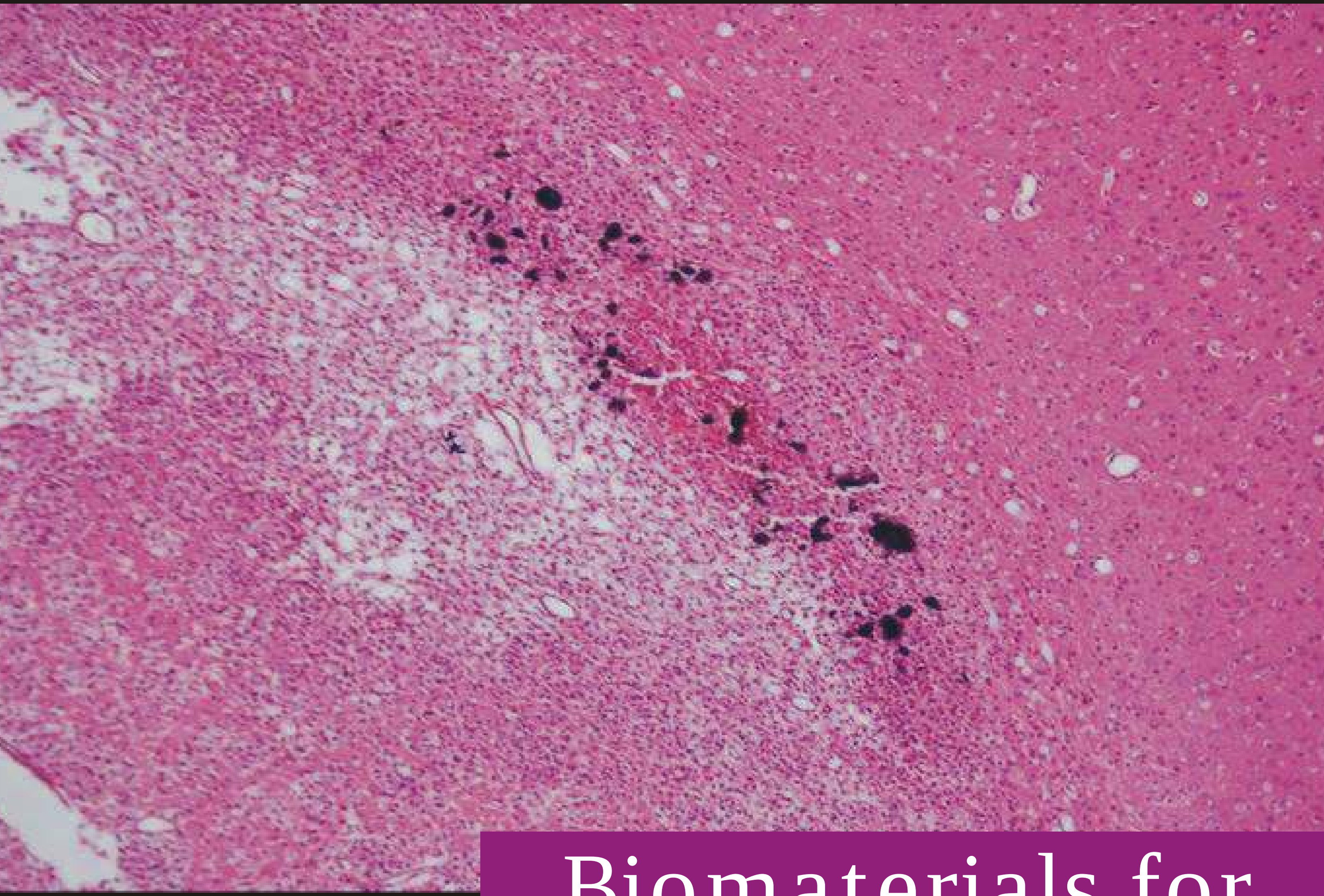
Indo-US Science & Technology Forum

Connect

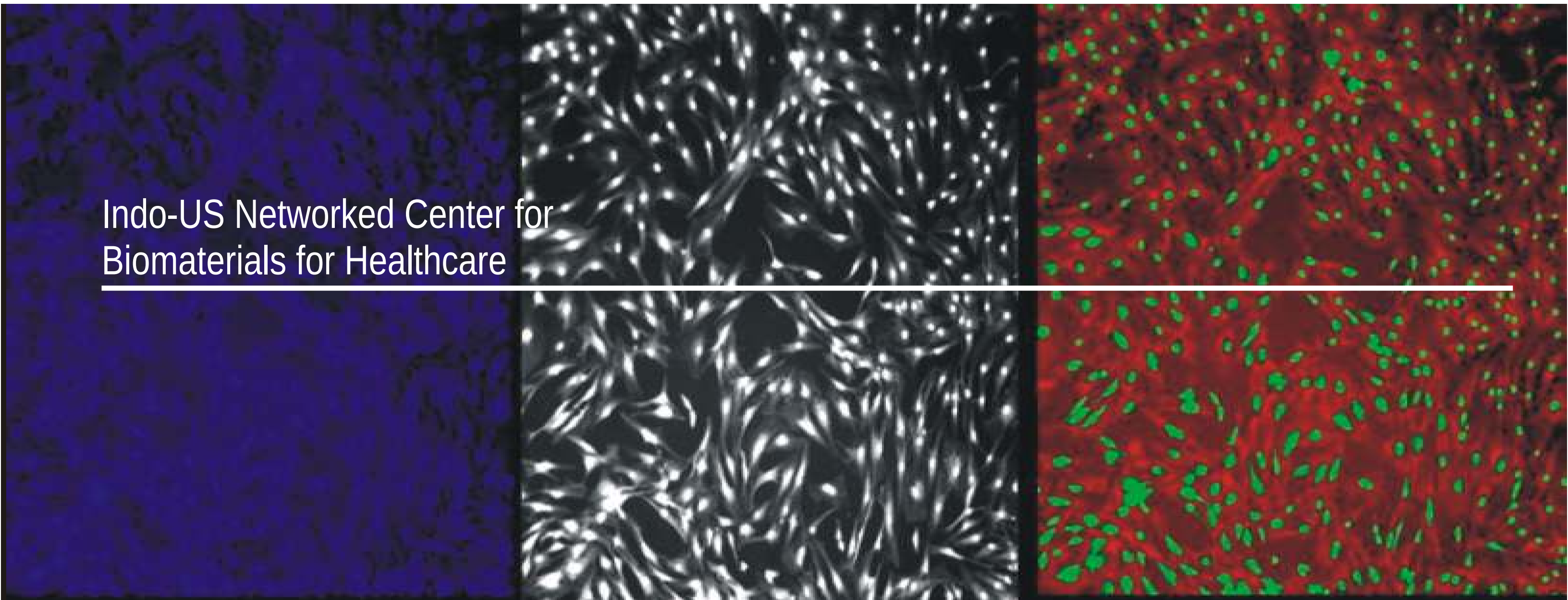
Newsletter of IUSSTF

Volume 2 (2) | September 2010



Biomaterials for Healthcare

IUSSTF
www.indousstf.org



Indo-US Networked Center for Biomaterials for Healthcare


Bikramjit Basu
Department of Materials
and Metallurgical Engineering,
IIT Kanpur, INDIA

Thomas J. Webster
Department of Orthopedics,
Brown University,
Providence, RI, USA

Implanted Wellness

Traditionally, biomaterials have been created by largely trial and error processes. For example, titanium was initially considered for orthopedic applications since it is light weight and strong (clearly important for artificial joint applications). This approach has sufficed to date to help restore organ function and at least partially return a quality of life to persons suffering from various diseases. However, all of the implants currently used to treat body ailments (from orthopedics to the vasculature) have limited lifetimes and often do not last as long as the lifetime of the patient. Clearly, approaches other than 'trial and error engineering' are needed to design better implants for the coming generations.

For these reasons, in 2009, the Indo-US Science and Technology Forum supported the establishment of an *Indo-US Public-Private Networked R&D Center on Biomaterials for Healthcare* with the overall objective to combine the cutting edge technologies between the US and India to design, fabricate and test a wide range of new biomaterials to serve the next generation of patients. Innovative Center projects include mimicking the natural chemical and nanostructure of our natural tissues to create improved biomaterials to developing sensors which can determine in real time in situ events surrounding implants to ensure their success. In particular, the Joint Center aims to combine innovative material science (including nanotechnology) with biological science to develop implants that can last the lifetime of the patient and