Light-activatable (nano)materials for cell regulation

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Nanomaterials are an emerging platform to control the activity of endogenous stem cells [1, 2]. These nanomaterials can be fabricated from a wide variety of components, including polymers, lipids and metals [3-5]. Because of their small size, surface chemistry for cell targeting, the possibility of remote activation, the chance of encapsulate both hydrophilic or hydrophobic molecules while protecting them during their circulation in the body, these nanomaterials are very promising for the control of (stem) cell activity. These nanomaterials may be used to replace viral vectors for gene edition and therapy, and thus preventing undesired side effects.

In case of stem cell niches spatially well defined, nanomaterials can be administered directly into the niche. This is the case of the subventricular zone niche located in the brain that hosts an important niche of neural stem cells. In this case, formulations may be administered by intracerebroventricular/intracerebral infusion [6]. This strategy increases the success of targeting, maximizing the amount of bioactive agent that reaches the stem cells. However, in most cases, the stem cell niche is not spatially well defined. For example, the hematopoietic stem cell niche is located in the bone marrow within the human body. In this case, the nanomaterials are administered systemically (alone or conjugated to stem cells [7, 8]) to access the stem cell niche. Alternatively, the nanomaterials should have components (e.g. ligands or antibodies) or properties (e.g. plasmonic activity) in their surface to overcome the multiple barriers in the human body and finally target the stem cell niche. After stem cell targeting, the nanomaterials need to overcome the endolysomal compartment and reach the cell cytoplasm.

An attractive possibility to facilitate the targeting of the formulations to the stem cell niche is by the use of external stimuli. In this case, nanomaterials respond to magnetic forces, light, or ultrasounds and release the cargo with spatio-temporal control. The use of external stimuli may improve significantly the therapeutic effect of the formulations in the stem cell niches. In addition, the nanomaterials may open biological barriers. For example, the thermal energy generated by magnetic heating of magnetic nanoparticles may increase BBB permeability [9]. During my talk, I will present our latest results in the use of light-activatable nanomaterials to regulate cell activity and cross biological barriers.

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