Microdevices based on microfluidics and MEMS (microelectromechanical systems) technology have been employed for numerous biological applications, thereby exploiting the possibility to create 3D structures with dimensions comparable to those of cells (few micrometers). Microdevices can be used to miniaturize laboratory functions (Lab-on-a-chip), and they offer the possibility of isolating or quantitatively measuring different aspects of a complex process, which is not necessarily possible in bulk plate assays. We developed an experimental platform with the specific aim to study tip growing cells, the TipChip. The device allows fluid-flow driven positioning of pollen grains or fungal spores at the entrances of serially arranged microchannels harboring microscopic experimental setups. The tip growing cells, pollen tubes, filamentous yeast or fungal hyphae, can be exposed to chemical gradients, microstructural features, integrated biosensors or directional triggers within the modular microchannels. We demonstrated that the device is compatible with high resolution Nomarski optics and fluorescence microscopy. Using this platform we were able to answer several outstanding questions on pollen tube growth. We established that unlike root hairs and fungal hyphae, pollen tubes do not have a directional memory. Furthermore, pollen tubes were found to be able to elongate in air raising the question how and where water is taken up by the cell. Finally, we quantified the invasive properties of pollen tubes. To reach its target in the in vivo situation, the pollen tube needs to exert significant penetrative forces. Using the TipChip we tested the pollen tube’s ability to navigate mechanical obstacles and to exert penetrative forces by guiding them through microscopic gaps made of elastic polydimethylsiloxane (PDMS) material. Based on the deformation of the gaps the invasive force exerted by the elongating tubes was determined using finite element methods.

Acknowledgement: This work was financed by a team grant from the Fonds Québécois de la Recherche sur la Nature et les Technologies (FQRNT) to AG and MP.