

Photobiomodulation on In-Vivo and In-Vitro Wound Models Under Simulated Microgravity for Future Space Travel

INTRODUCTION

Problem

- Wounds don't heal in space:** Prolonged exposure to microgravity results in chronic wounds, putting astronaut health and the mission at risk [1]
 - Chronic wounds** affect 12-18 million people globally.[2]
- We urgently need effective treatments on Earth and in space.

What is Photobiomodulation(PBM)?

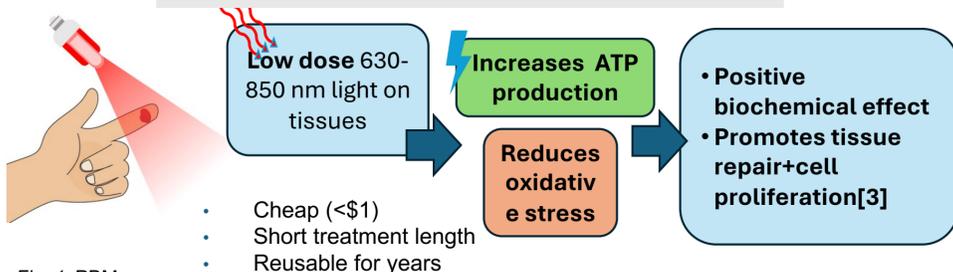


Fig. 1: PBM illumination
Graphic created by finalist on Canva, 2024

HYPOTHESIS

PBM will increase wound healing rate in both microgravity and normal gravity on planarian and human cell wound models.

METHODOLOGY

PART 1: PBM on Planarian Blastema Regeneration

1. Scale size using Planarian width to make up for size disparities

2. Amputate Planarians, Irradiate with PBM daily, → 3D Clinostat to simulate Microgravity

3. Data Collection and Quantitative Image Analysis of Blastema Size using ImageJ

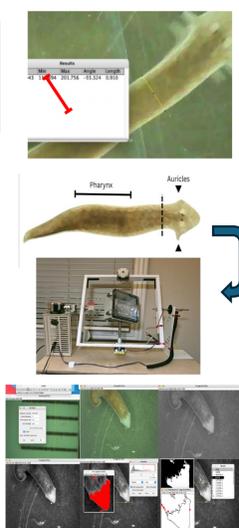


Fig. 3: Images depicting planarian procedure
Photos taken by finalist/parent. Image analysis pictures from ImageJ, 2024

PART 2: PBM on Human Cell Scratch Wound Healing Assay

1. Culture cell monolayer in 96 well plates for 24 hours

2. Inflict a scratch wound using a 5 µl pipette tip, Irradiate with PBM daily

3. Measure scratch area with ImageJ plug-in every 24hrs for 72 hrs, Calculate wound closure %

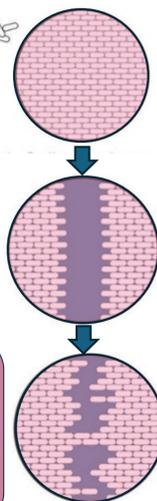


Fig. 4: Graphic of wound healing assay cell migration.
Graphic from Axion BioSystems, Inc. (2026). Wound-healing assay: What, why and how [Image/illustration]. <https://trends.medicalexpo.com/axion-biosystems/project-129270-434098.html>

Statistical Analysis- One Way ANOVA, Bonferroni Post Hoc Comparisons

DATA ANALYSIS AND RESULTS

PART 1: PBM on Planarian Blastema Regeneration

- Normal Gravity with PBM (AUC): **47.10% accelerated growth**
- Microgravity with PBM (AUC): **95.23% accelerated growth**

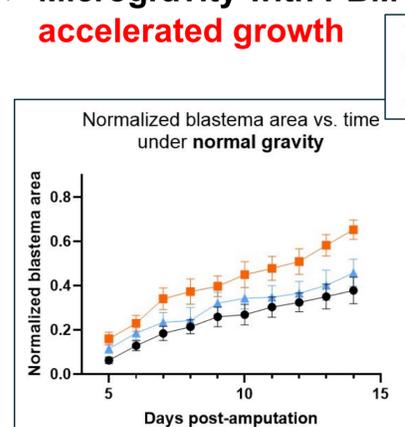


Fig. 5: Planarian blastema growth under normal gravity (mean ± 95% CI, n=8).
Created by finalist on GraphPad Prism, 2025

