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Microtubule Transport on 3D Biocompatible Nanostructures

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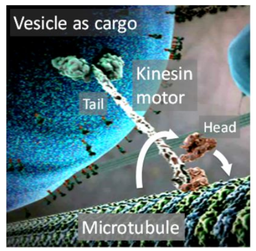
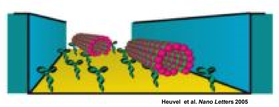
Introduction

- Microtubules (MTs) are cytoskeletal protein filaments that provide mechanical support for the cell, and serve as "tracks" for motor proteins to transport organelles
- Kinesin is a microtubule-based motor protein that "walks" along MTs by dissipating chemical energy, with a force of ~ 40pN nm and efficiency of ~ 50%[1]
- Kinesin-MT transport system has been used in many nanotechnological applications including biosensing[2], cargo transportation[3], and assembly of ring nanocomposites[4]





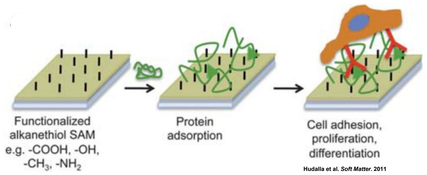
- MT guiding using lithographically nanostructured surfaces hinder MT motility and lead to MT loss[5]

Exploring alternative nanostructures is essential for reliable MT guiding

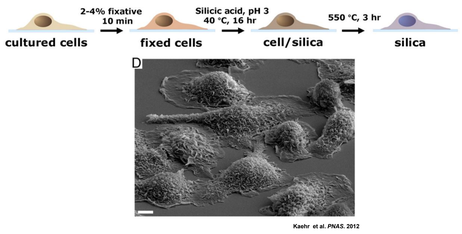
Cell patterning and preservation

- Self-assembled monolayers (SAMs) previously used to modulate cell adhesion and spreading, allowing for size and shape control of cell patterns

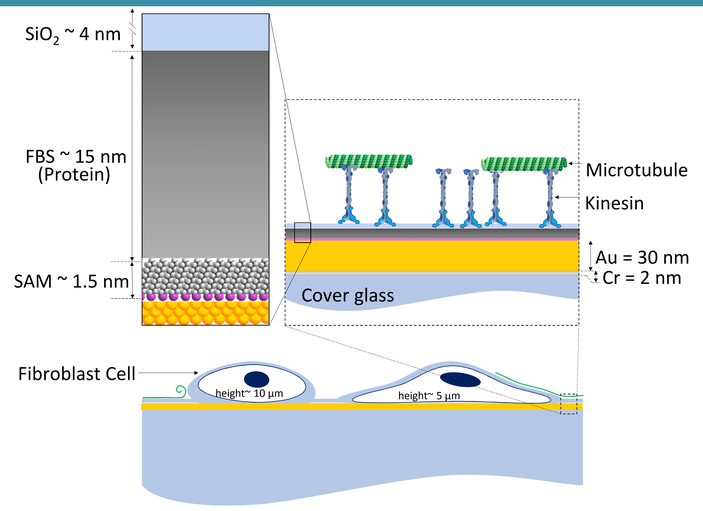
  Limitation: environmental conditions render cells unstable for long-term applications



- Preservation of cellular architecture through silicification process
  - Preserve user-defined 3D features
  - Provides simple alternative to specimen preparation and preservation (no expertise or specialized equipment needed)
  - Tolerate extreme environments

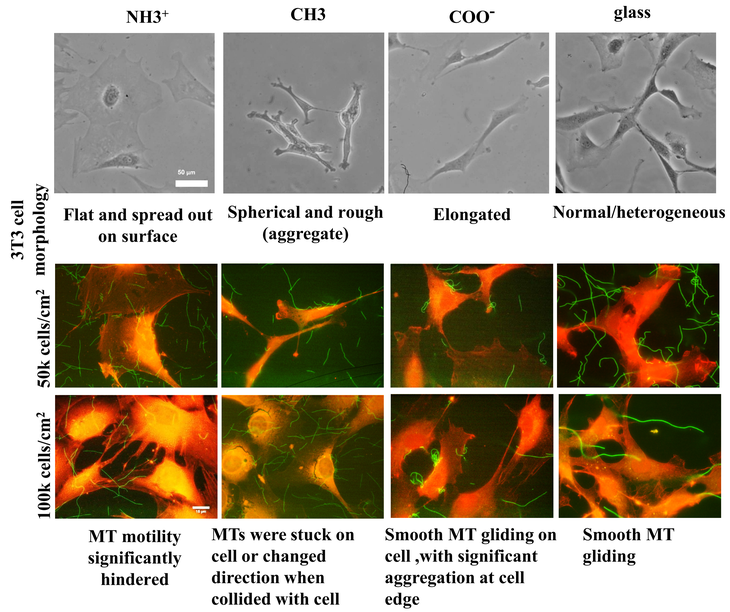


Approach

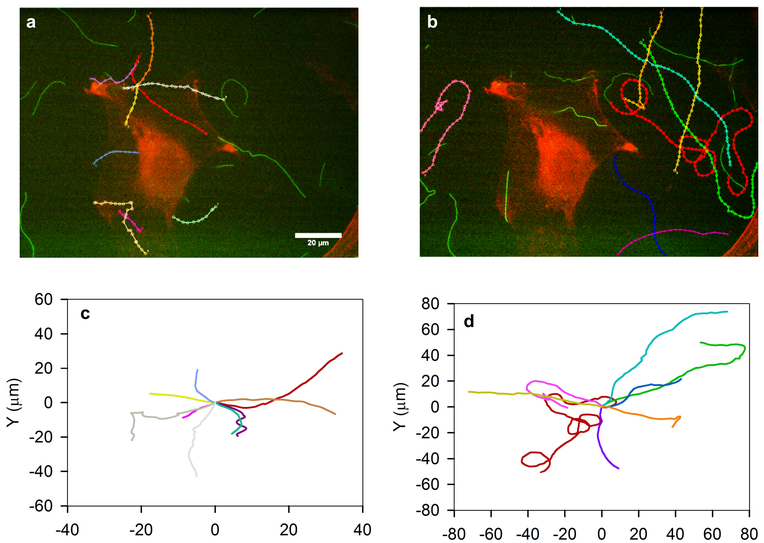


- Self-assembled monolayers (SAMs) with various functional groups are used to alter mammalian cell morphology
- Cells are preserved through silicification process, and used as 3D nanostructures to explore the behavior of kinesin-MT system

Effect of SAMs and cell confluency on morphology and MTs



Microtubule trajectories and velocity



- MT gliding trajectories were evaluated using carboxyl (COOH) terminated SAMs and low cell count (50k cells/cm^2)
- MT trajectories were linear on silicified cells (a,c), while curved trajectories were observed on silicified SAMs surface (b,d)
- Gliding velocity remained constant with an average of 1 µm/s, independent of surface

CONCLUSIONS

- We established a unique "bottom-up approach" by combining well-established techniques to generate preserved, 3D biocompatible structures dictated by SAMs and cell confluency
- Preliminary experiments show promising results of surface topographies influencing MT translocation
- Future experiments will provide insight into the development of applications involving Kinesin-MT transport on complex nanostructures

References:

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