

Military's environmental medicine research pushes limits of human endurance

There's only one place in Canada where you can climb 100 000 feet by stepping through one door and drop to a depth of 5000 feet by stepping through another. Toronto's Defence and Civil Institute of Environmental Medicine (DCIEM, www.dciem.dnd.ca), a little-known human-factors research facility, pits men and women against the environment by simulating high altitudes, great depths, powerful acceleration forces and temperatures ranging from -60°C with 50 km/h winds to 45°C with 95% humidity. "We're one of the few places in the world where all the disciplines come together," says Colonel David Salisbury, the physician who serves as deputy director general at DCIEM. "We're small by world standards, but we're complete."

Dr. Manny Radomski, the director general, is more effusive: "We're probably one of the top international, elite research institutions in the world." Better, he says, than its US counterparts, where cutbacks have led to contracting out. "We have the only altitude research facilities and the only [acceleration] research facilities in North America. Some say we're Canada's best kept secret."

DCIEM was founded in 1939 by Nobel Prize winner Sir Frederick Banting and moved to CFB Downsview in north Toronto in the mid-1950s. These days, the mammoth brick buildings house 130 civilian and 60 military personnel, many with PhDs. There are also 6 physicians, including 4 who practise aerospace medicine, an internist who specializes in travel and tropical medicine, and another who specializes in post-traumatic stress.

They work on both military and civilian projects. The facility has already garnered 97 patents for its innovative products, ranging from antigravity suits to artificial blood. Currently, it helps the Canadian Standards Association set values for noise protection and life jackets, and it has contracts with the US Navy and Boeing Aerospace. The largest ongoing contract involves testing children's car seats on its pneumatic crash track — the only one of its type in Canada.

DCIEM, 1 of 5 military research centres in Canada, also collaborates with other military forces. It is currently con-

ducting research on African sleeping sickness for the French army. And it is closely aligned with 8 universities and 5 Toronto hospitals. In one project, the University of Toronto is supplying ophthalmology expertise while DCIEM provides experts in hypobaric physiology to assess the effect of altitude on patients who have undergone laser surgery for retinal detachment.

But the institute's primary function is to support the Canadian Forces. In the air-tight thermal unit, researchers are trying to determine if modafinil, a drug used to treat narcolepsy, is affected by high temperatures. In an adjacent room, researchers are testing clothing in the world's largest freezer, which can produce temperatures of -100°C (with wind chill). Outside sits a peculiar inflated stretcher — a forced-air warming system for hypothermia patients (see photo).

But how well will new equipment work in the field? "We're always looking at human-factors input," says Radomski. Even simple things like helmets must be assessed, and tracked vehicles for use in the Arctic must be able to accommodate drivers in full winter gear, including mukluks.

Salisbury led the way to the world's deepest diving facility — capable of pressurizing to a simulated depth of 5000 feet, and ideal for testing equipment and personnel. In fact, DCIEM's decompression tables are in universal use for sports diving. The 3-part chamber, which resembles 3 giant drug capsules, features a wet, transfer and living chamber, since decompression from a depth of 700 feet can take up to a week.

In its altitude chambers, meanwhile, the institute conducts research with NASA and the Canadian Space Agency. They are trying to reduce the amount of time astronauts have to pre-breathe oxygen before going on a space walk in order to avoid decompression sickness. So far, researchers have been able to reduce pre-breathing time from 12 to 2 hours.



A portable forced-air warming system that suspends hypothermia patients on a bed of air is used on search and rescue missions.

"Whatever it takes to increase performance or protection of aircrew, we're willing to do it," says Commander Bill Bateman, the physician who heads the Aerospace Life Support Section. It studies gravity protection, spatial disorientation, life-support equipment and human-factors accident investigation.

Not only did DCIEM develop the first antigravity suit, but the institute has also produced what Radomski says may be the world's best protective equipment for aircrew flying high-performance jets. The STING (Sustained Tolerance to INcreased G), now being manufactured, increases tolerance to 9 Gs. Previous equipment has provided a combined natural and suit tolerance of about 6 Gs. DCIEM is now combining the STING suit with a pressure breathing device that increases pressure in the lungs, thus increasing blood pressure.

There is also intense research into spatial disorientation, which involves the erroneous perception of an aircraft's position relative to other planes and the ground. It is a major cause of aircraft losses; from 1982 to 1992, 20% of losses were caused by spatial disorientation.

Meanwhile, DCIEM's new, standardized, universal escape system for helicopters is being installed in US Coast Guard aircraft. (To help pilots who have to ditch in water, the insulating properties of new immersion suits developed by DCIEM make them comfortable at 30°C in the aircraft or 4°C in the water.)

A number of nonmilitary spinoffs may result from DCIEM's research. For example, G-suit and altitude research

may contribute to noninvasive cardiovascular monitoring to treat respiratory failure. "As an MD I can see all sorts of clinical applications," says Bateman.

One of DCIEM's major projects involves an artificial blood, Hemolink, which will soon be sent to the US Federal Drug Administration for approval. The new "blood" will provide unlimited quantities of a non-type-specific product.



DCIEM's new immersion suits, worn by military pilots, have special insulating properties that make them comfortable at 30°C in the aircraft or 4°C in the water.

Dr. Pang Shek, head of the Biomedical Sciences Section, says most of the institute's medical R & D work involves military trauma such as explosive-related injuries and postoperative challenges such as sepsis and shock. It is also developing artificial skin for use in wound management. Though promising, Shek says the product is still 5 years away from its first trials.

On the second floor at DCIEM, 6 young men mill about a table, nervously awaiting their next test in their quest to become a military pilot. DCIEM is a world leader in assessing aircrew for the military and civilian airlines, with about 400 candidates passing through its doors annually.

Candidates for the Canadian Space Agency and Canadian Forces pilot training program endure a battery of physical and psychological tests for more than 2 days. Under the watchful eye of flight surgeon Gary Gray, these half-dozen men undergo ECG, pulmonary function testing, echocardiography, cardiovascular stress testing, arrhythmia detection and more.

So far, data have been gathered on 15 000 personnel, which gives the Canadian Forces Medical Service a unique medical database that helps answer epidemiologic questions. Baseline and subsequent blood testing provide information on serial changes over a career. As

well, a 13-country, 1500-subject study looked at the effects of high gravity on the hearts of fighter pilots by comparing their test results with those of transport pilots. "There are no long-term changes," notes Gray.

Meanwhile, DCIEM's School of Operational Medicine trains physicians to be flight surgeons and diving medical officers. "Medicine teaches us to treat people with abnormal physiology in normal environments," says Commander Cyd Courchesne, the physician who heads the Medical Assessment and Training Section. "We treat normal people in abnormal environments."

Certainly the medical issues handled by flight surgeons, such as decreased oxygen, increased gravitational pressure and chronically fatigued transport aircrew, can be serious. Each year about 20 students, including military physicians from other countries and civilians, take the 6-week course. Salisbury, who is doing his second tour at DCIEM, says the institute is a "dream job" for medical researchers, simply because "there are so many interesting projects on the go." —

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Reference

1. Shephard RJ, Castellani JW, Shek PN. Immune deficits induced by strenuous exertion under adverse environmental conditions: manifestations and countermeasures. *Crit Rev Immunol* 1998;18:545-68.