Bioactive Glasses as Versatile Building Blocks for Tissue Engineering, Bioprinting, and Ionic Medicine

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Since Professor Larry Hench discovered bioactive glass (BG) more than 50 years ago, the field has expanded considerably, evolving from silicate systems used as bone replacement materials to novel BG compositions for advanced biomedical applications, including tissue engineering (TE), drug delivery, biofabrication, and, more recently, the emerging field of ionic medicine. The success of BGs in these applications is related to their high and controllable surface bioreactivity: important cellular responses can be modulated through the controlled release of ionic dissolution products from BGs.
Following a broad introduction to the field of bioactive glasses, including their compositions, types, and morphologies, this presentation will demonstrate how BGs support osteogenesis by stimulating bone-forming cells through ionic products released during BG dissolution.
Moreover, angiogenesis, an essential process in which new blood vessels form from pre-existing vasculature, can also be modulated by ions released from BGs, leading to applications in soft tissue engineering and wound healing.
A special class of BGs, namely sol-gel-derived mesoporous bioactive glass nanoparticles (MBGNs), will also be discussed. These materials are capable of simultaneously releasing biomolecules and therapeutic ions, thereby achieving synergistic effects.
In the final part of the presentation, applications of ion-releasing MBGNs in biofabrication and 3D bioprinting will be introduced, demonstrating how MBGNs can be incorporated into printable hydrogels to develop functional bioinks. Examples include cell-laden hydrogel-MBGN systems used to fabricate tissue-mimicking scaffolds of increasing complexity.
Finally, the challenges and opportunities for future research in the field will be discussed, including the rapidly expanding area of ionic medicine, such as the application of multifunctional BGs that release biologically active ions to promote angiogenesis, immunomodulation, and tissue regeneration through advanced growth factor-free strategies.