Institut de Bioenginyeria de Catalunya

COLLABORATIVE IBEC INTERNATIONAL PhD PROGRAMME

Position

1. Project Title:
   Radioisotope-Powered Nanobots for Bladder Cancer Therapy

2. Research project/ Research Group description

Nanobots are emerging as revolutionary nanosystems in cancer therapy, offering unparalleled precision and efficiency in overcoming the limitations of traditional treatments. Recent advancements, such as **Simo, Serra et al. (Nature Nanotech., 2024)**, have demonstrated their potential for site-specific delivery and enhanced therapeutic efficacy. These self-propelled nanosystems can navigate complex biological environments, providing precise targeting, controlled drug release, and improved therapeutic outcomes. By integrating propulsion mechanisms with functionalized nanomaterials, nanobots address challenges such as treatment resistance, systemic toxicity, and off-target effects, marking a new era in precision oncology.

Bladder cancer, a common malignancy with high recurrence rates, highlights the need for innovative therapeutic strategies. Current treatments, such as chemotherapy and immunotherapy, often suffer from limited targeting, systemic side effects, and the bladder's protective urothelial barrier. Radioisotopes like lutetium and actinium hold great promise for targeted radiotherapy due to their potent cytotoxicity and localized action. Combining these isotopes with nanobots represents a novel approach to delivering radiotherapeutics directly to tumour sites, minimizing systemic exposure and maximizing therapeutic impact.

This PhD project builds on **Simo, Serra et al.**, aiming to develop radioisotope-powered nanobots for bladder cancer therapy. The student will functionalize nanoparticle surfaces with chelators to form stable complexes with radiometals such as ^{177}Lu and ^{225}Ac securely, ensuring stability and controlled release to the tumour tissue. In parallel, the student will optimize nanobot propulsion and investigate the co-delivery of small molecules, focusing on pharmacology, dose optimization, and synergistic effects with radionuclide therapy. Comprehensive evaluations will include in vitro bladder cancer models and in vivo preclinical studies to assess efficacy and safety.

The project will be conducted collaboratively between **Prof. Sánchez group at IBEC**, pioneers in nanobot design and biomedical applications, and the **Dr. Llop group at CIC biomaGUNE**, experts in radiochemistry, chelation strategies, molecular imaging and theranostic applications. Together, these groups offer a multidisciplinary platform to advance cutting-edge nanomedicine solutions for bladder cancer treatment.

3. Job position description

This PhD project focuses on developing advanced nanobots for bladder cancer therapy by integrating radioisotopes like ^{177}Lu (beta emitter) and ^{225}Ac (alpha emitter) into innovative nanosystems. Building on **Simo, Serra et al. (Nature Nanotech., 2024)**, the research will explore the potential of nanobots as transformative tools for precise, localized cancer treatment. The project combines nanoparticle functionalization, multi-modal drug delivery, and preclinical evaluation, bridging nanotechnology and oncology to address unmet clinical needs.

The work will be conducted jointly by the **Samuel Sánchez group at IBEC**, experts in nanobot design and propulsion, and the **Jordi Llop group at CIC biomaGUNE**, leaders in radiochemistry and molecular imaging. This collaboration provides a strong multidisciplinary framework for developing and validating innovative nanomedicine strategies.

Objectives:

1. **Nanobot Design and Functionalization**
   The candidate will functionalize nanobot surfaces with chelators for secure binding of radioisotopes like ^{177}Lu and ^{225}Ac. The focus will be on ensuring isotope stability and robust propulsion in biologically relevant environments.

2. **Development of Multi-Modal Therapeutic Systems**
   The candidate will optimize nanobots for the delivery of small molecules at the tumour site, to achieve combined therapeutic and radiotherapeutic effects. This includes studying drug loading techniques, pharmacological dosing., and investigating potential synergistic effects to maximize therapeutic outcomes.

3. **Preclinical Evaluation**
   The nanobots will be evaluated in vitro using bladder cancer models and in vivo in orthotopic mouse models of bladder cancer. The candidate will assess tumour targeting capacity using in vivo nuclear imaging, therapeutic efficacy using the different therapeutic radionuclides, and potential side effects through advanced imaging and molecular analyses.

Impact:

This project aims to establish nanobots as a novel platform for bladder cancer therapy, offering precise, localized treatments with minimal off-target effects. The candidate will gain expertise in nanotechnology, radiochemistry, and preclinical oncology, contributing to advancements in precision cancer therapeutics.

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