

Mimicking Self-Assembly through VR game

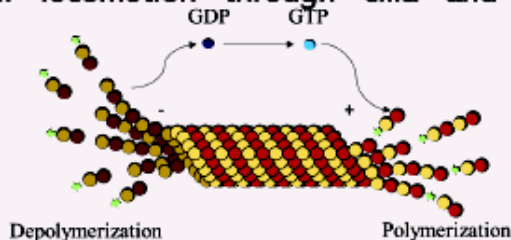
Wesley Witter^{1,3}, Sanjay Sarma O V^{2,3} and Ramana Pidaparti^{2,3}

Microtubules (MTs) are highly dynamic polymers distributed in the cytoplasm of a biological cell. MTs play a crucial role in many intracellular processes, predominantly in mitosis, organelle transport and cell locomotion. The intriguing intelligence behind these tiny machines resulting in complex self-organizing structures is mostly unexplored. In this study, we present a Virtual Reality game involving the self-organizing strategies demonstrating the behavior of MTs. We model the proteins agents and allow the player to strategize the assembly process for different scenarios arising in the cytoplasm of a cell, and record their behaviors. This pedagogic approach leverages molecular cell biology with virtual reality in STEM education.

Background

- Microtubules are complex networked protein structures responsible for many crucial intracellular processes in eukaryotic cells.
- These are highly dynamic polymers undergoing continuous polymerization and depolymerization.
- They resemble hollow cylinders with dimers arranged on its walls and are approximately 25 nm in diameter and have varying lengths.
- The building blocks of the tubules are heterodimers and each heterodimer has a pair of α and β tubulins.
- Microtubules are known to demonstrate complex organizations and intracellular functions by associating themselves with various MAPs. Some of these include chromosome separation during mitosis, organelle transport and cell locomotion through cilia and flagella.

Fig 1: Polymerization and depolymerization in microtubules controlled by GTPs and GDPs [1]



Give it a try?

Approach

Game Rules

- The game starts with a cannon holding α (red) or β (black) tubulins, generated at random.
- The player should shoot the tubulins, on to the cylindrical rotating silhouette in the space in front.
- An α tubulin can only go beside a β tubulin or a γ tubulin (yellow) and similarly for β tubulins.
- To start with, the player gets a γ (yellow) sphere placed in the silhouette.
- The spheres (α s and β s) fall off from the silhouette randomly (disassembly) and the player should plan to hold the structure as long as possible.
- Scores are based on the number of voids filled in the structure and how long the structure is held.

Results

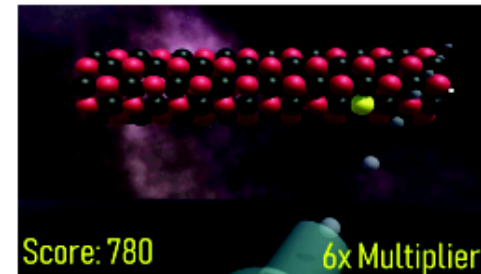
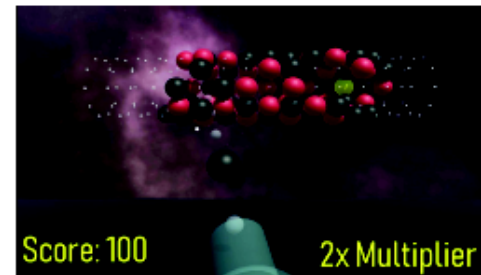
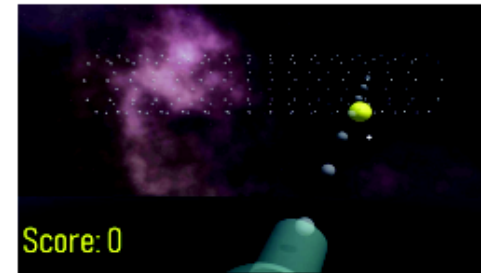


Fig 2: Snapshots of the MT assembly game on Google Daydream.

- In the future, we plan to add more features to the game from the observations in MT system.
- Currently we record the player actions and strategies and plan to train machine learning models, demonstrating intelligence in MT systems.

O. V., Sanjay S.; Palaparthi, Sruthi; Pidaparti, Ramana. 2019. "Mimicking Sub-Structures Self-Organization in Microtubules." *Biomimetics* 4, no. 4: 71.