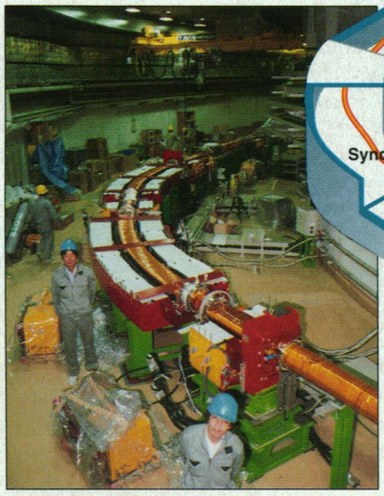
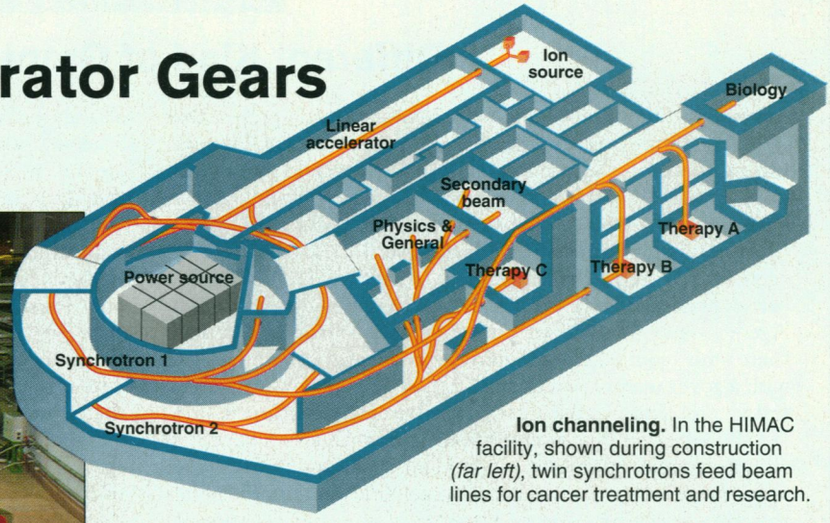
JAPAN

A Heavy Ion Accelerator Gears Up to Fight Cancer





SOURCE: HIMAC ILLUSTRATION: L. OWENS

Ion channeling. In the HIMAC facility, shown during construction *(far left)*, twin synchrotrons feed beam lines for cancer treatment and research.

As the debate over health care costs heats up in the United States, pricey high-tech medicine has reached a new height on the outskirts of metropolitan Tokyo. There, in the town of Chiba, accelerator physicist Yasuo Hirao and his crew are putting the finishing touches on the Heavy-Ion Medical Accelerator in Chiba (HIMAC), the first large accelerator in the world to be built solely for medical purposes. The $300 million facility, designed by Hirao, is now in the last stages of testing; next March, it will begin bombarding dozens of cancer patients per day with an assortment of ions, administering some of the most expensive cancer treatment anywhere.

The accelerator is a legacy of former prime minister Yasuhiro Nakasone's 10-year multifaceted anticancer campaign, announced in 1984. Encouraged by decades of research results suggesting that heavy ions can destroy some tumors more effectively than x-rays or chemotherapy, the Science and Technology Agency (STA) decided to build a facility capable of testing the promise of heavy ions on a large scale. Researchers who have been studying heavy-ion cancer treatment in the United States say they're envious. Says Bill Chu, a physicist at the Life Science Division of Lawrence Berkeley Laboratory who studied the biological effects of heavy ions at LBL's Bevatron until it was shut down last February, "The clinical research is at a stage where it should be tried in the hospital setting.... HIMAC responded to that need."

Not that cancer researchers are expecting a magic bullet. Pathologist Setsuo Hirohashi of Japan's National Cancer Research Institute says he expects the heavy ions to be effective at shrinking primary tumors but points out that "the most common reason for the failure of cancer treatment is the presence of metastases at the time of treatment." And the cost is raising some eyebrows. Says accelerator physicist Dieter Böhne of the Institute for Heavy-ion Science in Darmstadt, Germany, "It is a pity that this project has solidified the opinion that heavy ions are inherently expensive." On top of its construction costs, HIMAC will cost about $50 million per year to run—about $50,000 for each of the 1000 patients who will be treated at the facility each year.

The lure of the technology stems from the fact that the high mass and charge of heavy ions enables them to pack more destructive power than x-rays. What's more, most of that power is released at the end of the particles' flight, when they have slowed down enough to interact with DNA chains. That helps restrict the ions' destructive effects to the tumor—as does the fact that the charged ions can be focused and scanned with electromagnetic fields, resulting in much finer aim than is possible with x-rays and gamma radiation.

Some of those advantages had been put to the test well before Hirao proposed HIMAC in 1979. Researchers at Japan's National Institute of Radiological Science (NIRS) and at U.S. laboratories, especially LBL, had been sharing time on physics facilities to gather data on the effects of light and heavy ions on cancer cells. The bottom line, says Hirao, is that "the heavy-ion accelerator has been found to be the absolute best source for concentrating radiation just within the tumor."

To exploit this promise, Hirao's team designed a facility that includes a pair of synchrotrons, each 130 meters in circumference, which accelerate ions to between 100 and 800 million electron volts. That design will make it possible for technicians to zero in on tumors with both horizontal and vertical beams, concentrating as much radiation as possible within the tumor. In May, engineers tested the linear accelerator that will supply ions to the synchrotrons; testing of the synchrotrons is scheduled for this fall.

For most tumors, HIMAC will accelerate relatively light ions such as neon and carbon. Heavier ions, such as silicon, will be reserved for very radiation-resistant tumors, providing they are shallow. While heavier ions are more effective at destroying a tumor, explains Hirao, they also cause more havoc along the way, making their effects less localized. And precise targeting is HIMAC's goal. Along with the accelerator, which can deliver the beam with a precision of a few millimeters, the facility will include MRI and PET scanners for pinning down tumor sites.

The result, says Tadaaki Miyamoto, head of the Particle Beam Therapy Division of Radiological Medicine at NIRS, should be cure rates for eye, head and neck, and lung cancers better than can be achieved with standard combinations of x-rays, surgery, and chemotherapy. The facility should also point to the most effective ways of combining heavy-ion therapy with other treatment strategies. Says radiologist Joseph Castro of the University of California, San Francisco, "In combination with other forms of cancer treatment, this should provide a higher level of control of the cancer with fewer side effects." And both Japanese and foreign basic researchers will use equipment at nights and on weekends to study mechanisms of DNA and cell damage and develop 3-dimensional irradiation methods and new radioactive scanning techniques.

Though HIMAC—and a similar facility proposed for Hyogo Prefecture—will guarantee Japan a position as world leader in heavy-ion cancer therapy for a while, Japan's lead may not last. Chu notes that Europe already has medical accelerators, such as EULIMA (EUropean Light-Ion Medical Accelerator), on the drawing board; meanwhile, the University Clinic of Radiology, Heidelberg, and the German Cancer Research Center (DKFZ) are planning collaborative medical research with German accelerator centers. If HIMAC lives up to its builders' high hopes, a crop of imitators may follow. That's something for Hillary Rodham Clinton's task force on health care costs to ponder.

–Fred Myers

Fred Myers is a science writer in Tokyo.