return that patient to the lifestyle they were accustomed to before they suffered from a medical ailment. The focused activities for the Center are in the following areas: (i) metals, ceramics and polymer-based hard tissue replacement (orthopedic implant) materials, with particular emphasis on nano-biomaterials;

(ii) polymer based scaffold materials for tissue engineering applications; and (iii) formulating strategies based on novel manufacturing routes to produce complex shaped implant materials.

Of the many projects currently being investigated in the Center, three have been highlighted below:

Research Focus 1: Bacterial infection has caused many problems for biomaterials such as catheters, endotracheal tubes and hip implants. The goal of this collaborative project is to study the bactericidal effects of various iron oxide (IO) nanoparticles in several forms, such as nanoparticles and thin films. In order to study the effects of IO nanoparticles on *Staphylococcus aureus* (a key bacteria that forms detrimental biofilms on biomaterials), IO nanoparticles were synthesized via a novel matrix mediated method using polyvinyl alcohol. The IO nanoparticles were characterized by transmission electron microscopy and dynamic light scattering. This clearly represents a next generation approach since such IO nanoparticles can be controlled by external magnetic fields to fight infection 'at will' in the body.

Research Focus 2: Hydroxyapatite (HA) based biomaterials have been widely used in tissue replacement, bone reconstruction, and bone regeneration applications without any long term adverse effects. But HA is not suitable for load bearing orthopedic applications because it has very poor mechanical properties. Therefore, in the present investigation, a composite material that shows good mechanical properties without adversely effecting biological properties has been developed. Specifically, spark plasma sintered (SPS) hydroxyapaptitemullite (HM) nanocomposites have shown good mechanical and biological properties.

