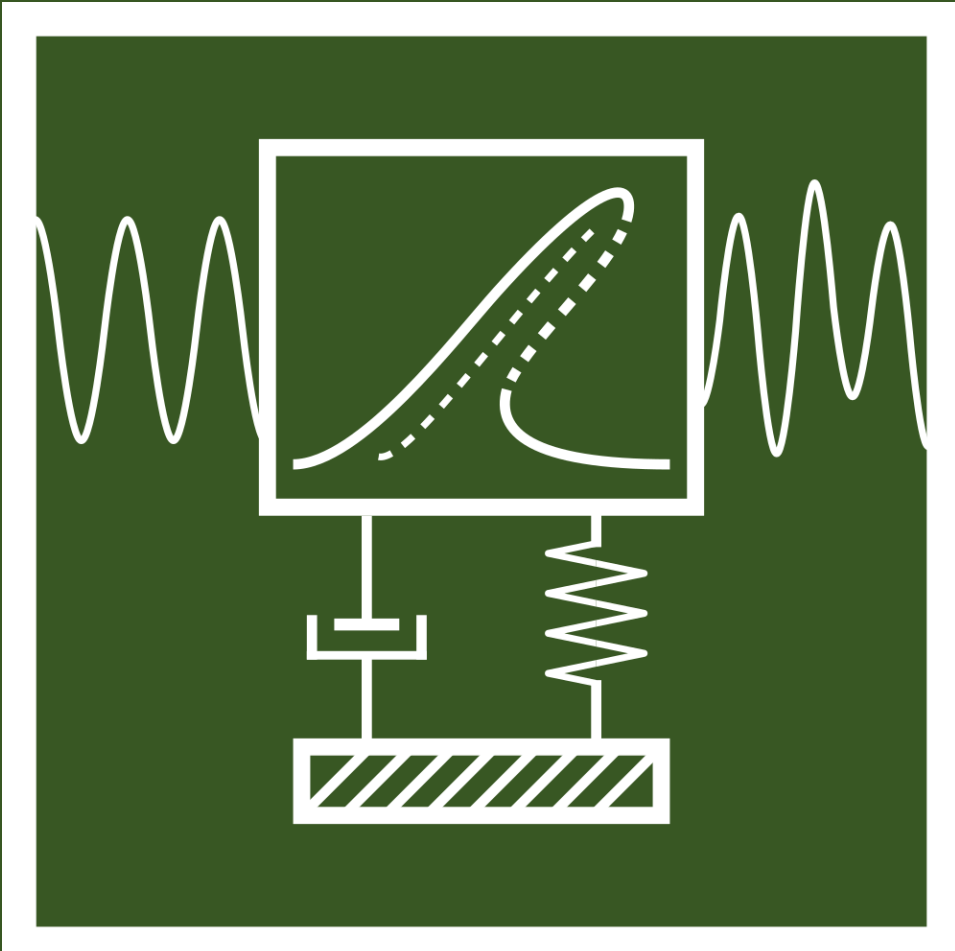


Numerical investigation of a mitochondria-inspired passive micromixer for enhanced mixing

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A Abstract

- Developed a mitochondria-inspired passive micromixer using cristae-like baffles and granule-inspired micropillars to enhance mixing without external energy.
- Compared four configurations: a conventional T-channel and T-channels with single, double, and triple cristae matrices.
- COMSOL simulations coupled Laminar Flow and Transport of Diluted Species for $Re = 0.1$ –100.
- The triple-cristae design achieved the best performance, with $MI = 95.85\%$ at $Re = 0.1$ and 85.84% at $Re = 100$.

01 Methods

- Cristae-like baffles and circular micropillars were integrated into a T-channel; single-, double-, and triple-cristae configurations were compared with the baseline T-channel.
- Simulations were performed at $Re = 0.1, 1, 10, 25, 50$, and 100 , with inlet concentrations of 0 and 1 and a diffusion coefficient of $10^{-9} \text{ m}^2/\text{s}$.
- Mixing performance was quantified using the mixing index at the outlet and along the channel, together with pressure-drop and figure-of-merit analyses.

