Interface Of Materials With Biology

New materials and devices are radically changing the medical treatment of injury and disease, yet because of the rapid growth of this segment of the materials industry an adequate measurement infrastructure does not yet exist. The program on the Interface of Materials with Biology develops measurement methods, standards, and fundamental scientific understanding at the interface between materials science and biological science. Within the health care industry we focus on dental and medical sectors that apply synthetic materials for replacement, restoration, and regeneration of damaged or diseased tissue.

Five major activities constitute this program:

- The dental industry is primarily composed of small manufacturers with very little R&D capability. The dental materials projects, carried out in collaboration with the American Dental Association, located in the Polymers Division, fill that gap by developing improved materials and techniques, patenting and licensing these inventions, and most importantly, providing technical assistance to the licensees for producing and improving their products. This has provided U.S. companies with products that successfully compete in a worldwide market. Our research focuses on improved understanding of the synergistic interaction of the phases of polymer based composites and the mechanisms of adhesion to dentin and enamel. This approach will ultimately lead to materials with improved durability, toughness and adhesion to contiguous tooth structure.
- In this era of interdisciplinary approach to research, the Materials Reliability Division is providing an added dimension to studying diseases and cellular function. By taking a physical/mechanical approach to how cells function, respond, and remodel we are able to provide insight into the progression of diseases using knowledge and skill sets typically absent in the biomedical community. We concentrate on mechanical property metrology for several biological systems, including natural as well as engineered tissue and spanning a considerable size range from individual neurons and muscle cells to complete pulmonary arteries. This necessitates the development of unique mechanical testing platforms ranging from electrical and mechanical probes of individual living cells to biaxial stressing systems. We interpret our measurements by focusing on the roles of structural elements such as cells, composition, and tissue anisotropy. This classical materials science approach to understanding properties is proving invaluable to the biomedical community.
- The tissue engineering industry shows the potential for explosive growth in the coming years as biomedical research is moving from academic science to industrial application at an increasing rate. Work in the Polymers Division seeks to bridge the gap between knowledge generation by cell biologists and product development in industry. In collaboration with the Chemical Science and Technology Laboratory, we are developing measurement methodologies and reference materials to use in assessing interactions in complex systems of living cells with synthetic materials. The expected outcomes of this work include methods to use reference substrates that induce specific cellular responses, and engineered DNA vectors that act as fluorescent reporters of cellular responses.
- Regenerating form and function to bone defects in an elderly, osteoporotic population of Americans is a daunting challenge. To meet this challenge, the Polymers Division is collaborating with the American Dental Association to develop metrology methods to characterize the biocompatibility of synthetic bone grafts. Quantitative methods being developed include assays for adhesion, viability, proliferation, and differentiation of bone cells, as well as optical coherence tomography and confocal microscopy for measuring tissue ingrowth. The combinatorial approach is used to rapidly identify compositions and surface features that provide desirable properties such as biocompatibility and mechanical durability.
- The NIST Center for Neutron Research and the NIST Biotechnology Division are engaged in the study of biomimetic films that serve as models of cell membranes and which are of fundamental importance in understanding such key biological processes as phospholipid self-assembly, molecular recognition, and cell-protein interactions. Recent improvements in neutron reflectometry at the NCNR, coupled with advances in biomimetic film fabrication at metallic interfaces pioneered in the Biotechnology Division, afford enhanced sensitivity for probing membranes and membrane-protein complexes. New phase sensitive measurement techniques and model-independent data analysis methods have demonstrated the feasibility of obtaining reliable depth profiles of membrane structures in contact with biologically relevant aqueous environments, achieving subnanometer spatial resolutions.

Fundamental to much of the work in this program is the recognition that surfaces and interfaces play a critical role in biological systems and, in particular, in the interactions of synthetic or designed materials with biological systems and function. By providing the unique expertise in the NIST Materials Science and Engineering Laboratory to characterization of surfaces and interactions at interfaces in biomaterials we will accelerate the introduction of improved materials and help provide the means to assure quality control that is critical to this industry.