Research Focus 3: Cartilage-bone interfacial tissue regeneration has been problematic for numerous decades mostly due to the fact that cartilage does not possess natural self-regenerating properties. However, promise has been seen when creating materials to mimic natural cartilage tissue. On the bone side of this interface, currently available bone regeneration techniques (for eg. using autografts) offer several limitations. Due to these limitations, various types of tissue engineered scaffolds that can deliver matrix-generating osteoprogenitor cells and chondroycte-modulating growth factors to the defect are being explored. The Center project aims to develop injectable scaffolds using natural polymers with osteoinductive and chondro-inductive factors entrapped within nanoparticles and hydrogel matrices for the slow and sustained release of growth factors. Someday this injectable bone and cartilage healing material would negate the need for an unnatural metallic joint implant, creating a more natural manner to heal tissue.

This Joint Center is a true demonstration of the synergistic flow and utilization of scientific concepts, technological ideas and expertise from an international team of renowned scientists. The Center is directed by Bikramjit Basu (IIT Kanpur) and Thomas J. Webster (Brown University) and is assisted by researchers from the University of Washington (Rajendra Bordia), University of Texas at San Antonio (Mauli Agrawal), IIT Kanpur (Dhirendra Katti and Ashok Kumar), IIT Mumbai (Rinti Banerjee), Non Ferrous Materials Technology Development Centre (Krishnamurty Balasubramanian), NML (Arvind Sinha) and Shaping Concepts, LLC (Animesh Bose). The participation of an industrial partner is expected to translate the R&D output into real commercial products.

PARTNERING INSTITUTIONS

INDIA
Indian Institute of Technology-Kanpur
Indian Institute of Technology-Bombay
National Metallurgical Laboratory, Jamshedpur
Nonferrous Materials Technology Development Centre, Hyderabad

USA
Brown University, Providence, Rhode Island
University of Washington, Seattle
University of Texas at San Antonio

INDUSTRY PARTNER
Shaping Concepts, LLC, USA

Acquiring Mettle in Metallurgy

Nhiem Tran
Brown University
Providence, RI

The research lab I work in as a Physics' Ph.D. student at Brown University (under the direction of Prof. Thomas J. Webster) has had numerous long relationships with various Indian institutions. But my first opportunity to learn about the Indo-U.S. Joint Center for Biomaterials for Healthcare was when Dr. Bikramjit Basu (IIT-Kanpur, Co-director of the Indo-U.S. Center) and Dr. Suprabha Nayar (National Maetallurgical Laboratory; NML) visited our lab at Brown University in 2009. Dr. Nayar was working with iron oxide nanoparticles, and she happened to bring some samples with her and I helped her characterize those samples using transmission electron microscopy. At that time, we had started to investigate the novel anti-bacterial properties of iron oxide nanoparticles, showing that without antibiotics, iron oxide nanoparticles can kill bacteria.

Later on, she asked me if I was interested in visiting her laboratory in Jamshedpur, and I was delighted to accept. My advisor also supported me wholeheartedly because it was not only a very good opportunity to improve my research skills, but also a way to learn from pioneers in the field of iron oxide nanoparticles. On December 13, 2009, I headed to NML in Jamshedpur, India.

My research project was to utilize NML's expertise in iron oxide nanoparticle synthesis and characterization and Brown's expertise to treat bone diseases (such as osteoporosis) and bacterial infections. As a testament to the technology, our results came quickly and were quite convincing. Our preliminary studies showed that iron oxide/poly vinyl alcohol (PVA) nanoparticles created at NML could inhibit the growth of bacteria *Staphyloccocus aureus*, one of the most prominent bacteria in medical device infections. We quickly published a paper on the results entitled "**Bactericidal effect of iron oxide nanoparticles on *Staphylococcus aureus***" in the open access journal, *International Journal of Nanomedicine*, in April 2010. It has already been downloaded 704 times (as of June 3, 2010).

My first impression of Jamshedpur was a small town with many friendly local people. I took a rickshaw to work every day and had many chances to talk to people. I also tried a lot of delicious authentic Indian dishes. All lab members were very nice and were always willing to offer me any help when I needed, so I had no problem settling in and was able to follow my research schedule from day one. Every day, we had lunch together where we exchanged thoughts about science and life. The mentors at NML were always there to give me advice, which facilitated my research work greatly.

With the help of the NML members, I was able to create iron oxide/PVA membranes using electrospinning, for which NML is widely known. The mechanical properties of the membranes were also investigated. The membranes were brought back to Brown in the U.S. where bacteria experiments were carried out.

My time in India I felt was very short. I brought back with me not only the samples and work experience, but also the memories of delicious food, a rich culture, and the hospitality of the Indian people. I cannot wait for another chance to visit my new friends in India through the Indo-U.S. Center for Biomaterials for Healthcare!