Science & Technology Briefs

DARPA Selects Contractor for Manned Space Rocket with Nuclear Propulsion

A July 26 *New York Times* article, reports that the Defense Advanced Research Projects Agency (DARPA) and NASA have selected military contractor Lockheed Martin to design, build, and test a nuclear-powered propulsion system that could, in the future, power a crewed spacecraft, for example, to Mars, reducing by half or more the travel time, compared to today's chemical-powered rockets.

The $499 million Demonstration Rocket for Agile Cislunar Operations (DRACO) project, will be powered by a fission-based reactor, fueled by a special high-assay low-enriched uranium (HALEU), to quickly convert cryogenic hydrogen into an extremely hot pressurized gas, which would then be funneled through the engine nozzle to create a powerful continuous thrust. Lockheed Martin has partnered with BWX Technologies to develop the reactor and produce the HALEU fuel.

To minimize the possibility of a radioactive accident on Earth, the reactor will not be activated until the vehicle is beyond Earth's farthest atmosphere.

The first test flight is scheduled for late 2026 or early 2027, to orbit Earth at 700-2,000 km, high enough to ensure that it stays in orbit for more than 300 years, long enough for radioactive elements in the reactor fuel to decay to safe levels.

DARPA's involvement means there are also military applications for this technology. No word on this, however.

Pathway to a Practical Cure for HIV?

Human Immunodeficiency Virus (HIV) damages the immune system, making it difficult for the body to fight infection. There is no HIV vaccine. When left untreated, HIV can progress to AIDS. Individuals living with HIV who take certain anti-viral medications daily, however, can decrease their viral load to an "undetectable" level, that is not transmissible to sexual partners. The availability of those relevant medications has decreased deaths from HIV by 86% over the period 1990-2019, and average life expectancy after an HIV diagnosis has gone from one year in the 1980s, during the height of the AIDS epidemic, to near normal, according to the U.S. National Institutes of Health.

A *Washington Post* story from Feb. 21, reports on a man in Germany, diagnosed with HIV, who has been declared free of the virus after receiving HIV-resistant stem cells through a bone marrow transplant originally intended to treat his leukemia. According to research published Feb. 20 in the journal *Nature Medicine*, the man was monitored for more than nine years after the 2013 transplant, and there is now "strong evidence" that he has been cured.

The remission of HIV, came after a team at University Hospital Düsseldorf destroyed the patient's cancerous cells and replaced them with donor cells that lack CCR5, the receptor that HIV particles use to infect cells. In 2018, the patient discontinued the maintenance antiretroviral therapy (ART) and has remained free of HIV ever since, the paper states.

This new treatment modality offers confirmation that HIV is not entirely incurable, as once thought. It also offers hope for a future without daily medical treatment for those infected with HIV and underscores the potential for other research pursuing a cure. In a statement to *Nature*, Björn-Erik Jensen, the virologist who led the study at Düsseldorf University, said that the research "shows it's not impossible—it's just very difficult—to remove HIV from the body."

Sharon Lewin, Director of the Doherty Institute in Melbourne, Australia, and President of the International AIDS Society has stated that the transplantation research was "very reassuring," noting that there have now been five patients who have been cured through this pathway. "This is real, and it's reproducible." The approach is "not a reasonable strategy for 38 million people living with HIV" globally, but it offers other avenues for more "scalable" research. "The most important thing is that what we've learned from these studies is that if you make every cell resistant to HIV, the virus has got nowhere to go and eventually melts away."

There could be less invasive ways to create that resistance, such as gene therapy, which could make it possible to modify an HIV patient's own cells to make them HIV-resistant. Lewin said there have been "some really big advances" in gene therapies over the past five years that might make that particular approach "highly feasible."

Global Warming Attributed to Decay of Potassium-40 in Earth's Crust

TimeNews reports May 23 on findings released by the Scientific Council of the Russian Academy of Sciences on

its Telegram channel, by its Chairman Sergei Glazyev, of a study conducted by Dr. Leonid Bezrukov. Bezrukov is Chief Researcher at the Institute for Nuclear Research; he hypothesizes that the warming of the Earth's surface and oceans is a result of the radioactive decay of potassium-40 isotope under the Earth's surface, the heat from which is about 1 watt per square meter, much more than the anthropogenic influence on the atmosphere.

