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Nanotechnology and Stem Cell an Integrated Advancement

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STEM CELL

Nanotechnology and stem cell sciences are two of the contemporary and most prominent areas of research with major contributions towards the improvement of human health. While Stem Cells (SC) contain significant prospects for rejuvenating medicinal moieties, however, their applications have been restricted by the lack of effective ways to monitor the differentiation and long duration of engrafted cells or tissues in-vivo. It is claimed that by integrating the two exciting fields of study, nanotechnology, and SC, our knowledge about the differentiation of SCs regulation will significantly advance, which in turn will potentially lead to SC-based treatment strategies for better understanding of human disease, and their prevention, and treatment.

Nanotechnology-based methods have been developed by utilizing non-toxic and biodegradable nano-holds/nano-fibers such as collagen nanofiber, carbon nanofiber, Graphene-Oxide Nanoparticles (GO-NPs), poly-ε-caprolactone, Tri-$CaPSO_4$ (Tricalcium phosphate), tri-Ca-silicate and auto-assembled peptide, for the stem cells differentiation and regeneration therapy. Superparamagnetic-iron-oxide (Fe_3O_4) NPs could be applied for the labeling of grafted cells and studied by Magnetic-Resonance-Imaging (MRI). Polymer-based scaffolds like heparin-hydroxyl-apatite chitosan NPs (CNPs), PLGA-nano-hydroxyapatite, and chitosan-based imageable NPs have significantly helped in the differentiation, tagging, and monitoring of different kinds of SC, mainly hMSCs. Another new technique in stem cell nanotechnology is nano-patterning. In the absence of specific media or chemical checks, nanopatterned coats or forms may be employed to the better direct attachment, spreading, auto-renewal, and led differentiation of pluripotent stem cells.Studies have demonstrated that therapeutic cells are predicting transmitters in the active directed drug delivery. Drug-NPs coats of therapeutic cells provide novel avenues in SC therapies to enhance the clinical efficacy of the transferred cells. In any SC therapy, we should be capable to study the delivery of mobes (cells) and monitor their distribution to their biological targets. Hence, it is significant to formulate NPs with special surface applications to ameliorate uptake and long-run monitoring of stem cells without involving their increment.

Previously numerous studies have reported the therapeutic uses of embryonic SCs (ESCs) for the therapy of crippling inherited, painful and degenerative disorders, and the development of progenitor cells has been reported within-vivo reconstitution properties. Non-invasive efficient imaging of grafted cells to control biodistribution (*in-vivo* tracking) is a significant obstacle to the therapeutic applications of these pluripotent cells. Besides, reproducible strategies should be established that allow efficient intracellular distribution of biomolecules necessary to regulate ES cell differentiation, including RNA, DNA, peptides, and proteins.

Physical techniques like nucleofection and electroporation give the benefit of high performance in transmission, but also inflict significant harm to ES cells. In-vitro results with viral vectors, considering retro-lenti- and adenoviruses showed the effective transfection and reproducible handling of ESC differentiation. The chance of toxicity accelerated mutagenesis, and immunogenicity, however, greatly reduces the therapeutic feasibility for the clinical field of these viral vectors. Consequently, as being the most exciting nanotechnology medium, non-viral vectors including liposomes and polymeric NPs are presently explored to transform promising laboratory results with ESCs into real-time clinical applications. No. 5 generations polyamidamine dendrimer-functionalized fluorescent multi-walled nanotubes of carbon (dMNTs-C) is highly effective in penetrating the CCE embryonic stem cell line in mice. When the incubation time increases, it can reduce cell proliferation in a dose- and time-dependent manner and less than 5 μg/mL dose will boost the distinction of embryonic stem cells. A dose of more than 20 μg/ml will cause embryonic stem cells to get narrower. Dendrimers, a new and unique type of organic molecules, through a sequence of chemical changes, can take various functional groups, and their inner body cavities provide depot facilities for several genes and drugs.

Dendrimers could be a successful non-viral transmission vector as, compared to viral vectors which are more unsafe for therapeutic use, they have the benefits of ease of application and bulk production. Dendrimer-modified MNPs of Polyamidoamine (PAMAM) have been reported to dramatically increase the gene delivery efficacy. The dMNTs could be an extremely expeditious form of gene transmission for ESCs and may have possible applications in ES science. NPs like MNPs and QDs are capable to

enter into the human MSC cells and can sustain within ES cells for a longer time. Previously, it has been reported that SiO_2 coated CdTe nanoparticles could join Murine Stem Cells (MSCs) and sustain inside these induced-differentiated cells of the neurons, hematopoietic cells, and endothelial cells, showing no cytotoxicity within the concentration used. It can be easily demonstrated that teratomas consisting of tissues of all three primary germ strata were produced by such grafted stem cells with MNPs. Recently, a biological delivery method to transfer genes into living cells was developed using nanoneedle and Atomic Force Microscopy (AFM). A less-invasive method of gene delivery using etched AFM tip or nanoneedle for nucleus injection without inducing cellular injuries was identified by Han et al. The nano-needle had a 200 nm diameter with 6 μm length and was operated by utilizing an AFM device. The likelihood of nanoneedle can incorporate human MSCs and Human embryonic kidney cells (HEK293) were greater than that of the capillaries used for microinjection. On a poly-L-lysine-altered nanoneedle base, inserted into the single human MSCs (primary cultured), a plasmid containing the Green Fluorescent Protein (GFP) gene was observed. In human MSCs, over 70% of effective gene delivery was achieved, which contrasted more favorably with other methods of non-viral gene delivery.