Control of fungal contour sensing and its relevance to growth mechanics and hyphal tip structure

Andrew D. Bowen¹, Fordyce A. Davidson², Robert Keatch³ and Geoffrey M. Gadd¹

¹ Division of Environmental and Applied Biology, Biological Sciences Institute, School of Life Sciences, University of Dundee, Dundee, DD1 4HN, Scotland, UK.
² Division of Mathematics, University of Dundee, Dundee, DD1 4HN, Scotland, UK.
³ Division of Mechanical Engineering and Mechatronics, University of Dundee, Dundee, DD1 4HN, Scotland, UK.

Contour-sensing (thigmotropism) is proposed to be a significant influence on fungal growth patterns in many environments. It has been studied in both plant (Read et al., 1997) and human pathogenic fungi (Watts et al., 1998), but due to the complex nature of fungal growth control, it is still relatively poorly understood. Current hypotheses regarding the control of thigmotropism centre on stretch-activated calcium channels which are located in the fungal cell membrane and react to its deformation (Silverman-Gavrila and Lew, 2002). However, the positioning and specific mode of action of these Ca²⁺ channels is the subject of some debate. To try to elucidate some of the mechanisms behind thigmotropic control we have developed a method to quantify contour sensing in complex hyphal systems. We created a chemically inert ridged surface that was surrounded by nutrient agar and inoculated with the ubiquitous soil fungus *Aspergillus niger*, which subsequently colonized the etched slide. This separation of the experimental substrate from the nutrient source was important in eliminating potential interference from chemotropic influences. Using imaging software we calculated two important parameters:

1. Hyphal deflections away from ridges (thigmotropic behaviour)
2. Hyphae crossing over ridges without deviation (no thigmotropism)

The ratio between these two simple factors provided an approximate index of the degree of contour-following behaviour exhibited in any given area of the fungal colony. After applying this method to sections of the fungal colony we found that the strength of the thigmotropic response appeared to be dependent upon the level of nutrient availability or colony development: as contour sensing decreased as the fungus penetrated further onto the etched slide. We also observed that the intensity of contour-sensing varied depending on the area of the hyphal tip which initiated contact. We suggest that this may be due to the fluid nature of the immature hyphal tip and its inability to transmit stretch information via the calcium channels. We have used cryo-scanning electron microscopy to visualize the profile of *A. niger* hyphal tips and used these images to estimate the dimensions of this sensory “blind spot”. These results contribute to a further understanding of hyphal growth control and tip maturation, as well as fungal colonization of solid substrates.