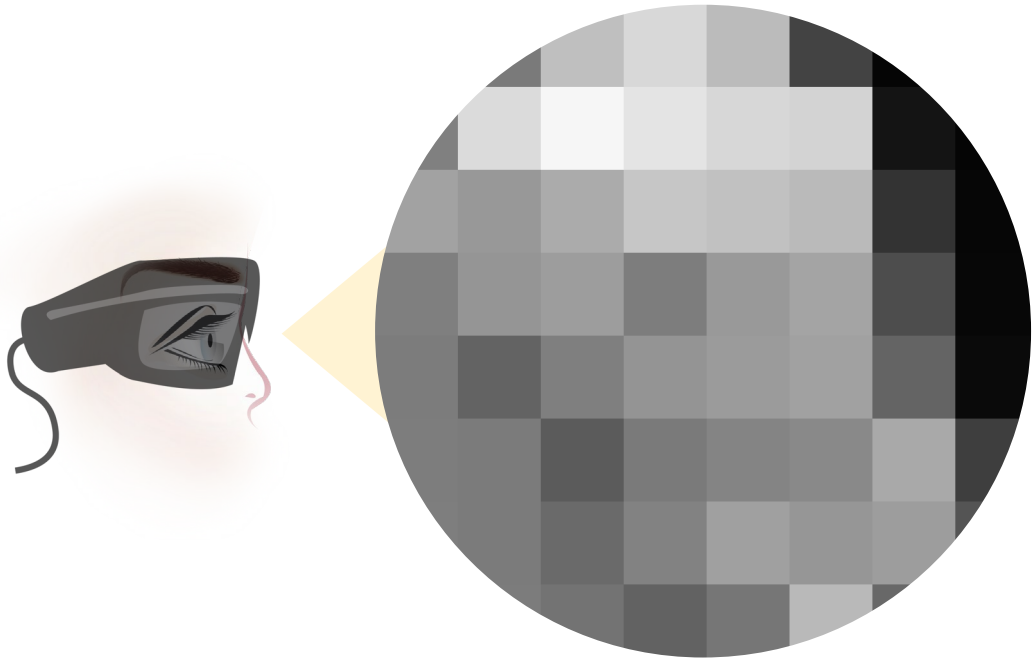
- **Founded:** Dr. Robert Birge, Distinguished Professor, UConn
- **Stage:** Preclinical
- **Funding:** >$10M

Market Opportunity

- **Product:** Bacteriorhodopsin-based artificial retina
- **Lead Indication:** Advanced retinitis pigmentosa
  - 100K US, 1.5M Worldwide (~1 in 4000)
- **Follow-on Indication:** Age-related macular degeneration
  - 10M US, ~50M Worldwide
- **Current Treatments:** No cure exists, and there is an unmet need to restore meaningful vision to those affected.

