THE MYSTERIOUS STEM CELL
What's possible?

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FEBRUARY, 1961. An article is published in Radiation Research by Drs. Ernest McCulloch and James Till, entitled, A direct measurement of the radiation sensitivity of normal mouse bone marrow cells.

FEBRUARY 2, 1963. McCulloch and Till, with a graduate student, Dr. A.J. Becker, publish Cytological demonstration of the clonal nature of spleen colonies derived from transplanted mouse marrow cells in Nature.


CUT TO TODAY, 47 YEARS AFTER THAT LAST ARTICLE. What have come to be called ‘stem cells’ represent a possibility that boggles our minds – that there really could be a serious, realistic way of actually curing the ills that devastate so many people around the globe. Diabetes. Damaged hearts, livers and kidneys. Spinal cord injuries. Cancer. Alzheimer’s disease. Blindness. Parkinson’s disease.

Generations of scientists and hopeful patients have been energized by the promise of Ernest McCulloch’s and James Till’s pioneering work that was described in those articles from the early 1960s.

In medical research, that discovery created a promising vista of wondrous possibilities. And it came from the brilliant work of McCulloch and Till, two University of Toronto professors and scientists at the Ontario Cancer Institute (now the research institute of Princess Margaret Hospital).

In the late 1950s, McCulloch and Till had been conducting research on the effects of radiation on mice, with the intention of transplanting various numbers of bone marrow cells into irradiated mice. Their question: Was there a direct relationship between the number of marrow cells transplanted and the number of mice prevented from dying of bone marrow failure?

“…that had obvious implications for the possibility of nuclear warfare where troops would be exposed to total body radiation and if there could be a bank of normal marrow set aside they might be then subsequently rescued, even after exposure,” Till told CBC Radio’s Bob McDonald in an interview on the Quirks and Quarks program in 2005.

But in conducting that research, McCulloch and Till found something else. “It came about, as so often happens, as an incidental result on an experiment done for a completely different reason,” said McCulloch in the same interview.

After injecting normal bone marrow cells into the
Their work has resulted in a wave of new work that is redefining what we know and what is possible. This field of research is exploding.” Janet Rossant told the University of Toronto Magazine earlier this year. Rossant, professor of molecular genetics at U of T and chief of research at the Hospital for Sick Children, is herself a stem cell scientist. “Stem cell research is going to be quite revolutionary in the way we think about human disease, allowing us new ways to understand disease, as well as new ways to develop and deliver therapies.”

One of the most recent advances has come by way of the work of Shinya Yamanaka of Kyoto University. In 2006, he discovered that he could reprogram adult stem cells to function as embryonic stem cells – a discovery of becoming any tissue in the body – simply adding four genes to the equation.

Within a year, his idea was to file when he and his colleagues successfully altered human skin cells back into embryonic-like stem cells. Today, hundreds of scientists across the globe are using Yamanaka’s technique – now coined “induced pluripotent stem (iPS) cells.”

Among this group are U of T scientists James Els and William Stanford (see page 11) who co-direct the Ontario IPS Cell Facility, an institute that collaborates closely with Yamanaka and his team, and Rossant, who oversees the Ontario Initiative in Personalized Stem Cell Medicine where Yamanaka chairs the external advisory board. The Province of Ontario invested $10 million in the initiative in 2009. And other funding bodies, such as the Canada Foundation for Innovation, have injected millions of dollars into stem cell research, supporting a Canada-wide stem cell community that is enhancing our understanding of the country’s competitiveness in this hot field.

In fact, it is becoming clear that collaboration is the key to understanding the tremendous possibilities of stem cell research into real therapies. “We’ve built quite a stem cell community here in Toronto and there are groups in Ontario and across the country now that are all interacting, sharing research, building on each other’s ideas,” Rossant told EDGE. “Because in the end, if we’re going to make a difference, we have to pool our resources. Every group has different strengths and you have to bring them together in different combinations. If we don’t all exchange the best ideas, it will just take us that much longer to make advances. If we want to use iPS cells to develop stem-cell therapies, we need to be working together.”

In 2006, Shinya Yamanaka – a scientist from Kyoto University – discovered induced pluripotent stem cells that can be genetically altered skin cells that function much like embryonic stem cells. Other sources include fetal stem cells (derived from an embryo after eight weeks of growth) and cord blood stem cells (derived from the umbilical cord and placenta).

Note: In Canada, embryonic and fetal stem cells used in research are derived from unused embryos from in vitro fertilization.

