BEST BREAKTHROUGHS

Canadian scientists are revolutionizing patient care and research knowledge—as these four exciting advances make abundantly clear **By Celia Milne**

Amid alarming health headlines and concerns about the future of medicare, it's inspiring to remember that Canadian researchers and doctors are second to none in pioneering medical innovations. Whether they're isolating genes involved in type 2 diabetes or unveiling a seismic shift in stem cell thinking, our scientists are dedicated to improving our health. "Canadian education and research is well respected throughout the U.S. and the rest of the world," says Dr. Michael Neumeister, chair of the plastic surgery division at Southern Illinois University (and a Canadian himself). We spoke to researchers across the nation to identify the medical advances that will change—and potentially save—our lives.

RECONSTRUCTING BREASTS—AND SELF-ESTEEM

Jackie Stephen remembers the way her grandmother's chest looked after the mastectomy—it was a "constant reminder" of the breast cancer she'd survived. When Stephen herself developed breast cancer 30 years later, the outcome was very different, thanks to a revolutionary technique perfected by Dr. Edward Buchel, a reconstructive surgeon at the Health Sciences Centre in Winnipeg. Called a deep inferior epigastric artery perforator (DIEP) procedure, it allowed her surgical oncologist to remove the diseased breast, and Buchel to rebuild it, using harvested skin, blood vessels and fat from her lower abdomen. The beauty of the new procedure is that it leaves the muscle on the abdomen intact. "There is no functional loss, less pain, a quicker return home and fewer narcotics," says Buchel.

The dual surgery sounds frightening, but is certainly preferable to disfigurement. Stephen, a 49-year-old marketing director living in Winnipeg, was told she should have a full mastectomy after her breast cancer diagnosis in early 2007. "The cancer experience comes as a shock—you're trying to be brave for your kids, while your emotions are running amok," says Stephen, who has an 18-year-old daughter and a 14-year-old son.

Buchel learned this intricate surgery while studying in Asia and working at the Mayo Clinic in both Rochester, Minnesota and Scottsdale, Arizona. It's his refinements to the technique that are most noteworthy, however. In 2007, for instance, Buchel and his partner also started offering women the transverse upper gracilis (TUG) procedure, which takes tissue from the upper inner thigh. And in 2008, a special surgical device called a near infrared spectroscopy monitor was introduced, reducing post-operative complications.

Buchel and his surgical partner now offer breast reconstruction to every woman in Manitoba who undergoes a mastectomy—400 cases a year. "What's revolutionary is that it's not just a great new technique, but that we made it the routine in Manitoba," he says. Observing from Illinois, Neumeister is impressed. "What Dr. Buchel has done in →

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Jackie Stephen's DIEP procedure inspired her to found "Keeping Abreast" to raise funds for breast cancer reconstruction surgery, research and education.

Winnipeg has transformed the care of many women in that part of Canada."

As for Jackie Stephen, she is very grateful to Buchel. "I went in with two breasts and came out with two breasts," she says. "I still felt like myself–a little beat-up, but I didn't mourn the loss of a part of me. Sometimes I can even forget I've had cancer."

PROVIDING A BETTER LOOK AT OUR BODY, TODAY AND TOMORROW

Imagine you and your doctor looking at a larger-than-life 4-D image of you. Using computer technology, you peer inside your virtual body and see your problem, whether it is a brain lesion, a broken leg or a blocked artery. Futuristic? Not any more. Scientists in Calgary recently announced the completion of CAVEman, the most detailed computer model ever made of a human body. CAVEman has 3,000 movable body parts. When viewed in a special cube-shaped room (the "cave"), the virtual human has height, width and depth, and also gives researchers the ability to predict and dramatize health changes over time.

"It is very exciting, like *Star Trek*," says Christoph Sensen, the inventor of CAVEman and director of the Sun Center of Excellence for Visual Genomics at the University of Calgary faculty of medicine. CAVEman, which took six years to complete, will be used for education, planning surgery, testing disease treatments and showing patients what their injuries look like.

Scientists can load diagnostic tests such as MRI images, CAT scans, X-rays and even genetic data into CAVEman. Already, the model is being used to study the effects of a multiple sclerosis drug on patients' brains. "This has the possibility to prolong the life of those with MS," says Sensen. While CAVEman exists only in Calgary at the moment, developers are creating a spin-off company to market it elsewhere.

DECODING DIABETES RISK

Thanks to groundbreaking research in Montreal, doctors in the near future will be able to pinpoint who is genetically susceptible to developing diabetes, and help prevent or treat the condition. McGill University researchers found four genes involved in type 2 diabetes. "It is a world first, and Canada led the way," says Dr. Constantin Polychronakos, a professor of pediatrics and human genetics at McGill University and one of the research leaders. Adds Andrew Hattersley, a professor of molecular medicine at the Peninsula Medical School in Exeter, England: "They discovered new secrets about why some people get diabetes and others do not."

Of the more than two million Canadians who have diabetes, 90 percent have type 2 diabetes, which is the fastest-growing type. It is thought to be caused by a combination of genetic susceptibility and environmental factors, such as obesity. The disease is a major cause of death and disability, and is associated with blindness, amputation, kidney failure and heart disease when not managed properly. Currently, one in three people with diabetes don't know they have it.

Using new, lightning-speed technology, the researchers studied the DNA of 700 people with type 2 diabetes and 700 people without the condition. The team, including Polychronakos and Dr. Robert Sladek, also from McGill, and Dr. Philippe Froguel from Imperial College in London, England, looked for genetic differences between the two groups. The Canadian discovery of four genes provides a critical contribution to the worldwide quest to identify all of the genes involved in type 2 diabetes. "There are 11 genes now, and probably 10 to 15 more will be found," says Polychronakos, who estimates that all will be identified within a couple of years.

"That information will allow us to do genetic prediction," Polychronakos says. These findings have special value for women because doctors will be able to predict who is prone to gestational diabetes mellitus (GDM), a dangerous type of diabetes that can be prevented, but currently affects about four percent of Canadian women during pregnancy.

The next step is genetic testing, which Polychronakos estimates will start in three to four years. Testing would allow individuals to begin lifestyle modification sooner, thereby altering their chances of getting sick. Within a decade, diabetes medications tailored to an individual's genetic makeup will also be available. "Knowing the gene profile of each individual means we can find the best treatment for them," he says.

CONTROLLING STEM CELL DEVELOPMENT

Stem cells—the tiny, crucial cells from which cells in our bodies grow—are the building blocks of all human tissue, including skin, muscle, bone, heart, liver and brain tissue. They can also form cancerous growths; consider them stem cells gone bad.

Scientists worldwide understood that stem cells lived in a microenvironment, or niche. In a landmark discovery, Canadian researchers have now identified that embryonic stem cells produce distinctive niche cells themselves, and that these niche cells feed the parent cells. It is such a fundamental finding that textbooks will have to be rewritten and university science curricula changed to incorporate the discovery, says stem cell researcher Mick Bhatia, scientific director of the Stem Cell and Cancer Research Institute at McMaster University.

Manipulating the niche, or stem cell microenvironment, could enable researchers to generate specific types of tissue. For instance, says Bhatia, "we want to make neurons out of stem cells and transplant those neurons into the brains of those who have Parkinson's." (This degenerative disease involves the loss of dopamine-producing brain cells.)

The finding also has implications for cancer treatment. "We might be able to kill tumours by cutting off the nutrients [to stem cells]," explains Bhatia. "Instead of killing the cancer cells, we can just starve them." Although it will probably be five to eight years before this discovery has a tangible impact on Canadians, the scientific world is already richer for it. □