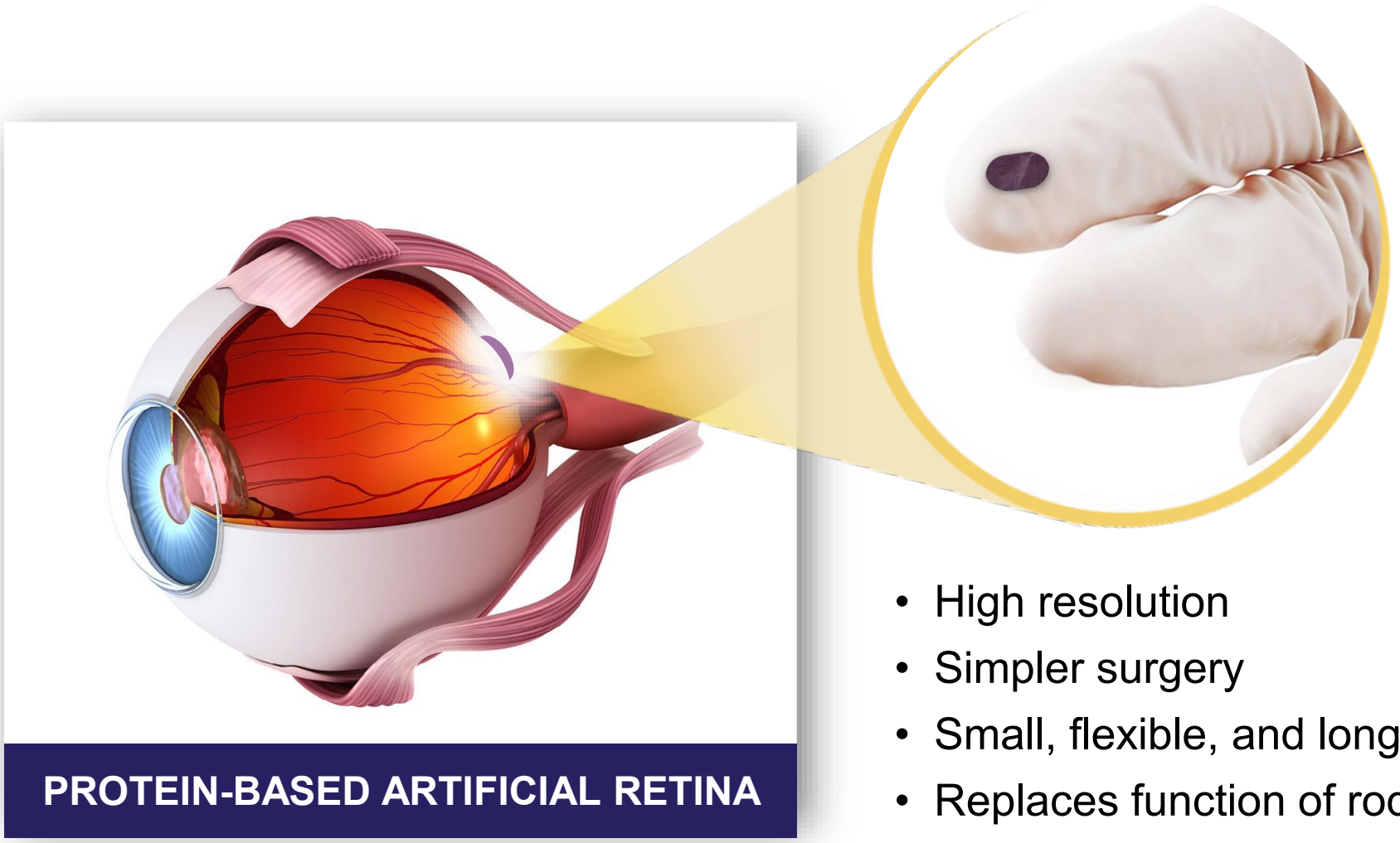
CURRENT TREATMENTS FOR RETINITIS PIGMENTOSA

Normal Vision



State of the Art

LAMBDAVISION'S SOLUTION

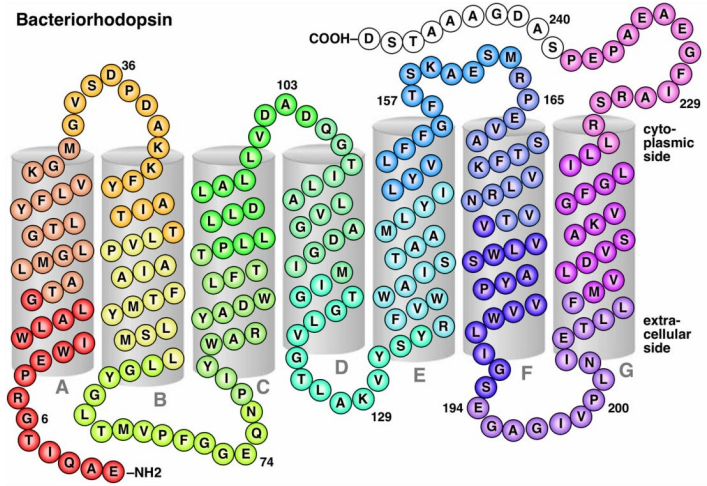


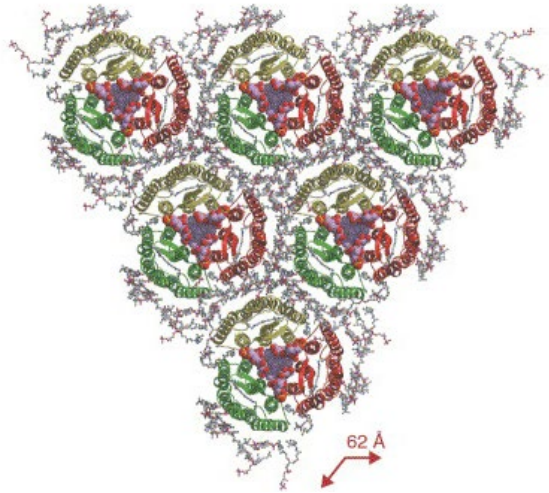
PROTEIN-BASED ARTIFICIAL RETINA

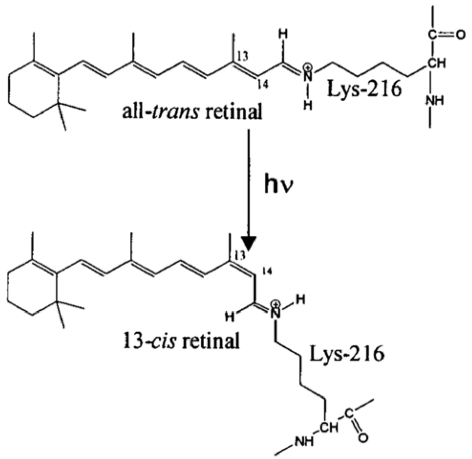
- High resolution
- Simpler surgery
- Small, flexible, and long-lasting implant
- Replaces function of rods and cones

