Integration of FRAP experiments and simulations of diffusion in the lumen and on the surface of the Endoplasmic Reticulum

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We present simulations of isotropic and anisotropic diffusion in real three-dimensional geometries of the lumen and the surface of the Endoplasmic Reticulum as reconstructed from micrographs.

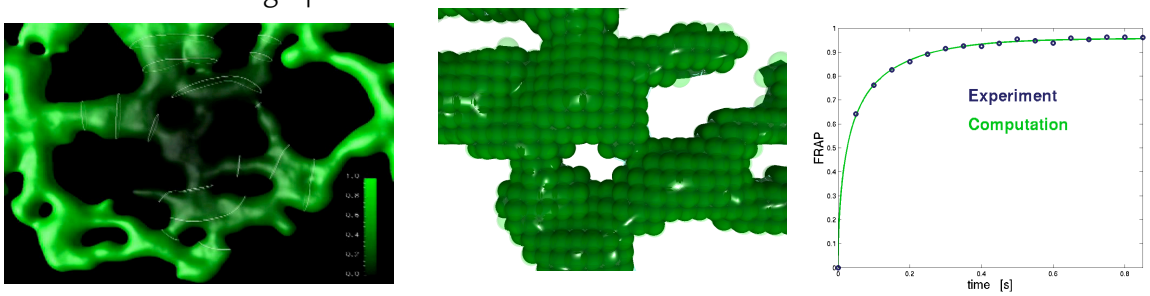

FIGURE : FRAP simulations on the surface of the Endoplasmic Reticulum (left) .The computational elements adapt to resolve the complex geometry (middle) . Diffusion estimations taking geometry into account (right).

A novel computational method integrates imaging and simulations in complex geometries. The proposed method is second order accurate in space and time and is capable of handling surfaces of high curvature and complex shape, that are often encountered in biology. We present detailed simulations of diffusion in the lumen and on the membrane of Endoplasmic Reticula (ER) in live cells. Simulations of (an)isotropic diffusion are conducted on geometries reconstructed from real ER samples and are compared to Fluorescence Recovery After Photobleaching (FRAP) experiments in the same ER samples. Such comparisons allow derivation of geometry-corrected molecular diffusion constants for membrane components from FRAP data.

The results of the simulations indicate that the diffusion behavior is strongly affected by the geometry of the lumen and the surface and that it is imperative to consider the geometry of the domain when deriving diffusion constants in biological organelles. The present results indicate that current diffusion constants are up to 500% underestimated due to ignoring the geometry of the organelles.

References

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