The source of the theoretical work on which this hypothesis is based is attributed to Vladimir Larin, Doctor of Geological and Mineralogical Sciences, who studied the metal hydride composition of Earth, the expansion of which releases hydrogen and other gases. However, the first person to pose the theory of the existence of hydrogen in the Earth's surface was Vladimir Vernadsky (1863-1945), who was also the first to indicate a much larger effect of the decay of nuclear elements in the Earth in determining the heat of the Earth, through his concept of the "migration of atoms," well below the thin layer of the Earth's biosphere. Vernadsky developed this concept most extensively in his last, unfinished, work, *The Chemical Structure of the Biosphere and Its Environs*.

Room-Temperature Superconductivity?

About 10% of the energy generated at every power plant is lost in thermal dissipation during transmission to users because the cables and wires that carry the electrical current resist the flow of electrons. That heat loss can be mitigated to a large extent, however, by using materials that do not resist the flow of electrical current, or do so much less. Physicists discovered such materials a century ago: they are called superconductors. They have since then realized that superconductors have the potential to enable revolutionary technologies, including facilitating fusion energy production, speeding up progress on quantum computers, and ushering in an era of superfast transport.

All the materials we know of that can be made to be superconductors, become that way under very special circumstances. For example, aluminum superatoms become superconducting at temperatures colder than –272° Centigrade. (A superatom is a cluster of atoms that exhibits some of the properties of the individual atom.) Other conductive materials require even lower temperatures. Creating and keeping a conductor at those very cold temperatures is both difficult and costly.

In what appears to be a potential major breakthrough, a group of South Korean scientists—Sukbae Lee, Ji-Hoon Kim, and Young-Wan Kwon—have reportedly synthesized a material with superconductive properties, but at room temperature and pressure. In their research paper, published July 22 by Cornell University's arXiv, a repository for preprint research, they call the new material LK-99. It is a copper-doped lead apatite, a type of phosphate mineral.

Biodegradable Gel Shows Promise for Cartilage Regeneration

The June 21 issue of *Nature* reports on new research by Canadian and Chinese scientists at the University of British Columbia (UBC), who have produced a biodegradable gel which may find use in biodegradable implants for joint injuries.

Dr. Hongbin Li, professor in the UBC Dept. of Chemistry:

"Cartilage is tricky. Articular cartilage repair represents an important medical challenge because naturally speaking, it doesn't repair itself."

Biodegradable cartilage implants must strike a delicate balance in that they need to be both stiff and tough, like actual cartilage. Mechanically, when something is stiff, it resists being bent or deformed, but that usually means it's brittle—when bent, it breaks. When something is tough, however, it resists breaking, even when bent, but it might be too soft to be useful in a joint. That's the case with current implants that are made from proteins, creating a mismatch between what the cells need and what's being provided. This leads to the cartilage not repairing as well as it could.

Dr. Li and his team have developed a new approach to stiffen a protein gel without sacrificing toughness, by physically tangling the chains of a particular protein that make up the gel's network.

The new gel is super tough, even able to resist slicing with a scalpel, but stiffer than other protein hydrogels. Its ability to resist compression was among the highest achieved by any such gel, comparing favorably with actual articular cartilage. The gel was able to rapidly recover its original shape after compression, as does real cartilage.

In the study, rabbits implanted with the gel showed notable signs of articular cartilage repair twelve weeks after implantation, with no hydrogel remaining and no rejection of the implant by the animals' immune systems. The researchers observed bone tissue growth similar to the existing tissue, and regenerated tissue close to existing cartilage for the gel implant group—much better results than they saw with a control group.

Further animal testing is ahead before human trials. Next steps include fine-tuning the current gel composition and adding additional biochemical cues to further promote cell regeneration.

Read the full study, in the June 21, 2023 issue of *Science Daily*.