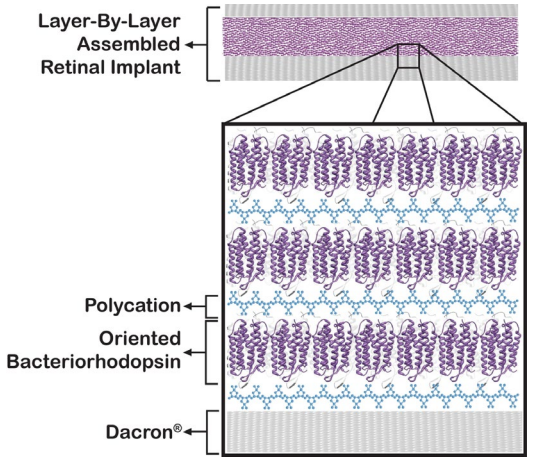
PROTEIN-BASED ARTIFICIAL RETINAS

The artificial retina is comprised of oriented layers of the light-activated proton pump, bacteriorhodopsin.





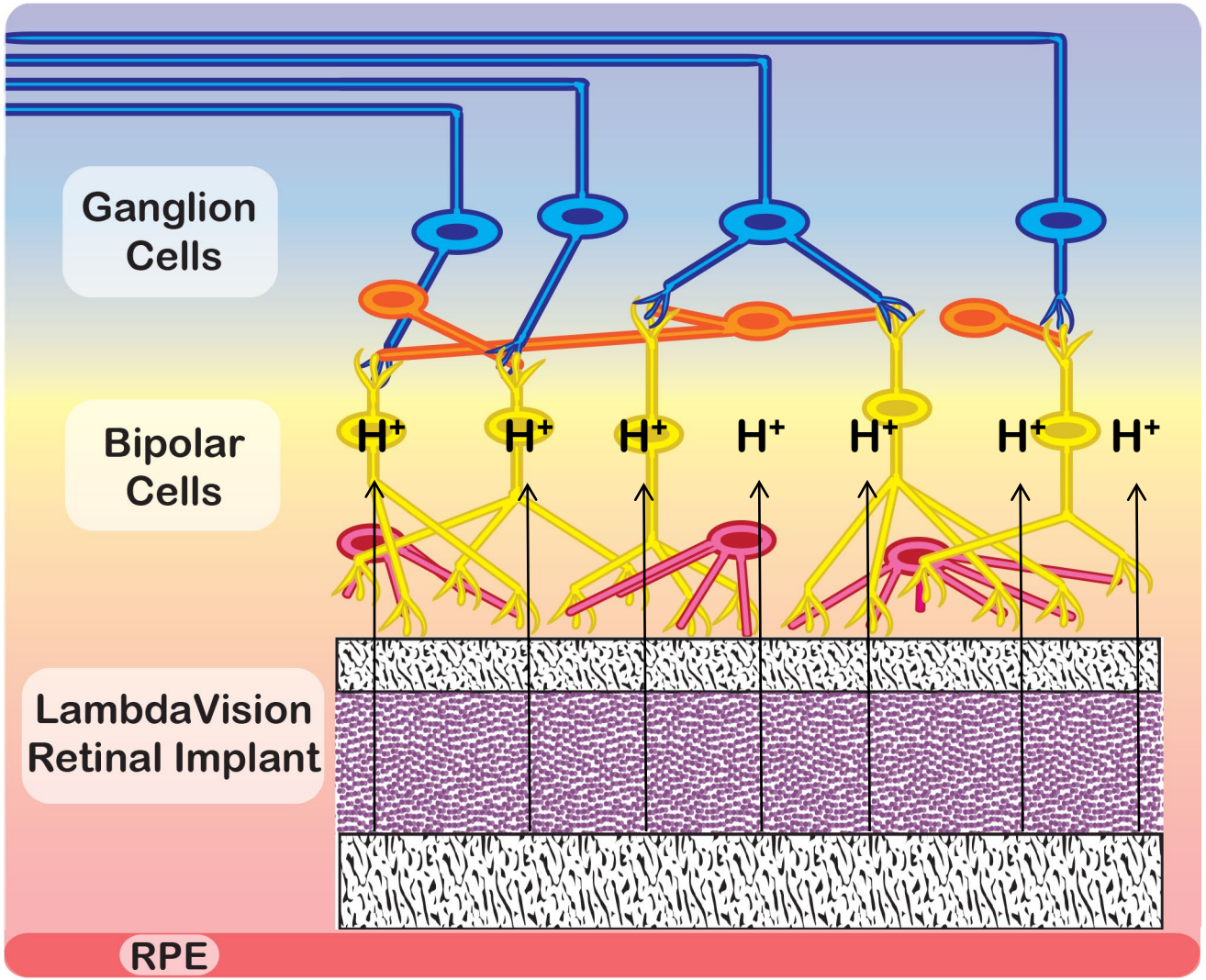




Birge, R.R. et al. J. Phys. Chem. B. 1999; 103: 10746-1076.
