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MICHAEL G. DUNN, PHD, ASSOCIATE PROFESSOR AND DIRECTOR, ORTHOPAEDIC RESEARCH LABORATORIES, AND **CHARLES J. GATT, MD,** CHAIR, DEPARTMENT OF ORTHOPAEDICS, UMDNJ-ROBERT WOOD JOHNSON MEDICAL SCHOOL

INNOVATION

Technology

Restoring the Mighty MENISCUS

WORDS BY BARBARA HURLEY / PHOTOGRAPH BY ANDREW HANENBERG

"You can't kick a door down with a bum knee," Michael Dunn remembers a soldier saying. And anyone who watches the news from Iraq or Afghanistan knows how many doors have been kicked in over the course of the conflicts.

This helps explain why the tissue engineering research of Dunn and Charles Gatt is part of a major collaboration that includes UMDNJ and is underwritten by AFIRM, the Armed Forces Institute for Regenerative Medicine. The work group, one of two nationwide, is led by Rutgers and the Cleveland Clinic and charged with exploring the potential of regenerative medicine to restore the appearance and function of the injured. "The goal is to bring the best of the best together," Gatt notes, "to cope with the challenge of helping the severely disabled."

It's a tall order that includes hand and face transplants, repairs for skin damaged by extensive burns, nerve and limb regeneration, and restoration of limb function. To restore function in an injured knee, Gatt and Dunn are exploring novel biomaterials to replace the meniscus, a c-shaped piece of fibrocartilage that acts as a spacer and shock absorber between the femur and the tibia. It prevents friction between these two bones and allows normal joint fluid and its nutrients into the tissue, known as articular cartilage, which covers the end of the bone. The main purpose of rebuilding the meniscus is to maintain the integrity of this cartilage to prevent the development of post-traumatic or degenerative arthritis.

Knee injury is a major problem for the military, although it's typically sustained not on the battlefield but during training or recreation. "Someone limping around in battle," Dunn notes, "is a sitting duck." So their research takes on meaning far weightier than the small piece of fibrocartilage called the meniscus.

Dunn and Gatt have created what no one else has: the first weight-bearing scaffold to facilitate the body's repair of the meniscus. The idea is to provide a framework that will attract cells into a porous structure, rebuild the meniscus and then gradually degrade.

The team, constantly in fine-tuning mode to optimize the design, is now on the second generation meniscus replacement scaffold. The meniscus is a hybrid tissue combining properties of cartilage and ligament. The scaffold design mimics the natural meniscus, with anatomically-aligned fibers within a collagen and proteoglycan sponge. The fiber replicates the ligament element; the collagen-proteoglycan sponge replicates the cartilage. The special synthetic fibers, strong enough for the stress and strain of a knee joint, were developed by Dr. Joachim Kohn, director of Rutgers AFIRM and the New Jersey Center for Biomaterials at Rutgers. Cells attach to these fibers, lay down new collagen, and grow, supported by the scaffold. It took time to hit upon the proper arrangement of the fibers to mimic the natural fibers contained in the meniscus so that the rebuilt meniscus could function like a normal one. As the body regenerates a meniscus, there is a gradual transition from the implanted scaffold, which eventually degrades, to the new meniscus.

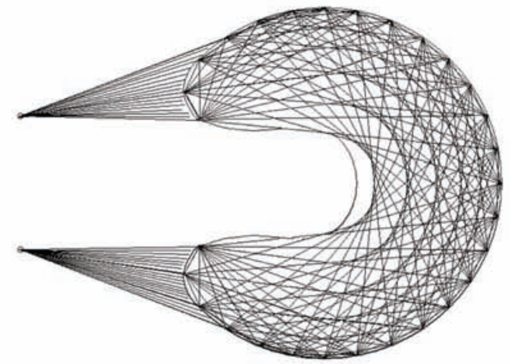
They have been working for five years to answer questions that would ensure the safety and efficacy of the scaffold. How porous should it be? How quickly should it degrade? How can they be sure that cells integrate into the scaffold rather than encapsulate it? How can they be certain that the scaffold is biocompatible, that it does no harm to the body? Over the years, two graduate students have helped answer some of these questions. The first, Eric Balint, PhD, is now deployed in the Middle East. The second, Aaron Merriam, BS, currently works in their research lab.

Other questions have been answered by two preclinical studies that have had good results, and the team is collecting preclinical data for eventual IRB approval of clinical trials. Their goal is to rebuild a functioning meniscus, but their guiding principle is caution. In fact, several more years of preclinical study may be on the horizon, according to Dunn. An international patent is pending and several potential industrial partners have expressed interest in the technology. These could accelerate the process of taking this novel translational research from the bench to the bedside.

There is reason to hope for speedy progress. "In the military, the most common injuries and the most common cause of disability are injuries involving the knee. Surgical treatment of meniscal injuries is among the most common orthopaedic surgical procedures," says Gatt. "Tissue engineering approaches could drastically improve outcomes in the future. Gone would be the plastic or metal implants that eventually wear out; the body could repair itself."

Whether we are talking about the walking — or rather limping — wounded in the military or the weekend warrior on the tennis court, this would be very good news. ■

A.



B.

FIGURE A. THIS UNIQUE FIBER NETWORK DESIGN ENABLES THE SCAFFOLD TO SUPPORT MECHANICAL LOADS IN THE KNEE.

FIGURE B. ACTUAL MENISCUS SCAFFOLD COMPOSED OF THE FIBER NETWORK EMBEDDED WITHIN A COLLAGEN SPONGE.

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