

Adaptation of fluid flow in the slime mould *Physarum polycephalum*

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The true slime mould *Physarum polycephalum* is a foraging organism, which grows as a continuously connected network of tubes. The morphological dynamics of *P. polycephalum* have been repeatedly characterised as “intelligent”. In quest for a mechanism to pass signals throughout the organism and generate this global adaptation the preeminent candidate is *P. polycephalum*'s characteristic periodic cytoplasmic streaming that extends throughout its entire network of tubes [3]. The tubes themselves consist of a gel-like outer tube enclosing the cytoplasmic fluid that oscillates back and forth with a period of about 100 s throughout the network. The same period is exhibited by cross-sectional contractions of the tubes, caused by the actin-myosin system in the outer gel wall of the tubes [4, 2]. All previous attempts to correlate the cytoplasmic flow and the cross-sectional contractions have failed, leaving the origin of the oscillating cytoplasmic flows unresolved. Accordingly no attempts have been made to correlate flows with morphological dynamics.

To resolve the origin and organisation of the cytoplasmic flows we study on *P. polycephalum* in its foraging state, in the absence of food sources. We image contractions and flows throughout the entire tubular network. Comparing this data with a theoretical model we showed that cytoplasmic flows are indeed driven by the cross-sectional contractions [1]. We investigate the large scale coordination of the contractions to find that the phases of the contractions are patterned in a gradient that extends over the length of the organism, with the phase gradient going through a sin-

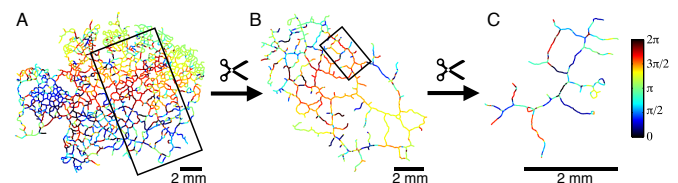


Figure 1: Patterns of the phases of contractions in *P. polycephalum* networks that were obtained from consecutive cutting. All display a phase gradient going through a single cycle of 0 to 2π , independent of size.

gle cycle from zero to 2π independent of organism size; the network version of peristalsis, see Fig. 1. Theoretical and numerical arguments show that the observed flow patterns, which agree with the theoretically predicted, are optimal for maximising transport. Thus, *P. polycephalum* seems to coordinate its foraging behaviour by optimising transport within its network tubes, with the result that resources get distributed isotropically throughout the whole organism. The observation that flow patterns adjust to organism size corroborates the initial hypothesis that the organism controls its flows.

This extended abstract summarises an invited presentation delivered at PhysNet 2015.

1. REFERENCES

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