Findings

Photoactive Dye Could Prevent Infection During Bone-Repair Surgery

A team at Jefferson has discovered that a green dye that sticks to bone grafts becomes antimicrobial with the flick of a light switch and could help reduce the risk of infections during bone-reconstruction surgeries.

When performing joint replacement or bone reconstructive surgeries for issues such as gunshot wounds or damage related to tumor removal, physicians follow extensive procedures to sterilize all bone fragments used. Despite these efforts, the rate of resulting infection remains around 5 percent and can reach 11 percent or even higher — and serious infections can require further surgery and threaten lives.

Jefferson researchers have demonstrated that an antimicrobial dye activated by light adheres to bone to prevent bacteria from growing on bone fragments used in reconstructive surgery and remove any bacteria that has already attached, thereby sterilizing the bone for surgery. The study was published in *Clinical Orthopaedics and Related Research*.

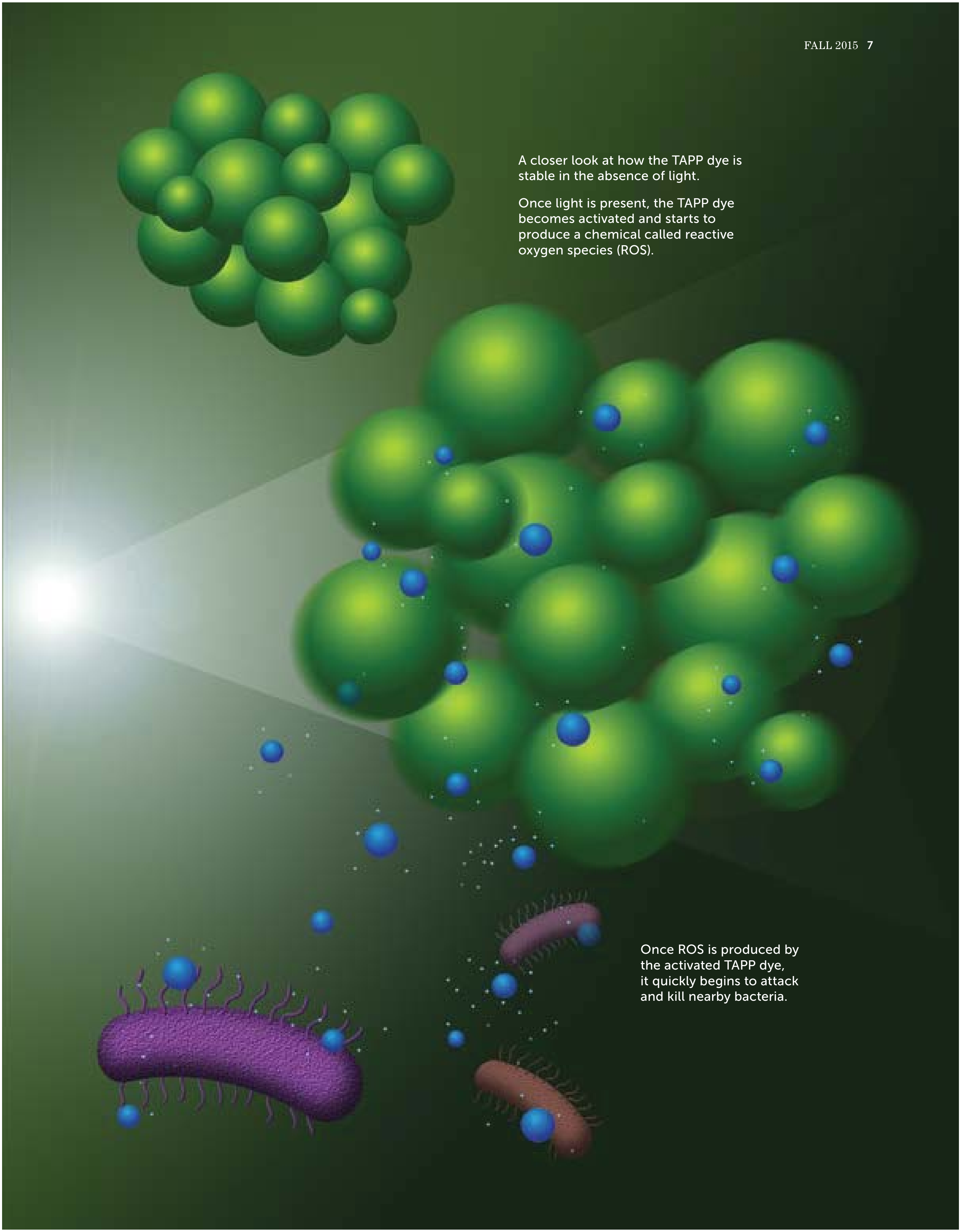
"We used a class of chemicals called porphyrins that are tolerated very well by the body in the dark and appear to have excellent antimicrobial properties in the presence of light," says Noreen Hickok, PhD, associate professor of orthopaedic surgery. "These properties allow sterilization during surgical procedures, which occur in bright light."

Surgeons often use bone chips or bone powder as a sort of putty during bone reconstruction to help areas of bone re-grow. Also, larger pieces of bone are used when a tumor or accident requires replacement of a large segment of bone. These bone materials can come from the patient or a donor and typically are sterilized with a series of methods including various detergents and high-pressure steam — but bacteria can still creep in once the material is handled again. "Bacteria love to hide and grow in the nooks and crannies of porous bone and bone fragments — it's one of the most perfect surfaces for bacterial growth," Hickok says.

The researchers took bone chips and treated them with a green dye called TAPP — which stands for 5,10,15,20-tetrakis-(4-aminophenyl)-porphyrin. They showed that in the dark, TAPP is stable. But when the lights go on, TAPP becomes active, producing chemicals called reactive oxygen species, or ROS, that rapidly kill the bacteria. Hickok and colleagues first treated the bone putty with TAPP and then exposed those fragments to bacteria. As long as the lights were on, bacteria were unable to attach and grow on the surface of the bone.

The researchers then showed that TAPP not only prevents bacterial growth but can also break up bacterial slime, or biofilms, already growing on the bone fragments. They demonstrated this by first allowing bacteria to colonize the bone and then treating with TAPP. Finally, they showed that the dye binds tightly to the bone without any trace of leaching out into surrounding fluid, suggesting that it could be safe and non-toxic to normal tissue once implanted.

In theory, says Hickok, the TAPP dye could be added to the currently used protocols for sterilizing the bone prior to surgery. "Sterilization could then occur in two steps — one that was achieved with a targeted illumination, and the other would be the continuation of the activation in the bright lights of the surgical suite so that the sterilizing effects of the ROS release could continue well into surgery and implantation," she says. "We need to continue testing in conditions that more closely resemble the surgical suite, but we think that this could offer a more effective method to help improve patient outcomes by reducing infection rates."


A closer look at how the TAPP dye is stable in the absence of light.
Once light is present, the TAPP dye becomes activated and starts to produce a chemical called reactive oxygen species (ROS).
Once ROS is produced by the activated TAPP dye, it quickly begins to attack and kill nearby bacteria.