# Computational Nanomedicine: challenges and opportunities in the rational design of polymeric nanoconstructs

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Over the past decade, multiple nanosystems have been developed for the diagnosis, imaging, and therapy of deadly diseases, such as cancer, cardiovascular and neurodegenerative.[1] These include nanoconstructs; microfluidic chips; nano-sensors and actuators for medical devices; hierarchical scaffolds in tissue engineering. The majority of these nanosystems have been developed following empirical approaches, while the notion of rationally designing them has been only recently realized.[2] The use of computational modeling would certainly help in optimizing the *in vitro* and *in vivo* performance of such nanosystems.

Nanoconstructs for the systemic delivery of therapeutic and imaging agents have been mostly demonstrated in pre-clinical studies. As compared to freely administered molecules, nanoconstructs-loaded agents – nanomedicines – exhibit improved bioavailability and blood longevity; better protection from enzymatic degradation; higher accumulation and controlled release at the biological target. Despite all these advantages, nanomedicines are yet to be fully integrated into clinical settings. Computational modeling, which in this case could be defined as *Computational Nanomedicine*, can help in addressing major challenges in facilitating the clinical integration of nanoconstructs.[2]

Multi-scale and multi-physics *in silico* approaches for modeling tumor growth, vascular transport and adhesion, and diffusion of nanoconstructs and molecules will be reviewed. This will include continuous finite element models for predicting the progression and response to therapies of tumor masses; the Isogeometric Analysis for describing and predicting the vascular transport and adhesion of nanoconstructs in complex blood vessel networks; the Immersed Finite Element Method and Lattice Boltzmann Method for analyzing the vascular and extravascular dynamics of nanoconstructs in microcapillaries; and Molecular Dynamics simulations for predicting the diffusion of water molecules within porous matrices. Finally, *in vitro* and *in vivo* data will be presented to describe the experimental tools currently available for validating and refining the predictions of computational models.[3]

Limitations and challenges will be exposed for each approach together with opportunities for computational scientists to develop novel techniques for solving relevant problems in nanomedicine.

## ESSENTIAL REFERENCES

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