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Stressed Cells Survive Better with Light

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Biostimulatory effects achieved in various biosystems irradiated with light lead us to recommend photobiostimulation for the compensation of external stress stimuli in tissue engineering, as well as in cellular imaging. Bioengineered cell assemblies and tissues are exposed to extreme environmental stress states during their transfer from artificial milieus into the body and in the first phase of their implantation. Similarly, cellular imaging via optical methods could represent a major stress impact to the biosystems examined, in particular, in temporally extended investigations. In both cases, an elevated and gradually proceeding environmental stress would inhibit cellular functions and enhance cell death. In the first case, this could practically neutralize the therapeutic success, and in the second, it could limit the possible period of observation of extracellular and intracellular processes, and influence the physiological timescales. Thus, novel methods designed to prevent cell death, even for short times, are of vital interest—in cellular imaging, as well as in tissue bioengineering. To secure an effective protection of different cell types in vitro, and in various body tissues in vivo, the methods must be as nonspecific as possible. Here, we propose Low Intensity Light Activated Biostimulation[1] (LILAB) as a protective tool for both biomedical applications. LILAB operates at nonthermal energy densities, usually in the $(1-4) \times 10^4$ J m^{-2} range. Such moderate energy densities have been observed to effectively ameliorate the vitality level of a large body of stress-exposed cells, in vitro and in vivo. For cells irradiated in vitro, biostimulatory effects have been reported at doses as low as 0.5×10^4 J m^{-2}.[2] The biomedical applications, so far, reach from accelerated wound healing processes[3] to nerve tissue recovery,[4] including strategies to counteract the severe biological imbalances experienced by astronauts in microgravity (e.g., muscle and bone atrophy), and additional photostimulation during noninvasive cellular imaging (e.g., in near-field optical analysis).[5] In the majority of biosystems, reproducible biostimulatory effects required, apart from homogeneous light energy densities in the $(1-4) \times 10^4$ J m^{-2} range, a minimum light intensity of the order of the solar constant ($I_S \approx 1000$ W m^{-2}) for linearly polarized white light[6] and of about $I_S/50$ for monochromatic laser irradiation, depending on the particular wavelength. Biostimulatory effects could require an adjustment of the dose to the spectral distribution or the light wavelength, repectively.[1] The beneficial administration of $(1-4) \times 10^4$ J m^{-2} and the primary importance of intensity thresholds[1] has been verified in vitro and in vivo in as different biosystems as fibroblasts, keratinocytes, osteoblasts, neurons, retinal receptor cells, heart cells, sperm, and, recently, in cultured nanobacteria.[6] Depending on the nature of the target cells, clearly visible improvements of clinical relevance could be realized in three days (e.g., in wound healing) or in three months (e.g., in the treatment of the severe, painful peripheral neuropathy associated with burning feet syndrome).[7] LILAB, a nonspecific cell-protective method, suggests itself for both tissue bioengineering and cellular imaging. LILAB has been demonstrated to increase the survival rate of heart cells under ischemic conditions as a result of an increased mitochondrial capability, ATP production, and an induction of heat shock proteins (protective proteins), as shown in the ischemic heart.[8] LILAB could be of prime significance in the overall field of tissue engineering, where the maximal survival of the cells is vital following their implantation into the targeted site of the body. Presently, clinical successes involving cell transplantation have been partly limited due to the poor survival of donor cells. The ability to significantly increase (5-fold) the total antioxidant content in cells by LILAB[9] offers a potentially powerful treatment for the cells prior or parallel to their analysis and implantation.

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