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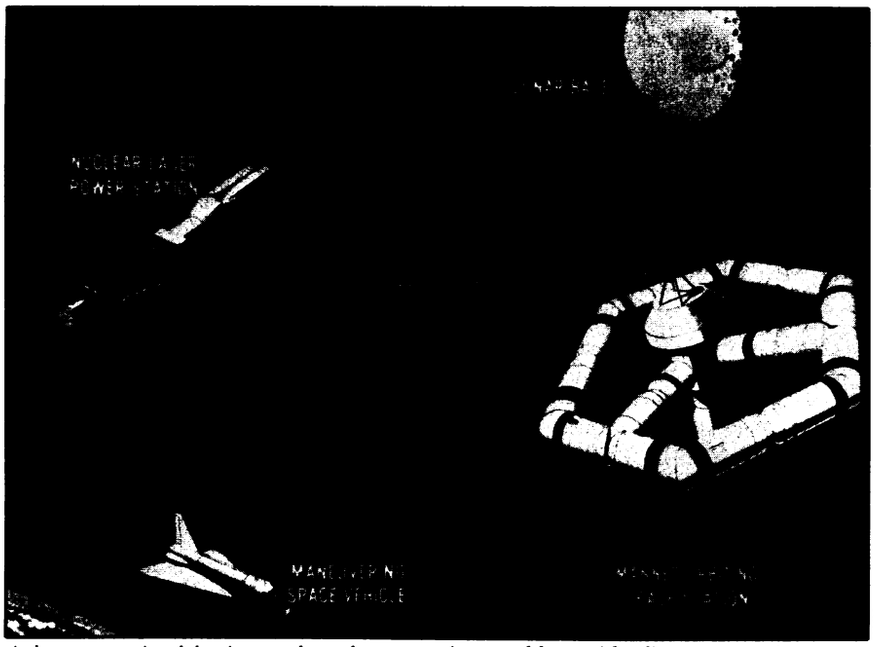


NASA

A laser sustained by internal nuclear reaction could provide direct power in space.

Extremely high-powered lasers, with possible applications ranging from shooting down missiles to providing power for space stations, came a step closer to reality last week with a major achievement by a group of National Aeronautics and Space Administration researchers. Their accomplishment was a key milestone in the development of what is called a self-critical, nuclear-pumped laser—a nuclear reactor whose gaseous core literally becomes the laser itself.

A nuclear-pumped laser is one that uses the energy released by nuclear fission, rather than that of an electrical generator, to "pump" or boost the energy in a laser tube until lasing takes place. The first such laser was demonstrated in September 1974 (SN: 10/12/74, p. 229) as part of a NASA-sponsored research program at the Los Alamos Scientific Laboratory in New Mexico, followed about a week later by another at Sandia Laboratories. Until last week, all the tests of such devices had used neutrons from nuclear reactors to bombard a coating of enriched uranium oxide on the inside of the laser tube. The resulting fission energy produced the energy-pumping that caused the lasing.

On May 6, says Frank Hohl of the NASA Langley Research Center in Virginia, his team succeeded in achieving for the first time in a nuclear laser what is known as "volume pumping," a long-sought goal. The problem with uranium coatings on the laser-tube walls has been that all but about 20 percent of the fission energy produced is wasted—absorbed by the tube itself. When the gas pressure in the tube is high, an important avenue to achieving high power, an additional problem shows up in that only the outer part of the gas—the part next to the tube walls—gets pumped.

Volume pumping circumvents both of these ills by producing the fission energy directly in the lasing medium. In last week's test, using a reactor at the U.S. Army's Aberdeen Proving Ground as the "pump," Hohl and his colleagues used a laser tube filled with 90 percent helium 3 and 10 percent argon. Bombarding the helium with neutrons from the reactor produced tritium nuclei and protons, together with enough energy to cause lasing in the argon. Furthermore, says Hohl, the gas mixture was at a pressure of about one atmosphere; since the source of energy (He-3) was thoroughly mixed with the lasing gas, there was no problem of non-uniform pumping.

The next step, in about a month, will be to try volume pumping with more efficient lasing mediums, called excimers, such as xenon fluoride. And then, a couple of months later if all goes well, the stage will be set for the really big step: the introduction of uranium hexafluoride.

