Spatiotemporal Patterns of Fungal Bioluminescence

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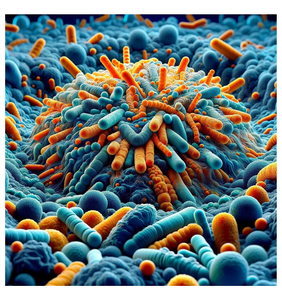
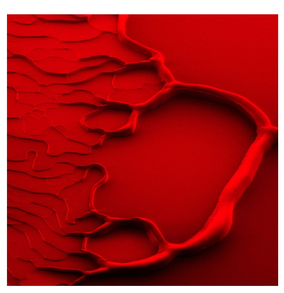
PhysMechBio Team

We explore the hidden links between mechanics, structure and dynamics of biological systems ranging from red blood cells and bacterial flagellar motors to bacterial biofilms and bioaerosols.

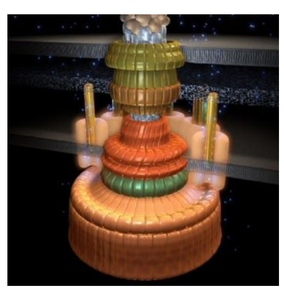
We are developing a toolbox of cutting-edge techniques, such as nano- and micro-manipulation, fast optical microscopy, holography, iSCAT, microfluidics, macro- and micro-rheology.



Biofilm formation



Hemophysics



Bacterial flagellar motor

Airborne pathogen transmission

Fungal Bioluminescence

Recently, we have begun a collaboration with the University of São Paulo in Brazil to study the mechanisms and evolutionary benefits of fungal bioluminescence.

'Glowing mushrooms' have fascinated humans for thousands of years, going back to Aristotle and Pliny the Elder. While their light emission is captivating, one might wonder: why do certain fungal species expend energy on producing light?

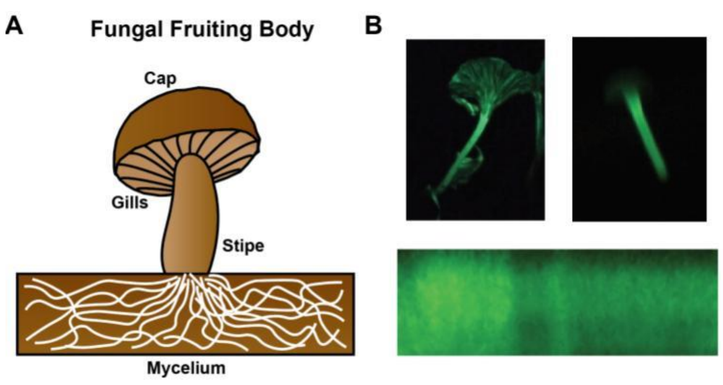


Figure 1: A) Cartoon of different parts of a fruiting body (mushroom) and mycelium. **B)** Different species express different patterns of bioluminescence in the whole fruiting body (top left), stipe (top right), or mycelium (bottom).

Background

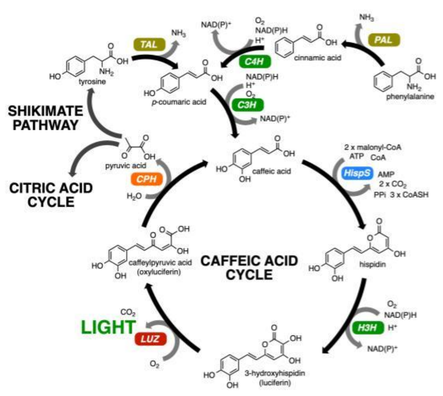


Figure 2: Caffeic Acid Cycle (CAC) is the mechanism by which bioluminescent fungi produce luciferin and light.

Fungal bioluminescence is created via the Caffeic Acid Cycle and can exist in the fruiting bodies (e.g. mushrooms) or in the mycelium. Interestingly, while light production in the mushrooms can aid in spore dispersal, the evolutionary benefits of light emission in the mycelium remains unknown.

