An ion-implanted hip joint

ION-IMPLANTED MATERIALS

Real Artificial Joints

The remarkable discovery of ion channeling by purely theoretical means at ORNL ultimately led to accelerator-based programs to introduce ions into materials. Ion implantation was found to improve the surfaces of many materials, including alloys used to make artificial hips and knees. Research was performed by ORNL's Jim Williams in collaboration with Ray Buchanan, then at the University of Alabama and now at the University of Tennessee. They discovered in 1980 that implanting the titanium alloy used in artificial joints with nitrogen ions hardens the alloy and greatly improves its resistance to wear and corrosion.

Ion implantation was found to improve both the titanium and cobalt-chrome alloys used to make surgically implantable artificial joints, but different mechanisms are involved. The technique hardens the titanium alloy's surface so that it cannot be scratched by the alloy's own oxide coating (which reduces surface chemical reactivity). For the cobalt-chrome alloy, ion implantation improves its wettability so that the artificial joint slides more easily and makes the surface hardness more uniform. Thus, the alloy interacts better with its mating polymer component, extending its life. In the early 1990s the Food and Drug Administration issued guidance requiring that all newly submitted titanium orthopedic devices be ion implanted.

Ion implantation of orthopedic materials was first applied commercially by Spire Corporation and then by Implant Sciences Corporation. Combined sales of several hundred thousand devices per year amount to about $10 million annually to the orthopedics manufacturers for wholesale surface treatments. Williams estimates that cumulative sales for the treatments are well over $100 million. The more important benefit, however, lies in the improved lives and comfort levels for millions of Americans who have ion-implanted artificial hips, knees, and other joints.

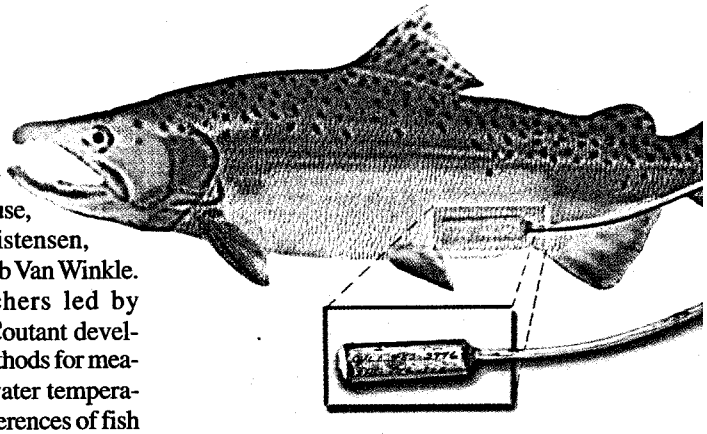
ENVIRONMENTAL IMPACT ANALYSES

Searching for the Balance

Before federally funded or approved installations can be constructed, the effects of the projects must be scrutinized. Their costs and benefits must be weighed in environmental impact statements (EIS), which have been prepared for nuclear power plants since 1971. Researchers from ORNL and three other national laboratories became involved in a crash project to draft EIS's for 90 operating nuclear power plants, as well as those under construction or on the drawing boards. Also in the 1970s, ORNL was involved in decisions about whether cooling towers should be built for proposed power plants to protect the Hudson River's striped bass.

During that decade and after, many questions arose. Will fish populations decline if fish pass through power plant cooling systems or are exposed to heated water discharged by nuclear facilities? How much radioactivity are workers and the public exposed to during normal operation of nuclear plants? What are the environmental and socioeconomic impacts of geothermal, solar, fossil, synthetic-fuel, biomass-conversion, and hydropower projects? To address these and other questions, the EIS team headed by ORNL's Ed Struxness, Bill Fulkerson, Tom Row, and Johnnie Cannon conducted considerable research.

To assess impacts on fish of passing through intake screens, ORNL researchers developed computer models under the leadership of Larry Barnthouse, Sig Christensen, and Webb Van Winkle. Researchers led by Chuck Coutant developed methods for measuring water temperature preferences of fish and motivated the development of power plant engineering controls to minimize damage to nearby fish populations.

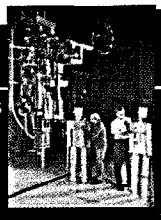


ORNL engineers developed an electronic tag that can be surgically implanted in a fish. This tag, which emits ultrasonic signals, is being used to observe the behavior of salmon near hydroelectric dams—information that will facilitate the fish's safe upstream and downstream passage.

ORNL researchers have been national leaders in developing fish protection devices for hydropower plants, examining socioeconomic and cultural impacts of power plant construction and operation, and predicting risks and benefits of operations ranging from research facilities in Antarctica to the permanent high-level nuclear waste repository approved by Congress for Nevada's Yucca Mountain.

1962

Health Physics Research Reactor completed

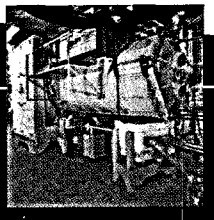


Ion channeling discovered with aid of computer modeling

Civil defense research program started

Forest stand tagged with cesium-137; analyses showed hazards of fallout from nuclear weapons testing

1963

Radiation Shielding Information Center established at ORNL

Oak Ridge Isochronous Cyclotron first operated