World’s Toughest Bacterium holds promise for rapid vaccine development against deadly diseases

Bethesda, MD -- Scientists from the Uniformed Services University of the Health Sciences (USU) have developed a new preparation method that renders a virus or bacterium non-infectious while preserving its immune-boosting ability after exposure to gamma radiation. A vaccine exposed to megadoses of gamma radiation was successfully tested in mice against drug-resistant Staphylococcus aureus bacteria by colleagues at the National Institutes of Health (NIH), and holds promise for other such deadly diseases. The results of the breakthrough study titled "Preserving Immunogenicity of Lethally Irradiated Viral and Bacterial Vaccine Epitopes Using a Radio-Protective Mn2+-Peptide Complex from Deinococcus" were published in the July edition of Cell Host and Microbe.

High doses of radiation typically destroy a pathogen’s genome, rendering it unable to cause infection when used in a vaccine. However, radiation also damages a microbe’s protein epitopes, which the immune system must recognize for a vaccine to be protective. Organisms inactivated, or killed, by radiation trigger better immune responses than those inactivated by traditional heat or chemical methods. Although live vaccines may provide better immune protection than irradiated vaccines, live vaccines are frequently not an option as they can carry an unacceptable risk of infection with an otherwise untreatable disease (e.g., HIV). Lethally irradiated vaccines could also help the developing world, where the need for cold storage limits the availability of live vaccines.

To separate genome destruction from epitope survival, the researchers borrowed some complex chemistry from the world’s toughest bacterium Deinococcus radiodurans, nicknamed “Conan the Bacterium,” which can withstand 3,000 times the radiation levels that would kill a human being. In 2000, Deinococcus was engineered for cleanup of highly radioactive wastes left over from the production of atomic bombs. Now, unusual Mn(II)-antioxidants discovered in this extremophile have been successfully applied to preparing irradiated vaccines.

Deinococcus accumulates high concentrations of manganese and peptides, which the scientists combined in the laboratory —forming a potent antioxidant complex which specifically protects proteins from radiation. They found that the complex preserves immune-related epitopes when applied to viruses and bacteria during exposure to gamma radiation, but did not protect their genomes.

Michael J. Daly, Ph.D., professor of Pathology at USU, and his research team, collaborated on the work with Sandip K. Datta, M.D., and colleagues at NIH’s National Institute of Allergy and Infectious Diseases (NIAID). Daly devoted 20 years to studying Deinococcus radiodurans, which has led to three patents for his work.

The scientists used the Mn-peptide complex in a laboratory setting to successfully protect from radiation damage the protein epitopes of Venezuelan equine encephalitis virus, a microbe that causes a mosquito-borne disease of the nervous system. They also used the preparation method to develop an effective vaccine against methicillin-resistant S. aureus (MRSA) infections in mice.
Learning to Care for Those in Harm’s Way

The researchers believe the whole-microbe vaccine approach could extend to any infectious organism that can be cultivated, whether fungi, parasites, protozoa, viruses or bacteria—including agents that mutate rapidly, such as pandemic influenza and HIV. The groups aim to demonstrate this method of irradiation as a rapid, cost-effective approach to vaccine development.

The project was funded by the Air Force Office of Scientific Research (AFOSR) and the intramural research program of the NIAID. For more information on Deinococcus research, visit http://www.usuhs.mil/pat/deinococcus/index_20.htm. For information on AFOSR, contact Dr. Hugh DeLong (hugh.delong@afosr.af.mil).

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The Uniformed Services University of the Health Sciences (USU) is the nation’s federal health sciences university. USU students are primarily active duty uniformed officers in the Army, Navy, Air Force and Public Health Service who have received specialized education and training in tropical and infectious diseases, preventive medicine, the neurosciences (to include TBI and PTSD), disaster response and humanitarian assistance, and acute trauma care. A large percentage of the university’s more than 4,800 physician and 600 advanced practice nursing alumni are also supporting operations in Afghanistan and elsewhere, offering their leadership and expertise. USU also has graduate programs in biomedical sciences and public health, open to civilian and military applicants committed to excellence in research.