02 Results

- Cristae-equipped channels produced substantially greater interfacial deformation, transverse transport, and concentration uniformity than the conventional T-channel. The triple-cristae design consistently provided the highest mixing, reaching approximately 95.86% at $Re = 0.1$ and 85.84% at $Re = 100$.
- Mixing decreased from very low to intermediate Re , then increased again at higher Re as geometry-driven advection became dominant.
- Increasing cristae density improved mixing but also increased pressure drop; the single-cristae design had the highest figure of merit.

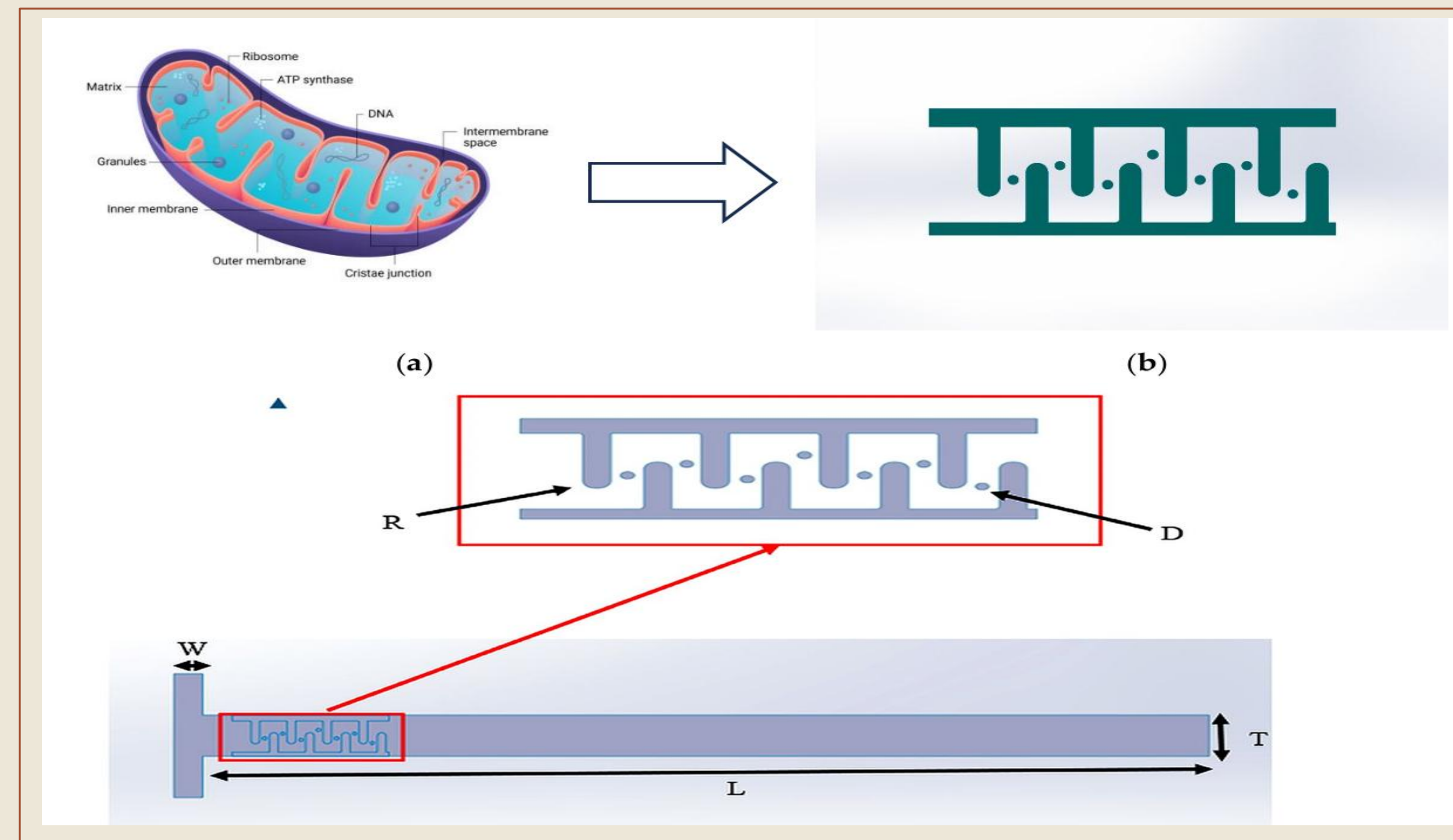


Fig 1. Cristae inspired Micromixer design

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03 Discussion

- Mixing is diffusion-dominated at low Re , while cristae-induced advection becomes stronger at higher Re , improving mixing.
- Higher cristae density enhances mixing but increases pressure drop, creating a performance–hydraulic cost trade-off.

04 Conclusions

- Cristae-inspired structures significantly improve mixing uniformity and transverse transport compared with a conventional T-channel.
- The Mito-mixer provides an effective compact passive-mixing strategy across a broad Reynolds-number range.