PART 2: PBM on Human Cell Scratch Wound Healing Assay

- PBM on human cells: **29.8% increased wound closure**
- In both models, 0.36 J/cm² of 660nm red light for 5min from 5 cm away produced the largest increase in tissue regeneration and cell migration

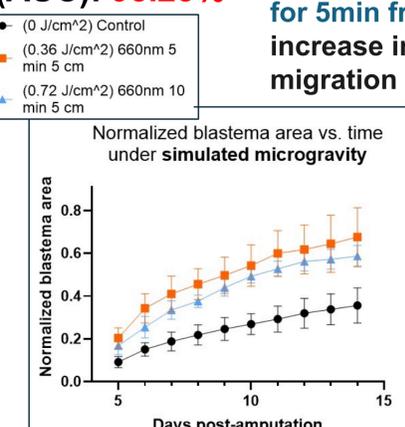


Fig. 6: Planarian blastema growth under microgravity (mean ± 95% CI, n=8).
Created by finalist on GraphPad Prism, 2025

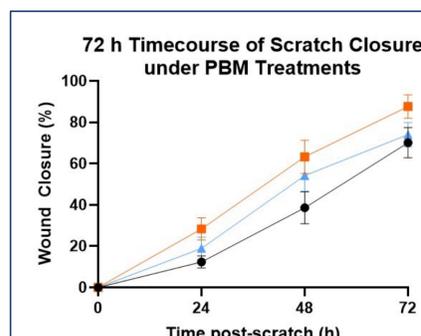


Fig. 7: Mean % wound closure at 0, 24, 48, and 72 h for control and PBM groups (mean ± 95% CI, n=9).
Created by finalist on GraphPad Prism, 2025

BUILDING A MICROGRAVITY SIMULATOR

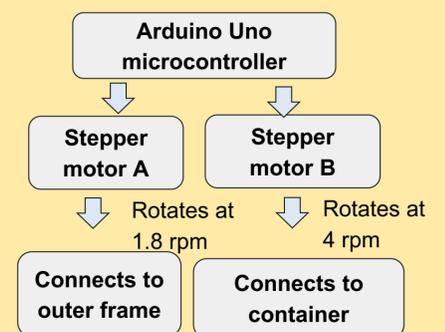
Sending samples to space is costly and inaccessible.

Solution: Use a 3D clinostat, a device NASA uses to simulate microgravity (SMG) by time-averaging the gravity vector.

Since commercial clinostats cost ~\$50,000, I built my own.



Fig. 2: 2nd clinostat prototype
Image taken by finalist, 2024



- My clinostat was able to reduce force of gravity from 1G → < 10⁻³g, which is within the range of typical ground-based SMG
- A 3-axis accelerometer on a cell phone and Phyphox software (RWTH Aachen University) was used to measure deviation from freefall in the clinostat and check rotation stability/vibration

CONCLUSIONS

- PBM (660 nm, 0.35J/cm²) produced the strongest improvement in wound-healing readouts across both wound models.
- **These findings support PBM as a cheap, simple, scalable, and reliable approach for protecting astronauts and for expanding access to wound healing therapies in resource-limited settings worldwide.**
 - Demonstrated dose-dependence and biphasic response
 - Wavelength matters: 660 nm was an optimal treatment
 - PBM may help buffer gravity-related impairment in repair processes

Benefits/impact

- Non-medicinal, reducing risk of adverse side effects in space
- **Addresses critical global health needs:** PBM can help those with little access to medical care and in underserved communities: natural disasters, humanitarian crises, warzones, military operations.
- **At less than a dollar per LED, PBM can dramatically cut treatment costs, and making wound care universally accessible.**

Future work

- Investigate full-body PBM for muscle loss and bone demineralization
- Determine PBM mechanism of action
- Optimize treatment dosage and wavelengths across skin tones
- Re-design clinostat with anti-wobble frames and built-in incubator

[1] Bacci S, Bani D. The Epidermis in Microgravity and Unloading Conditions and Their Effects on Wound Healing. *Frontiers in Bioengineering and Biotechnology*. 2022;10:666434. doi:10.3389/fbioe.2022.666434
[2] Martinengo L, Olsson M, Bajpai R, et al. Prevalence of chronic wounds in the general population: systematic review and meta-analysis of observational studies. *Annals of Epidemiology*. 2019;29:8-15. doi:10.1016/j.annepidem.2018.10.005.
[3] Dompe C, Moncrieff L, Matys J, et al. Photobiomodulation—Underlying Mechanism and Clinical Applications. *Journal of Clinical Medicine*. 2020;9(6):1724. doi:10.3390/jcm9061724.