Essen, J.O. et al. Curr. Opin. Struct. Biol. 2002;12:516-522
Greco J.A, et al.. J. Neural Eng. 2021, 18, 066027

PROTEIN-BASED ARTIFICIAL RETINAS

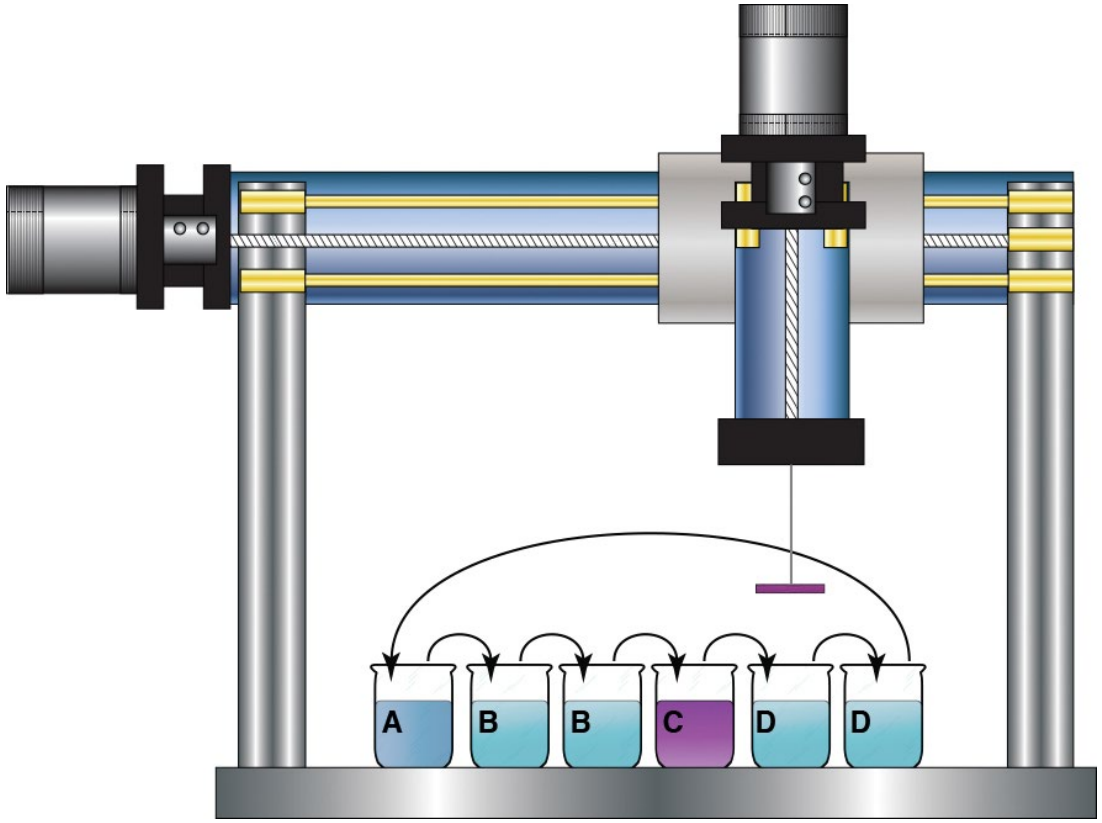
The artificial retina creates a unidirectional ion gradient that activates the remaining retinal cell network.



WHY MICROGRAVITY?

