Title of the Thesis:

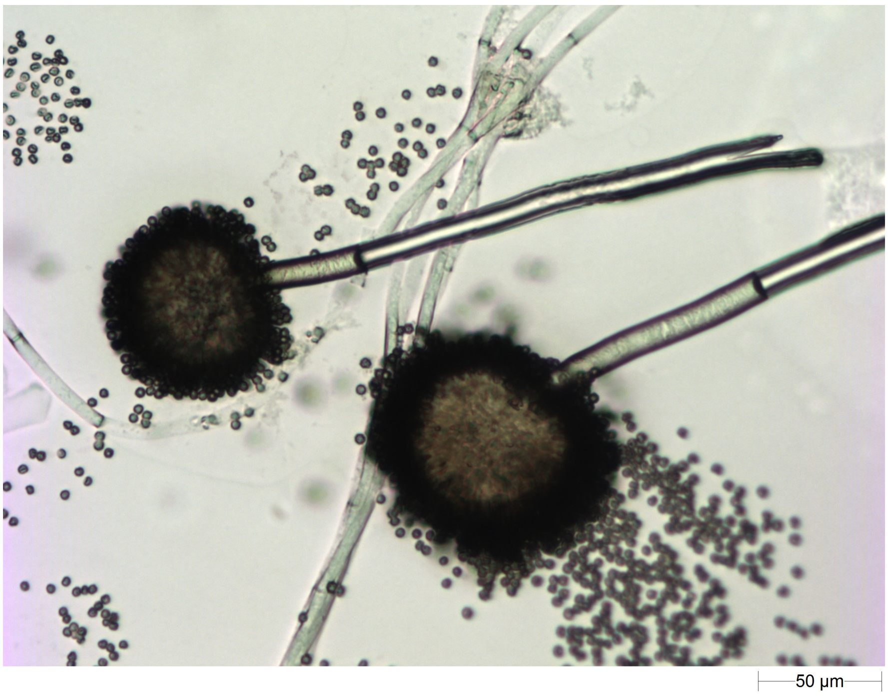
FLOWS: Fungal Spore Germination and Hyphal Growth Under Shear Flow – Unraveling Adhesion Mechanisms in Soft and Dynamic Environments

Abstract:

Filamentous fungi play a crucial role in various natural and industrial environments, including biotechnological processes, and bioremediation systems. Spore germination and hyphal growth under flow conditions strongly influence their adhesion to surfaces and overall development, yet the underlying mechanisms remain poorly understood.

This doctoral research aims to experimentally characterize the influence of flow conditions on spore germination and hyphal growth using milli- and microfluidic chambers. Adhesion measurement approaches, combining advanced microscopy and real-time tracking techniques, will be implemented to analyze the impact of hydrodynamic constraints on initial adhesion, morphogenesis, and hyphal growth dynamics.

A key innovative aspect of this study is the **development of a shear flow chamber adapted for soft materials**, allowing for the investigation of hyphal adhesion and growth on biomimetic or deformable substrates. This setup will enable a deeper understanding of how mechanical forces influence surface colonization and the structural organization of fungal pellets.



Example of filamentous fungi during sporulation phase (On going PhD in TBI)

PhD Student Responsibilities and Research Steps:

1. **Literature Review & Theoretical Framework:**
    - Review existing studies on fungal adhesion, germination, and growth under flow.
    - Explore hydrodynamic effects on microbial colonization and biofilm formation.
    - Investigate experimental and modeling approaches relevant to milli- and microfluidic systems.
2. **Design and Fabrication of Experimental Setups:**
    - Develop and optimize a **shear flow chamber** suitable for soft, biomimetic, or deformable materials.
    - Design and fabricate milli- and microfluidic devices for fungal culture under controlled flow conditions.
    - Implement modifications to existing platforms to enhance experimental flexibility.
3. **Experimental Studies on Spore Germination and Hyphal Growth:**
    - Perform controlled flow experiments to assess adhesion, germination rates, and early-stage hyphal development.
    - Investigate the influence of **shear stress and substrate stiffness** on fungal colonization.
    - Optimize culture conditions and establish reproducible protocols for quantitative analysis.
4. **Microscopy and Imaging Analysis:**
    - Use advanced microscopy techniques (e.g., **confocal, fluorescence, phase contrast**) to track fungal development.
    - Implement image analysis methods to quantify adhesion strength, growth directionality, and structural changes.
    - Explore time-lapse imaging for dynamic monitoring of fungal adaptation under flow.
5. **Biophysical Modeling and Data Analysis:**
    - Develop or adapt models to describe fungal adhesion kinetics and hyphal growth dynamics.
    - Analyze experimental data using statistical and computational approaches.
    - Correlate experimental results with theoretical predictions of flow-induced mechanical effects.
6. **Application-Oriented Investigations:**
    - Evaluate potential applications of findings in biotechnology, material engineering, or medical microbiology.
    - Consider implications for biofilm control strategies or fungal-based biofabrication.
7. **Scientific Communication & Thesis Writing:**

- Publish results in peer-reviewed journals and present findings at international conferences.
- Collaborate with interdisciplinary teams working on fungal biology, bioengineering, and fluid dynamics.
- Write and defend the PhD dissertation.
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The expected findings will provide fundamental insights into the mechanisms governing fungal colonization under hydrodynamic constraints and could have applications in biotechnology, biofilm engineering, and fungal infection control.

Background of the Candidate:

The candidate should have a solid foundation in **laboratory techniques** such as **microscopy** (e.g., fluorescence, confocal, phase contrast), **culturing microorganisms**, and **experimental design**. Experience with **micro/millifluidics** and **shear stress applications** would be an advantage, but not a strict requirement, as training will be provided.

Familiarity with **quantitative analysis** (including statistical and computational tools) and **data modeling** to interpret experimental results would be a key strength. Knowledge of **biophysical principles** related to flow, adhesion forces, and material properties is important, as the project will involve developing experimental setups and analyzing the mechanical interactions of fungi in dynamic environments.

Additionally, the candidate should possess **skills in image processing**, particularly for analyzing microscopy data such as fluorescence, confocal, and phase contrast images. Proficiency in using image analysis software tools like **ImageJ**, **Python**, or **MATLAB** for extracting quantitative data from visual recordings of fungal growth, spore germination, and adhesion behavior will be essential for the project.

Finally, strong communication skills for writing scientific papers, presenting results at conferences, and contributing to collaborative research efforts are essential. The candidate should be self-motivated, eager to explore new research areas, and able to work both independently and as part of a multidisciplinary team.

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