Uranium hexafluoride is the gas that is at the heart of a closely related research effort, the gas-core nuclear reactor. Since they do not use the solid fuel rods of conventional nuclear plants, gas-core reactors enable much higher operating temperatures—so much higher, some scientists believe, that they will be able to burn up most of the long-lived waste products that otherwise pose serious disposal problems. The use of UF_6 in the laser tube would mean that the source of the fission energy—in other words, the pump—would be contained within the laser itself. No big electrical generators, not even an external reactor. A neat, self-contained, "self-critical" package.

One difficulty, says Hohl, is that it is hard to make the big UF_6 molecules lase, since they have many transition states which tend to "quench" the lasing action. The alternative is to add a second gas as the lasing medium. In fact, Hohl says, as little as 5 to 10 percent UF_6 mixed with xenon fluoride may be enough to produce a sustained lasing process.

The applied version, probably no sooner than the 1990s, could provide direct power in space to space stations, spacecraft and other recipients using its own, self-generated laser beam. But efficient, high-powered lasers have also been a long-sought goal of weapons developers, so earth-lubbers will be watching too. □

Pain as a passion

Although it's been 2,000 years since Plato and Aristotle described pain as a "passion of the soul," the origins, comings and goings of pain are still largely elusive. This revelation was brought home last week by some of America's leading pain authorities at a Society for Neuroscience Seminar for Science Writers at Airlie House, Va.

The pain researchers agree that pain is an enormous problem for millions of people, and that help is especially needed for patients who suffer excruciating and intractable pain. One of their major leads now for better understanding and combating pain is the recent discovery of pain-relieving molecules that are naturally present in the central nervous system.

True, scientists have made some progress in pinpointing the physiological pathways of pain since they started to study it some 100 years ago, explained Edward R. Perl, a physician and pain researcher at the University of North Carolina School of Medicine. During the latter part of the 19th century, for example, investigators found that the pain message is carried by the sensory nerves. During the early 1900s researchers identified the spinothalamic tract as a major pathway for pain. This tract consists of sensory nerves running up the spinal cord to the brain. Then Perl and co-workers discovered, in the late 1960s, that there are sensory nerves that respond exclusively to pain-producing stimuli, and that these neurons ultimately hook up with the spinothalamic tract. After pain messages pass along these fibers and up the spinothalamic tract, they apparently enter the brain to be processed. But even these nerve pathways aren't the only culprits involved in spiriting the pain message along, said John A. Jane of the University of Virginia School of Medicine.

As a neurosurgeon, Jane deals with

some 3,000 pain patients a year, and many suffer agonizing, constant central nervous system pain whose origin is hard to pin down compared to pain originating in the peripheral nervous system. The origin of the latter is easy to diagnose—for instance, pain resulting from a tumor pressing against the pelvis or pain originating in arthritic joints. Whereas drugs, acupuncture or spinal cord stimulation can help relieve pain of peripheral origin, it rarely helps patients with pain of central origin. So Jane and other neurosurgeons often sever these patients' spinothalamic tracts in select areas to relieve pain.

Such nerve deletion, Jane says, is "encouraging, but by no means uniformly successful." What often happens is that other nerves in the brain and body find ways of reacting to the same pain stimulus, whatever it is, so that pain returns. In fact, the patient's pain is frequently even more severe the second time around as if the nerves, in being frustrated in their pain expression, find even more diabolical ways to torment people.

But even the forebrain is probably not the ultimate nerve switchboard of pain processing. When patients with constant, overwhelming central pain finally have no recourse other than a lobotomy, which consists of severing nerves in the forebrain, they still feel pain, Jane reports. So some other nerves than those in the forebrain must be assisting this pain expression. But which ones? Researchers have yet to identify them.

Even if the ultimate seat of pain expression were identified, it would undoubtedly not completely explain pain, because pain appears to be as much one's emotional reaction to the physiological stimulus as the stimulus itself. (Which brings us full circle after 2,000 years to pain as a "passion".) For instance, while lobotomized pain patients say they can still feel pain, they also admit that it no longer bothers them, suggesting a change in attitude toward the pain.

At first glance, a lobotomy sounds like the ideal treatment for central pain patients. But unfortunately it carries grave risks. In some patients it adversely affects personality or intelligence. So Jane is pessimistic about treatments that are currently available to help these patients. But he is optimistic that science can come up with better approaches. The other pain authorities at the seminar agreed with him. They believe that the best way they can help these patients, and all pain patients, for that matter, is by better understanding the physiology and biochemistry of pain. And at the moment they have a hot lead.

