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Editorial Note on Biological Implants

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Journal of Bioceramics Development and Applications: An Open Access Journal, Journal of Ceramic Science, New Journal of Glass and Ceramics, Journal of Addiction Research & Therapy, Journal of Nutritional Disorders & Therap . Bioceramics and bioglasses are ceramic materials that are biocompatible. Bioceramics are an important subset of biomaterials. Bioceramics range in biocompatibility from the ceramic oxides, which are inert in the body, to the other extreme of resorbable materials, which are eventually replaced by the materials which they were used to repairing. Bioceramics are used in many types of medical procedures.

The term Bio inert Materials bioinert refers to any material that once placed in the human body has minimal interaction with its surrounding tissue, examples of these are stainless steel, titanium, alumina, partially stabilised zirconia, and ultra-high molecular weight polyethylene. Generally a fibrous capsule might form around bio inert implants hence its bio functionality relies on tissue integration through the implant.

Implants are widely used in various clinical disciplines to replace or stabilize organs. The challenge for the future is to apply implant materials to specifically control the biology of the surrounding tissue for repair and regeneration. This field of research is highly interdisciplinary and combines scientists from technical and life sciences disciplines. To successfully apply materials for regenerative processes in the body, the understanding of the mechanisms at the interface between cells or tissues and the artificial material is of critical importance. The research focuses on stem cells, design of material surfaces, and mechanisms of cell adhesion. For the third time around 200 scientists met in Rostock, Germany for the international symposium “Interface Biology of Implants.” The aim of the symposium is to promote the interdisciplinary dialogue between the scientists from the different disciplines to develop smart implants for medical use. In addition, researchers from basic sciences, notably cell biology presented new findings concerning mechanisms of cell adhesion to stimulate research in the applied field of implant technology.

Medical implants play a growing role in routine clinical practice. In addition to replace or stabilize injured tissue permanently or transiently, the application of implant materials to stimulate the regeneration of tissue is becoming a challenge in the field of regenerative medicine. The use of implant materials is based on the idea that biomaterials function not only as mechanical support for cells and tissue but also provide a matrix to induce signal transduction in the cells that control complex molecular mechanisms responsible for proliferation und differentiation. In this context, the interface between artificial materials and living cells or tissue is an exciting field of great scientific interest and constitutes one of the most dynamic and expanding field in science and technology. Progress in this field is mainly driven by the fundamental importance for clinical applications. The research is characterized by a multidisciplinary collaboration between physics, engineers, biologists and clinicians.

In May 2009, for the third time after 2003 and 2006 around 200 scientists met in Rostock-Warnemünde for the symposium “Interface Biology of Implants” to discuss biointerface processes at a fundamental level. The main goals of this symposium are to simulate the interdisciplinary dialogue between scientists of the different disciplines and to introduce current knowledge of basic research in cell biology and material science into the applied field of implant technology. The programme was organized in invited presentations of 20 internationally renowned scientists and complemented by short talks of mostly young scientists selected from the submitted abstracts. In addition, 80 posters presented latest results in this multidisciplinary field.

The symposium was opened with a keynote lecture presented by Hartmut Hildebrand (Lille). He gave an overview about the 7,000 years old history of application of implant materials. Rare photographs were shown which demonstrated that in these early times prostheses mainly made from metallic materials were used to restore teeth, extremities and the skull of the human body. These old documents stressed the historical relevance of medical application of implant materials.

The symposium on two days was composed of four sessions covering the interdisciplinary research in the field. The session “Stem cells and biomaterials” discussed the biological response and signalling mechanism of stem cells in the interaction with a material surface. The session “Bioactivation of implant surfaces” focussed on the tailoring of surfaces to control the cell physiology. To stimulate the field by recent data in basic cell biology, talks were presented in the third session, dealing with molecular mechanisms involved in cell adhesion. A special session dealt with the role and mechanism of controlling cells by mechanics.

Stem cells and biomaterials

Research in regenerative medicine is mainly driven by the field of stem cells. In vivo these cells are located in a stem cell niche and factors in the microenvironment which involve cytokines and cell-cell as well as cell-extracellular matrix interactions determine the fate of the cells. Scientists try to understand the molecular mechanisms of controlling proliferation and differentiation into multiple directions of these cells. The control of stem cells by characteristics of a material surface constitutes an ambitious aim in the field of implant technology. Concerning basic mechanisms in stem cell regulation, Bassem Abdallah from the laboratory of Moustapha Kassem (Odense) could identify a new factor, named Dlk1/FA1 which controls differentiation and proliferation of mesenchymal stem cells. It encodes a transmembrane protein which belongs to the Notch family. Overexpression of this protein inhibits differentiation into the main mesenchymal cells which was associated with the release of a number of inflammatory cytokines.In estrogen deficiency, increased serum levels of Dlk1/FA1 were found which inhibit bone formation. Mouse models demonstrated that this protein is a novel regulator of the transition from proliferation to differentiation.

Bioactivation of implant surfaces

Strategies to control cells by tailoring a bioactive material surface involve the modification of physical and chemical characteristics. Molly

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Stevens (London) presented an overview about the recent developments of biomaterials in her laboratory.The work is focussed on the fabrication of novel nanostructured scaffolds that mimic the nanostructure of the tissues in the body and involves materials for hard and soft tissue engineering. For orthopaedic implants, coatings which release strontium were developed. These materials are tested concerning the interaction with cells and for bone regeneration in vivo. The talk of Josep Planell (Barcelona) dealt with strategies to bioactivate titanium surfaces and polymers. In his laboratory an elastin-like polymer derived from bacteria was used to be immobilized to the titanium surface by a silane agent. This polymer contains RGD sequences which are binding sites for cellular integrin receptors. The bioactivation of polymers involves the structuring of PMMA and chitosan. PMMA films were patterned using nano-imprinting lithography. The patterns consist of lines in the µm range. This structure was tested concerning the behaviour of neuronal cells. Mathis Riehle (Glasgow) presented fabrication technologies to create polymer surfaces with nanofeatures. A film of poly caprylactone (PCL) was spin cast on a wafer and structured using micro and nanostamps. The final PCL film contained 50 µm high pillars, as well as pores and grooves. To create a third dimension the film was rolled to a tube. Smooth muscle cells were then used to test and optimize the material.

To create bioactive surfaces, Martin Möller (Aachen) demonstrated that to prevent unspecific protein adsorption, hydrogels are coated with star branched polyglycols and polyglycerols that enable controlled introduction of branching, activation of side chain substitution and specific functionalization. Polyglycerol is a water soluble polymer and can be substituted by a variety of functional side groups. The prepolymers can further be linked to biologically active compounds. By combination of lithographic techniques, copolymer templating and solid-phase synthesis, the concentration, spatial distribution and clustering of bioactive ligands can be precisely controlled ranging from several nanometers up to a few micrometers. Such a model system allows a systematic study of the cellular responses.

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