Nanotechnology is a rapidly evolving field with immense potential in various scientific and medical applications. Objects within the nanoscale range, typically ranging from 1 to 100 nm, have garnered significant attention due to their unique physical and chemical properties compared to their macroscopic counterparts. These nanomaterials exhibit capabilities such as overcoming biological barriers and possessing distinctive optical and magnetic properties, making them versatile tools in biomedical diagnostics and therapy.

Among the wide array of nanomaterials utilized in biomedicine, nanoparticles composed of metals or metal oxides, such as silver, gold, copper, iron oxides, are particularly prominent. Additionally, lipid-based nanoparticles like liposomes and micelles, as well as carbon-based materials including graphene, carbon nanotubes, and fullerenes, are extensively studied. Research efforts are focused on developing novel nanostructures and exploring their potential applications, alongside assessing their impact on human health and potential risks.

An ideal approach involves the development of multifunctional nanomaterials capable of both diagnostics and therapy, known as theranostic nanoparticles. Therefore, there is a search for nanomaterials that are multifunctional, efficient, cost-effective to produce, biocompatible, and exhibit minimal cytotoxicity in biological systems. One promising candidate is the emerging class of up-converting nanoparticles (UCNPs).

UCNPs are luminescent nanomaterials doped with lanthanide ions, possess unique optical properties allowing them to convert lower-energy radiation, such as near-infrared (NIR) light, into higher-energy emissions, such as ultraviolet (UV) or visible (VIS) light. This optical phenomenon is characteristic of lanthanide compounds, which naturally emit luminescence upon excitation with NIR light at a wavelength of 980 nm. UCNPs also offer advantages such as relatively low cytotoxicity, excellent photo-stability, and resistance to photo-bleaching. Furthermore, the choice of dopant ions influences the emitted light colour or imparts magnetic properties to the nanoparticles, enabling their use in multimodal imaging.

Multimodal imaging combines different imaging techniques, such as optical and magnetic resonance imaging, to enhance diagnostic accuracy and provide comprehensive insights into the studied subject. The most intriguing aspect is the potential utilization of the chemical composition of UCNPs for multimodal imaging, leveraging their natural ability for photoluminescent imaging while also employing nuclear medicine techniques (PET and SPECT) for detect radioactivity. These innovative structures are referred to as nano-radiopharmaceuticals and can be employed in theranostic medicine, simultaneously serving diagnostic and therapeutic purposes.

**The primary objective of the proposed project is to develop and synthesize novel nano-radiopharmaceuticals for theranostic applications. These tools will be based on a new generation of up-converting nanoparticles radiolabelled with diagnostic and therapeutic radionuclides.**

To date, there have been limited attempts at radiolabelling UCNPs with radioisotopes. These primarily involved raidolabelling with diagnostic isotopes such as $^{64}$Cu, $^{68}$Ga, $^{99}$mTc, $^{18}$F, and $^{124}$I, as well as therapeutic isotopes like $^{177}$Lu, $^{90}$Y, $^{153}$Sm, and $^{125}$I. Most of these radioisotopes were attached to UCNPs through surface adsorption or using a metallic chelator. The proposed radioisotope radiolabelling method will involve incorporating the natural component of UCNPs, yttrium (Y), in the form of its two radioisotopes: therapeutic Y-90 and diagnostic Y-86, into the core or shell of the obtained nanoparticles.