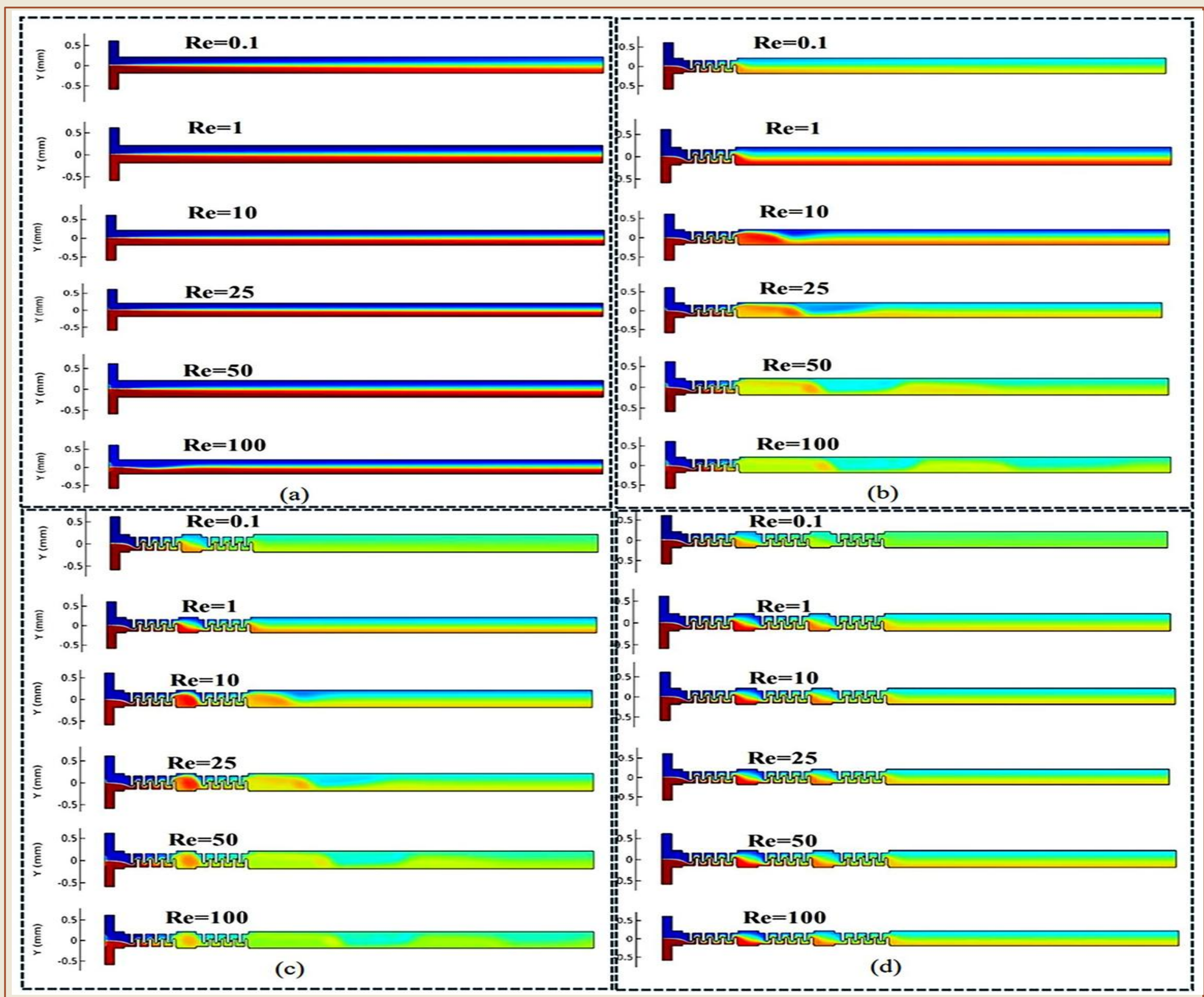


Fig 2. Simulation Results for different configuration at $Re=0.1$ -100