Fungal mycelium growth and bioluminescence exhibit fascinating time- and spatial-dependent patterns influenced by environmental conditions, genetic regulation, and circadian rhythms. Understanding these dynamics is critical for advancing knowledge in fungal biology, biochemistry, and biotechnology. Despite the significant role these processes play, visualizing and quantifying such changes over time remains a challenge, particularly in controlled settings like incubators. Time-lapse imaging offers a powerful solution to capture the progression of mycelial growth and the spatiotemporal dynamics of bioluminescence, providing insights into developmental processes and environmental interactions.

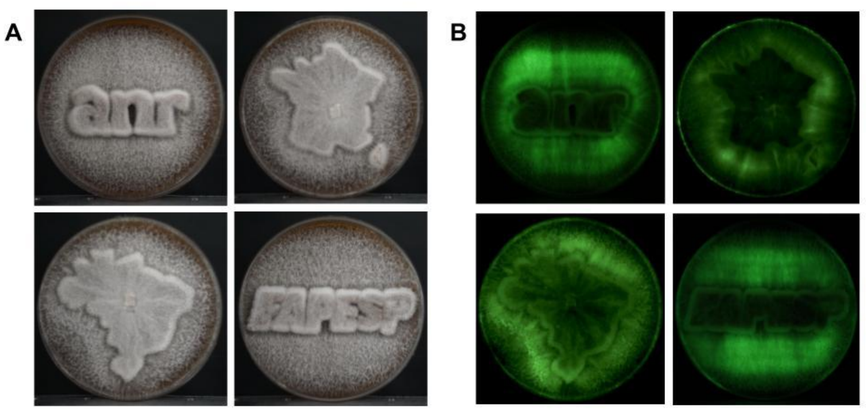
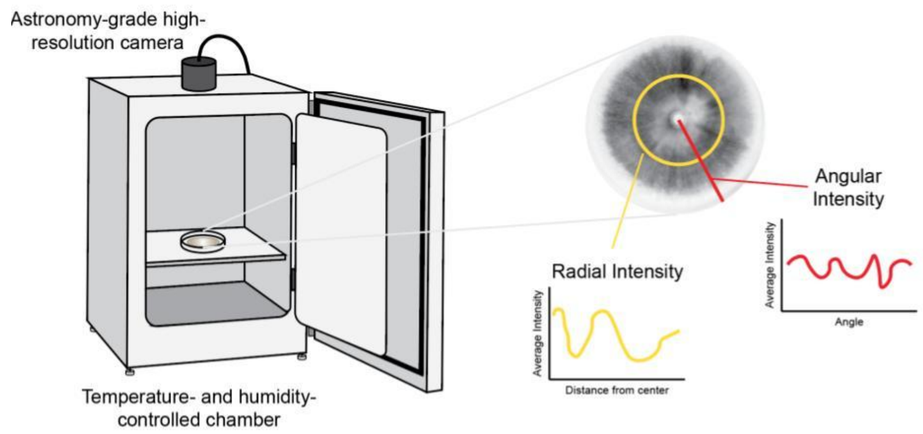


Figure 3: A) Growth of *N. gardneri* mycelium on MYA plates.
B) Bioluminescence of *N. gardneri* mycelium captured with a Sony a6000 camera with a 30 sec. exposure.

Project Outline

We have recently constructed an in-house incubator setup capable of capturing both bioluminescence and growth of growing plates of fungal mycelium. This project will involve learning culturing techniques for *Neonothopanus gardneri*, a species of bioluminescent fungi from Brazil, and recording growth and light emission in Petri dishes over a span of ~14 days. After image acquisition, the Master's student will be responsible for developing Python algorithms to perform image analysis, correlating growth speed with light intensity and uncovering spatial patterns in the non-heterogeneous signal. This project will provide the student with hands-on experience in engineering, coding, and biological research while developing a tool that enhances the ability to study fungal biology in real-time.



This project also provides the student with the benefit of engaging in a newly evolving project, requiring adaptability but also creating the opportunity for a sense of personal ownership. Other aspects of the project, such as the fabrication of microfluidic circuits and imaging fungal hyphal bioluminescence at the microscopic level are also possible depending on the student's interests and time available.

The world of fungal bioluminescence, despite being a fascination for scientific minds for thousands of years, is still in its scientific infancy. As such, we welcome any motivated students who are interested in learning fungal culturing, image acquisition, and image processing techniques to reach out and join us in exploring this enlightening domain.