Actual and Simulated Microgravity Offer Unique and Useful Mechanical Conditions for Mammalian Tissue Culture

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In the 1980's NASA undertook a program to utilize the unique conditions of microgravity to investigate the possibility for enhanced culture of delicate primary mammalian cells. Analysis indicated that bioreactors operated in Space would exhibit an enhanced combination of low hydro-mechanical stress and high mass transport, beyond that achievable on Earth, and enable very high density cultures of very delicate cells. Pharmaceutical production was the targeted application. During development of this "Space Bioreactor" a method of simulating the conditions expected in Space was discovered and utilized for Earth based pre-flight studies. These techniques are based on a zero head-space horizontally rotating cylindrical culture vessel with methods to control the media dissolved gas and biochemical environment. In testing it was indeed possible to culture high densities of delicate primary cells but observations of the cultured tissue morphology were deemed more important in that they were recapitulating the structure of natural in-vivo tissue. Studies demonstrated that substrate matrixes, mesenchymal feeder layers, and epithelial tissue were able to organize as co-cultures and biochemically perform similarly to their in-vivo counterparts. The program was expanded to include specialists representing a range of normal primary, transformed cell lines, and cancerous tissues. Most cases produced similar results producing high quality in-vitro tissue recapitulating in-vivo counterparts. The physical-mechanical interaction of cells and substrates has become a key theme in tissue engineering. The unique mechanics of simulated and actual microgravity tissue culture, leading to these results, and several representative tissue models, will be presented. A range of tissue culture based applications may be enhanced, or even enabled, by controlled gravity methods. Testing in the actual microgravity of Space and simulated microgravity indicates the possibility of further progression of enhanced culture characteristics as well as a tool for elucidating mechanisms responsible for the mechanical sensitivity of cell interactions in tissues and tissue formation.