Multilayered Thin Films Generated by Layer-by-Layer Assembly

- Manufacturing process is subject to the effects of gravity.
- Sedimentation of solutions reduces implant homogeneity.
- Inefficient, irregular protein deposition impacts artificial retina performance.
- Reduction in usable area for preclinical experiments and clinical trials.



Lawrence, D. B. et al. Wiley-VCH GmbH. 2022: 285-301.

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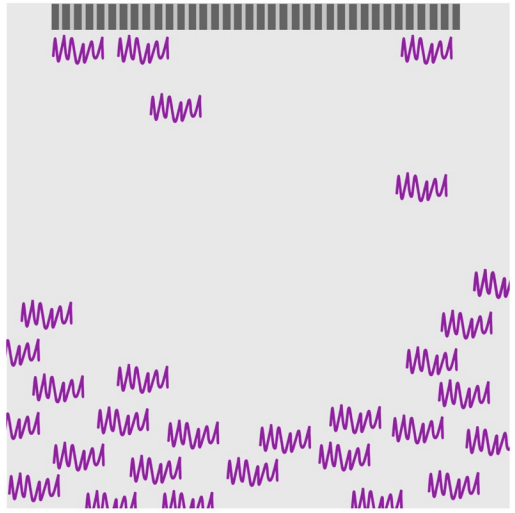
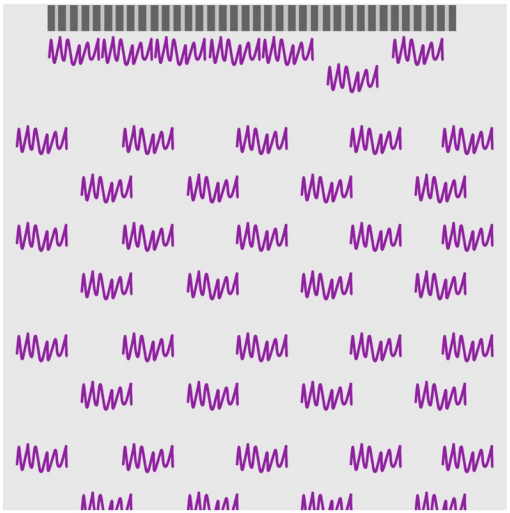
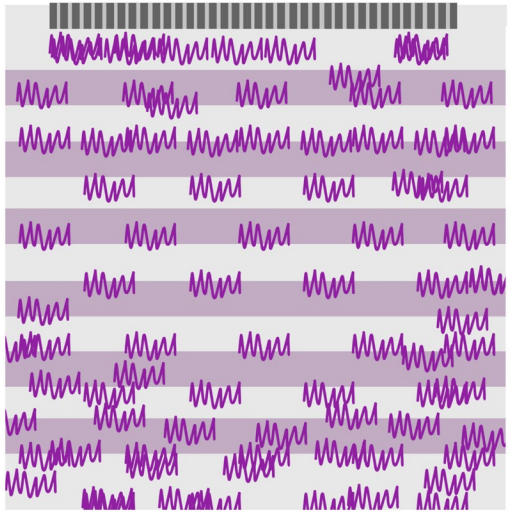


EARTH



MICROGRAVITY



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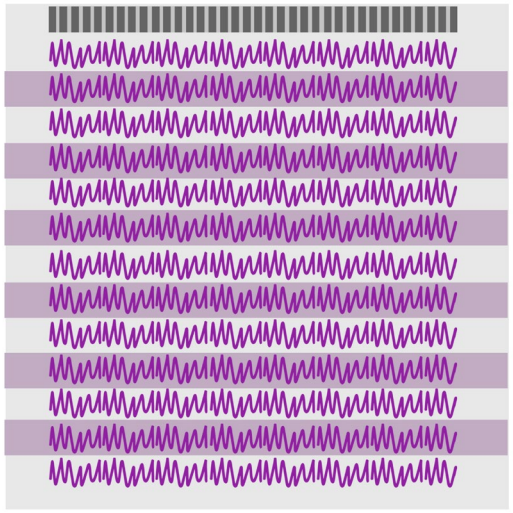

