

Initialize cells in simulation space

Propulsive forces ( $F_p$ )  
Elastic bending forces ( $F_b$ )  
Viscous drag ( $F_d$ )  
Slime reorientation forces ( $F_h$ )  
Re-orientation forces ( $F_r$ )  
Node restoration forces ( $F_a$ )  
Cell adhesion forces ( $F_{adh}$ )

Apply forces on nodes

Solve equations of motion using Box2D

Apply periodic boundary conditions

Quantify/visualize cell behavior

### Internal steps in physics engine

- Accumulate forces on nodes
- Integrate equations of motion

$$\mathbf{v}_{t+1} = \frac{\mathbf{F}}{m} \delta t + \mathbf{v}_t$$

$$\boldsymbol{\omega}_{t+1} = \frac{\boldsymbol{\tau}}{I} \delta t + \boldsymbol{\omega}_t$$

$$\mathbf{x}_{t+1} = \mathbf{v} \delta t + \mathbf{x}_t$$

- Correct for constraints on nodes
- Check for colliding nodes
- Apply collision resolving forces
- Correct  $(\mathbf{x}, \mathbf{v}, \boldsymbol{\omega})$  for collision forces