BIOMATERIALS IN REGENERATIVE MEDICINE: VIEW OF THE PAST & VISION FOR THE FUTURE

CHARLES JAMES KIRKPATRICK[1,2]

[1] EMERITUS PROFESSOR OF PATHOLOGY,
JOHANNES GUTENBERG UNIVERSITY, MAINZ, GERMANY
[2] DISTINGUISHED VISITING FELLOW, ST. JOHN'S COLLEGE,
CAMBRIDGE UNIVERSITY, UK

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Abstract

In the past two decades, the fields of Tissue Engineering (TE) and Regenerative Medicine (RegMed) have received important input from advances in stem cell research as well as in the biomaterial sciences, including new developments in composite materials and interactive polymer systems. In the latter, for example, biodegradable scaffolds and hydrogels can mimic essential characteristics of the extracellular matrix (ECM), which is the microenvironment of cells in their natural state in situ. Being able to simulate such cell-cell and cell-matrix interactions in vitro is important not only for testing new biomaterials, but also for understanding regenerative mechanisms after implantation. However, this is far from a trivial challenge, although it can be usefully assisted by employing co-culture models in three dimensions. The situation becomes even more complex, when novel biomaterials and strategies for regeneration are investigated in vivo. Testing in animals introduces namely a complexity which makes mechanistic interpretation of observations exceedingly difficult, if not impossible. Moreover, in the past the accepted norms in testing have generally involved, for example, implantation in healthy animals, although in reality most patients receive a biomaterial for a disease state. Thus, for in vivo models there is an acute need to develop relevant models of disease. Future developments must also address the challenges of understanding the effects of, for example, ageing, multi-morbidity and medication on tissue reactions at the implant interface. Such multifactorial considerations play a special role in the case of cancer patients.

In the future, biomaterials and TE & RegMed will be increasingly influenced by the broadening interface with biotechnology. The latter is so vast that it is difficult to put its elements into a single presentation slide which an audience could read without binoculars and a prolonged time slot! However, the COVID-19 pandemic has focussed attention on the power of mRNA technology in modulating the body's immune system. It remains to be established how this technology could be adapted to control unwanted reactions at specific sites, for example, at a tissue-biomaterial interface. Returning to biotechnology as a driver of future progress, it seems highly likely that both major scientific branches of biomaterials, namely the materials sciences and the life sciences, will receive transforming impulses from advances in biotechnology. Fields such as artificial intelligence, green technology, robotics and nanotechnology underline just how diverse biotechnology is. In addition, this diversity stresses the essential role of interdisciplinarity and its implications for university teaching for future generations of materials and life scientists.