MICROGRAVITY

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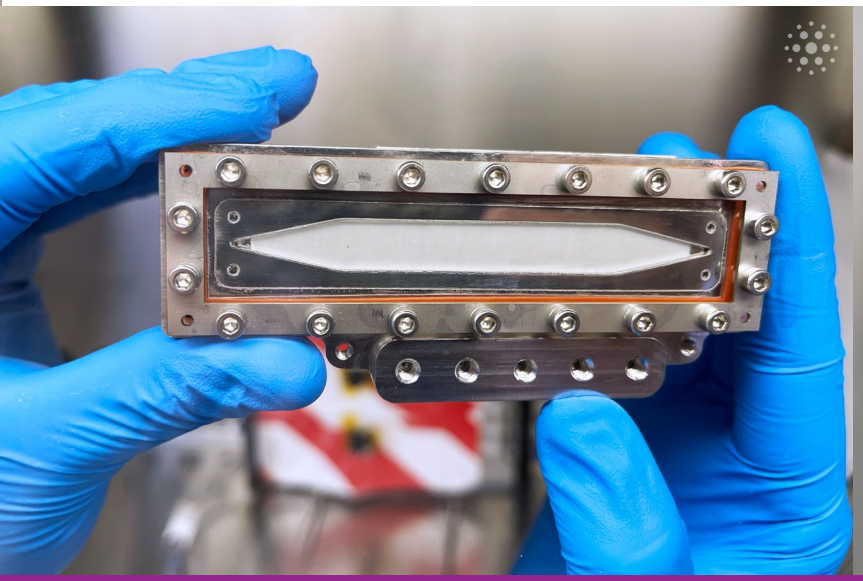
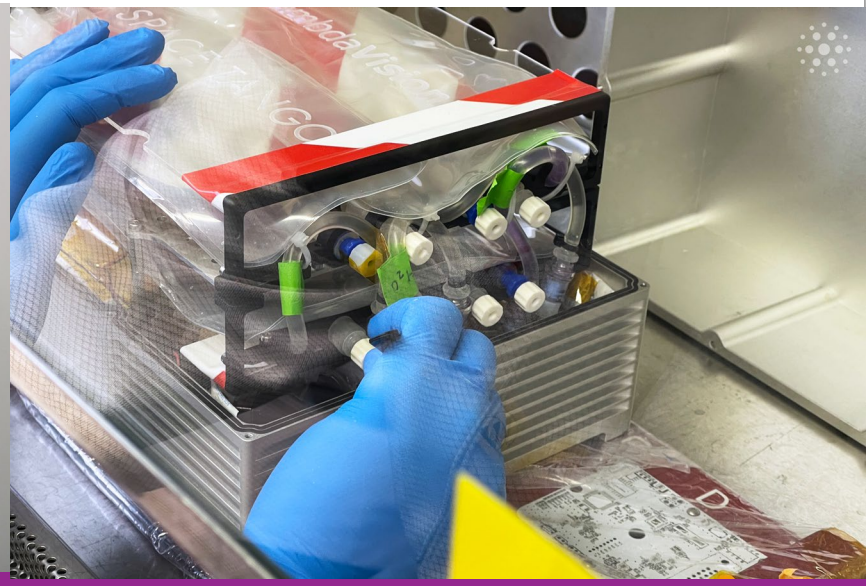
ISS NATIONAL LAB MANUFACTURING





MICROGRAVITY ENHANCES THE 3-DIMENSIONAL ASSEMBLY OF FILMS

- **Stable.** Improved homogeneity, stability, and performance.
- **Practical.** BR stability allows for manufacturing and storage in an ambient environment.
- **Efficient.** Automated process limits astronaut time and ISS resources.
- **Feasible.** Manageable production volumes required to supply clinical trials

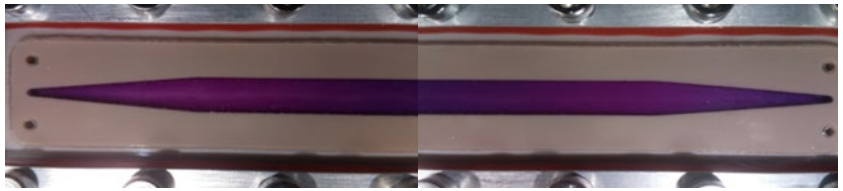
NASA SUPPORT ADVANCES ARTIFICIAL RETINA DEVELOPMENT

Lambda**Vision**, along with Space Tango secured ~$7M in contract funds to explore benefits of microgravity on production of the artificial retina.

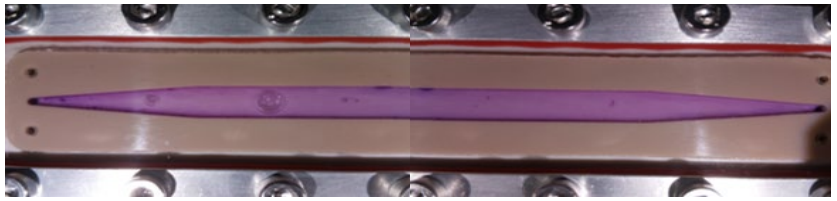
- Lambda**Vision** won CASIS/Boeing prize from MassChallenge in 2016.
- Pathfinder mission on SpaceX-16 in December 2018 demonstrated promising results.
- NASA Phase I/II SBIR and NRA awards supported 6 flights over 3 years to the International Space Station to evaluate and improve on-orbit processes for layer-by-layer deposition of proteins.
- Research and development supported by NASA/ISSNL is foundational and can support process improvements across a number of technology applications.
- NASA and ISSNL funding is critical in supporting chemistry manufacturing controls and assay development required for commercialization of the artificial retina and future technologies in LEO.