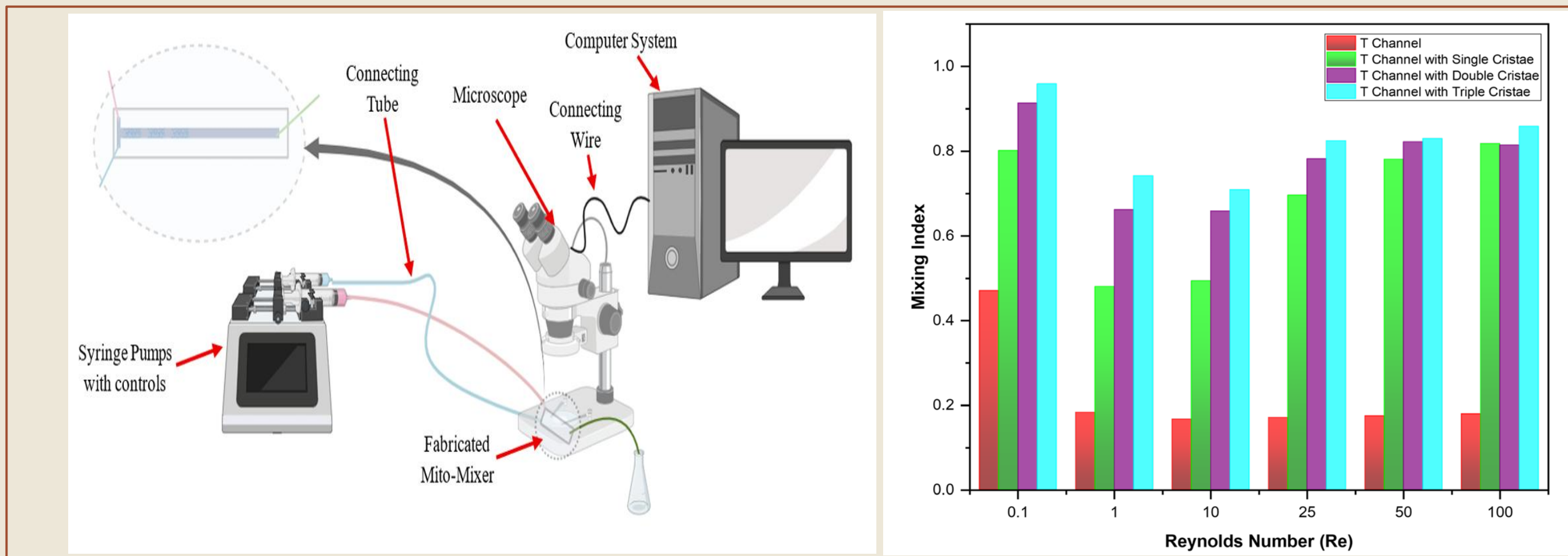


Fig 3. Proposed Experimental Setup and Simulation results

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