Nematic order as a fundamental force of biological organisation

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Background

Orientational alignment in nematic order is a fundamental driver of **organisation** across biological systems [1].

Outside mammalian contexts, its role in **early development** remains **underexplored**.

Rod-shaped **ascospores** in the lichen *Xanthoria parietina* exhibit nematic order as a **minimal system**.

Spores are **confined** within the ascus during development [2], creating a **mechanically constrained** environment.

Methodology

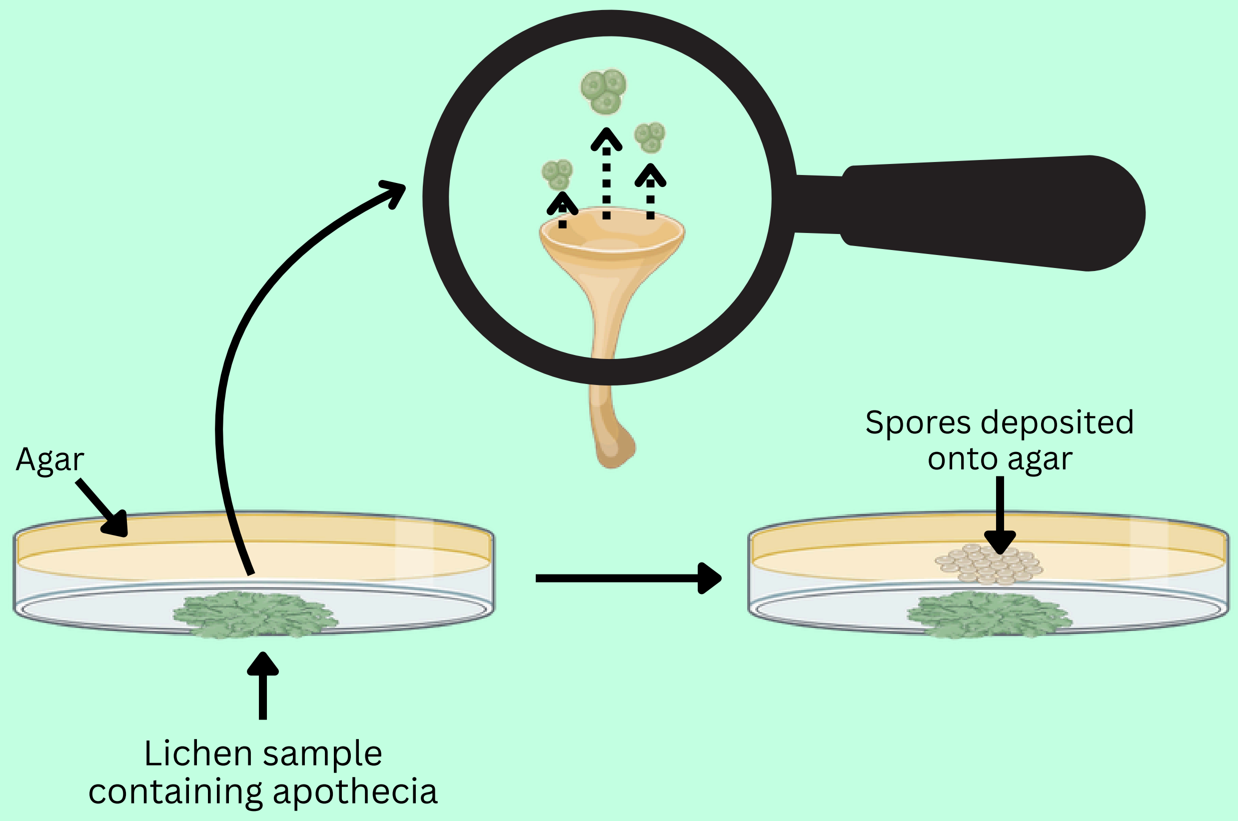

Figure 1: Ascospores obtained by the discharge method. Samples containing apothecia (spore-producing bodies) mounted on inverted petri dish lid underneath agar. Spores discharged directly onto agar.

Aim: Investigate if **mechanical confinement** within the **ascus** drives emergence of **nematic orientational order** in *X. parietina* ascospores.

Fundamental biological development

Orientational order is observed across many mammalian biological systems.

Nematic defects act as **organisational centres**, influencing **cell mechanisms** like proliferation [3].

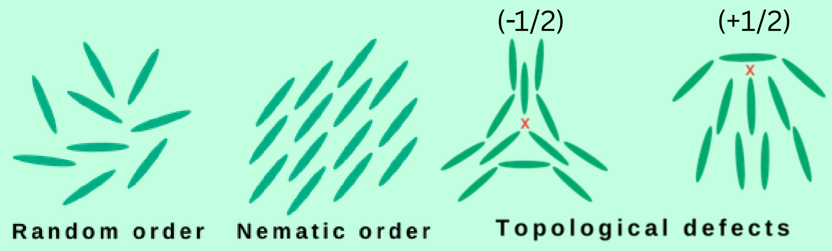

Figure 2: Nematic order and defects in rod-shaped units.