ISS NATIONAL LAB MANUFACTURING

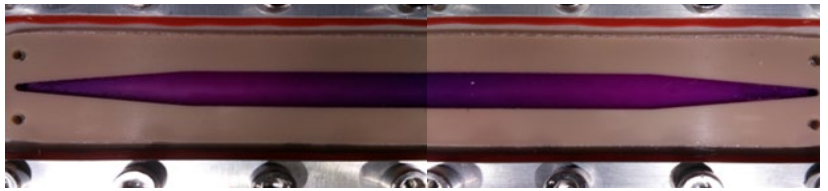
Seven missions on the ISS National Lab have been completed via NASA SBIR and NRA funding (SpaceX CRS-16, NG-14, NG-15, SpaceX CRS-24, Crew 4, Crew 5, and SpaceX CRS-24)



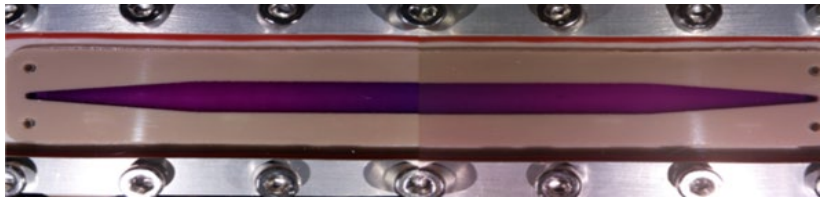
200 layer film (PAR04 – CH1)



50 layer film (PAR04 – CH2)

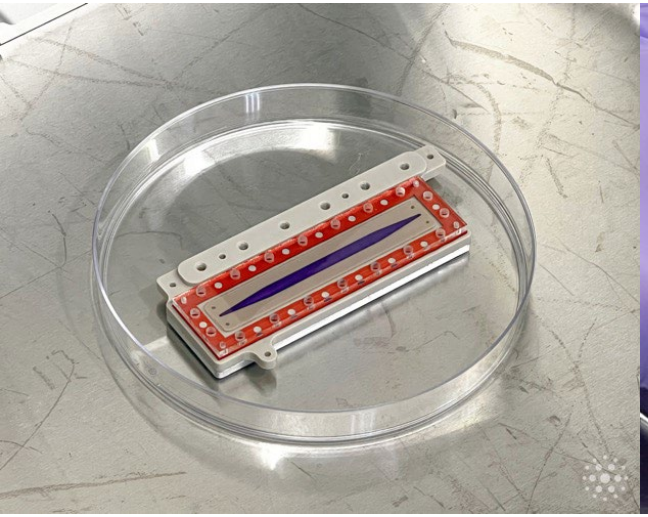


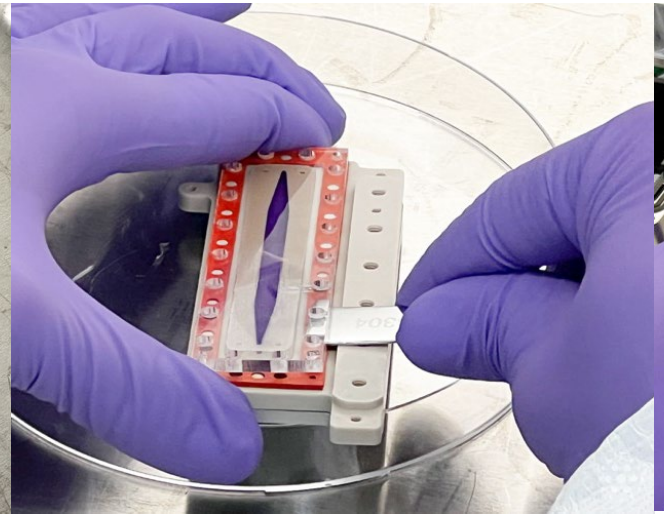
200 layer film (PAR05 – CH1)