Within the past year, John Hughes of the University of Aberdeen, Scotland, and several other biochemists have identified a molecule naturally present in the brain that has the same affinity for nerve cells that morphine has and that is blocked by the same agents (SN: 11/22/75, p. 327). Hughes has since purified the molecule and has synthesized it. It's a peptide; he calls it "enkephalin."

John C. Liebeskind, a psychologist and pain researcher at the University of California at Los Angeles, visualizes the synthetic enkephalin or a chemical analog of it being used to treat pain patients without some of the side effects of morphine. But Perl isn't particularly confident that enkephalin really is the answer since it would probably be tough to get it to reach a targeted pain area of the body. He is confident that enkephalin is going to open new avenues to understanding the nervous system and treating neural disorders including pain. Polypeptides similar to enkephalin have now been found in sensory neurons and other neurons of the central nervous system, and some of them act as neurotransmitter chemicals. So it's possible that there may be a network of pain-relieving neurotransmitters in the central nervous system, and that they may eventually be manipulated to relieve pain. □

CIA climate report: Assessing impact

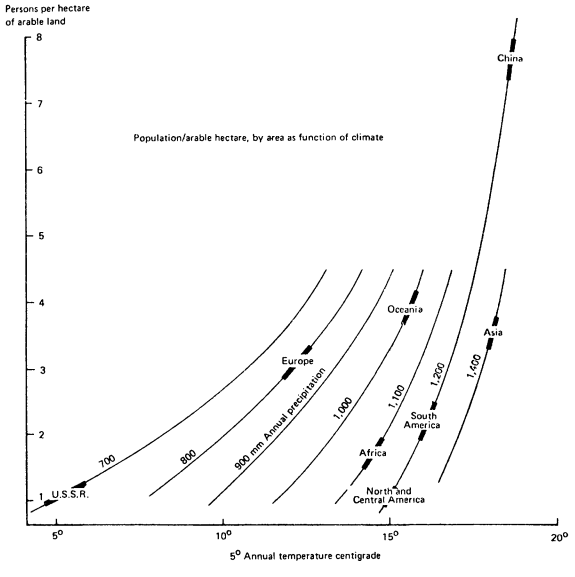
A just-released internal working paper of the Central Intelligence Agency concludes that apparent climate changes will result in new political alignments among nations to insure a secure supply of food and that "assessing the impact of climatic change on major nations will, in the future, occupy a major portion of the Intelligence Community's assets." The report, prepared by the CIA Office of Research and Development, calls for "decisive action" in developing new methodologies for climate forecasting and impact assessment.

"The western world's leading climatologists have confirmed recent reports of a detrimental global climatic change," says the report—a change that "brings a promise of famine and starvation to many areas of the world." Traditionally, such climate changes have been countered by migration to more favorable areas, but now "the world is too densely populated and politically divided to accommodate mass migrations." Though intelligence agencies do not yet have analytical tools capable of predicting what accommodations will occur, "the economic and political impact of a major climatic shift is almost beyond comprehension."

The study contains no startling new scientific revelations—the basic climatological data has been discussed for years (SN: 3/1/75, p. 138). Indeed, the report was prepared in August, 1974, some four months after the agency sponsored a meeting of climatologists in San Diego to resolve differences of opinion. There the authorities were able to reach a consensus on at least some key issues: that a global climate change is indeed taking place; that a reversion to favorable conditions will not soon occur; and that increased variability in climate conditions affecting crops is highly probable.

The study borrowed heavily from the pioneering work of climatologist Reid Bryson and his colleagues at the University of Wisconsin (SN: 12/13/75, p. 381). From this work, the CIA concluded that if the climate should return to that of the "Little Ice Age" (A.D. 1600 to 1850) India could support only three-fourths of its present population, China would need to import as much as 50 million tons of grain a year to prevent famine, the Soviet Union would lose Kazakhstan for grain production, and Canada would lose 75 percent of its grain export capacity.

Unfortunately, the report suffered a sloppy debut that could only hurt its chances for stimulating useful discussion. Some news stories credited Bryson with writing the report, which the CIA, with its traditional secrecy, would neither confirm nor deny. (Individual authors outside the agency do occasionally receive contracts to produce this sort of work.) Other rumors had the climatologist at least mak-



The effect of climate changes: As temperatures drop, the number of people sustained by arable land decreases. Europe, for example, now supports three persons per hectare; if the temperature drops three degrees, only two people could be supported.