The **8-cell stage** in embryogenesis is the transition of **dividing cells** into an **organised structure**, driven by **increasing cell density** under **confinement** [4].

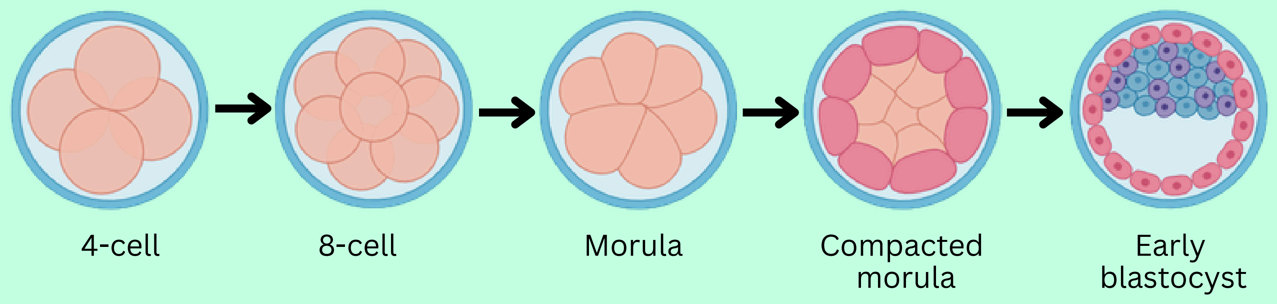

Figure 3: Stages of mouse embryogenesis from 4-cell to early blastocyst.

Results

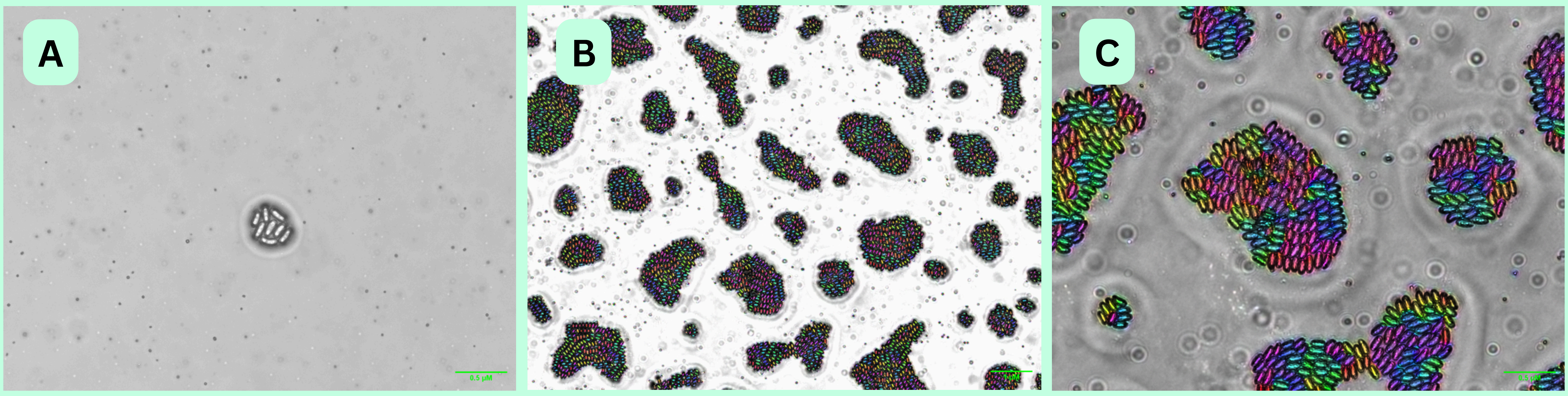

Figure 4: Light microscopy images of *X. parietina* ascospores using Olympus CKX53. A - discharged ascus containing 8 spores after 1 day of incubation (10x magnification); B - substantial increase of spores in asci after 2 days (4x); C - ImageJ colour survey of spores, where areas of common alignment are the same colour (10x).

Conclusion & future work

These results show that ***X. parietina* ascospores** exhibit **domains** of **common orientational order** within the ascus during **later stages** of development. The ascospores undergo a transition from proliferation to organisation under confinement, providing a **minimal biological model** for mechanically driven **self-organisation**. Nematic order represents a fundamental force of biological organisation across **different biological systems.** Future work will investigate how nematic order informs the next stages of spore development and analysis of physical defects.

References

1. Doostmohammadi and Ladoux (2022), 'Physics of liquid crystals in cell biology'. *Trends in Cell Biology*.
2. Trail and Seminara (2014), 'The mechanism of ascus firing - mergining biophysical and mycological viewpoints'. *Fungal Biology Reviews*.
3. Maroudas-Sacks *et al.* (2020), 'Topological defects in the nematic order of actin fibres as organization centres of Hydra morphogenisis'. *Nature Physics*.
4. Maître *et al.* (2015), 'Pulsatile cell-autonomous contractility drives cmpaction in mouse embryo'. *Nature Cell Biology*.