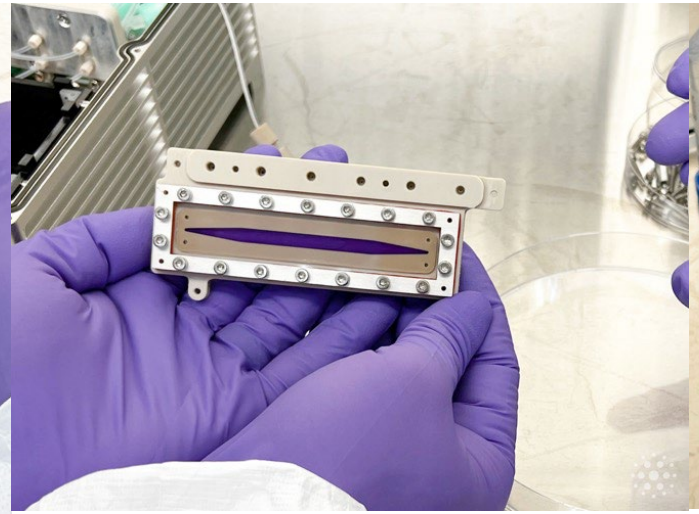


200 layer film (PAR05 – CH2)

PAR04 AND PAR05 DEINTEGRATION



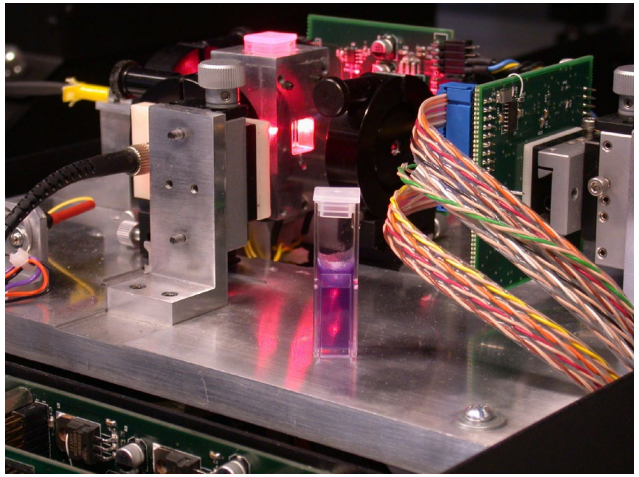


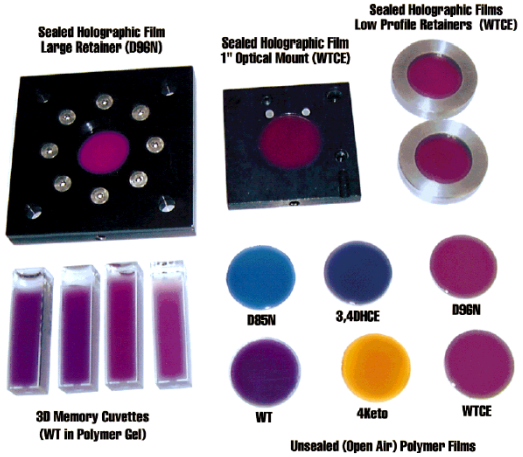


SUMMARY

- The fluidics, operational controls, and in-process quality measurements were validated through the assembly of multiple artificial retina thin films in microgravity.
- Multiple 200-layer thin films have been manufactured in microgravity and we have a proven tech stack of the CubeLab™ with good control and automation.
- Post-flight characterization on the flight solutions demonstrated no discernable change to protein and polymer quality.
- In vitro assay development is ongoing to further evaluate the functionality of post-flight samples.
- Additional flights planned to optimize manufacturing parameters, advance hardware, and evaluate opportunities for scale

BROADER IMPACTS





FUTURE OF LAYER-BY-LAYER MANUFACTURING IN MICROGRAVITY

Bacteriorhodopsin-Based Applications

- Artificial Retina
- Optical Data Storage
- Associative Processing/Neural Networks
- Optical Pattern Recognition
- Chemical/Environmental Toxin Detection

Additional Opportunities

- Biosensors
- Wound Healing
- Tissue Engineering
- Anti-Biofouling
- Products requiring good manufacturing practices

LEO COMMERCIALIZATION

- Leverage ISS capabilities and current flight opportunities to explore commercial development in LEO
- Demonstrate feasibility of biomanufacturing in microgravity and in space production of advanced materials
- Inspire new research and commercial product development that can foster a thriving LEO economy
- Promote dialogue around transition of ISS to CLDs and the development of business models for LEO
- Establish a robust ecosystem that supports in space production of products that have the potential to improve life for people on Earth

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Helping Patients Regain Sight

Dr. Nicole L. Wagner, PhD, CEO

nicole.wagner@lambda**vision**.com

774-280-0525