Why are stem cells important?

Stem cells provide the raw material needed for drug testing and cell-based therapies. As a result, new treatments for a wide range of conditions including diabetes, heart disease and numerous forms of cancer are being developed by U of T researchers and scientists across the globe.

Stem cells 101

What are stem cells?

Stem cells are unspecialized cells. Because stem cells are unspecialized, they can give rise to numerous specialized cells, such as brain cells, heart cells or muscle cells. When a stem cell develops into a specialized cell, the process is known as differentiation.

Stem cells also go through another process referred to as proliferation – meaning they can multiply over and over again. When stem cells proliferate they can either remain unspecialized cells or under the right conditions differentiate into a specialized cell, such as a brain cell.

Where do they come from?

Until recently, scientists dealt primarily with two types of stem cells: embryonic stem cells (derived from a five-day-old embryo) and adult stem cells (taken from adult tissues, such as the brain or heart). Embryonic stem cells can differentiate into any cell type. Adult stem cells, on the other hand, can only differentiate into cells related to the original tissue.

In 2006, Shinya Yamanaka – a scientist from Kyoto University – discovered induced pluripotent stem cells that can be genetically altered skin cells (from Kyoto University) – discovered induced pluripotent stem (iPS) cells. A breakthrough in biological sciences, the iPS cell is a form of stem cell that is similar to an embryonic stem cell. Unlike embryonic stem cells, which can only develop into specific types of cells, iPS cells are pluripotent, meaning they can develop into any cell type in the body.

Stem cells are formed during the process of differentiation, which occurs in the womb. They are responsible for the development of all the different cell types in the body, including the cells that make up our blood, nervous system, and immune system. Stem cells are also important for the repair and regeneration of tissues and organs. They are found in many parts of the body, including the bone marrow, skin, and brain.

Stem cells are of two types: embryonic stem cells and adult stem cells. Embryonic stem cells are derived from the inner cell mass of an embryo and have the potential to develop into any cell type in the body. Adult stem cells are found in various tissues and organs throughout the body and have the ability to renew themselves and differentiate into different cell types. These stem cells are usually associated with the ability to regenerate or repair damaged tissues.

Stem cells provide hope for the treatment of many diseases and conditions, including diabetes, heart disease, and certain forms of cancer. They are also being used in the development of new treatments for diseases such as Parkinson’s and Alzheimer’s. Stem cell research is an exciting and rapidly advancing field, and scientists are working to better understand the potential uses of these cells for the benefit of human health.
Cancer fighter

John Dick discovers cancer cells are not created equal by Karen Ramulli

John Dick, a University Health Network researcher, profiled in molecular genetics at U of T and Canada Research Chair in Stem Cell Biology, is changing the way we think about cancer and offering new hope for curing some forms of the disease.

It was during Dick’s research on new treatments for leukemia in the 1990s that he discovered leukemia-causing stem cells and the revolutionary concept that not all cancer cells are the same. Since then, other researchers have found cancer-causing stem cells in the brain (See below, bulding the cause of brain tumors) and breast.

Cancer stem cells act like parent cells from which all other cancer cells develop. They seem to fuel the uncontrolled growth of certain types of cancer and unlike other cancer cells, can grow very slowly, making them resistant to anti-cancer drugs.

“Most kinds of chemotherapy are designed to kill fast-growing cancer cells,” explains Dick. “This is why leukemia can come back after treatment. To get rid of the cancer, you have to find ways of eliminating the cancer stem cells.”

Dick recently made international headlines by finding a way to do just that.

In a study using mice, he used an experimental anti-cancer drug that interferes with a specific protein on the cancer stem cells to cure acute myeloid leukemia (AML) in mice.

Leukemia stem cells need this protein to help them navigate their way to special parts of the bone marrow— the only place they can live and thrive. By blocking the proteins, Dick was able to prevent the stem cells from travelling to the marrow to grow and multiply into AML.

All of the mice in his study had a reduction in AML and some were completely cured. Dick’s research reveals the changes a normal cell undergoes to become a leukemia stem cell (identifying which genes and molecules might be working together in the process).

Ultimately, the research is designed to understand the properties of these stem cells that make them unique so we can then use the knowledge to devise even more effective therapies to kill them.

Cracking the mystery of bone

Jane Aubin takes on the challenge by Jennifer Hsu

Bone has the capacity to regenerate throughout life. By this reasoning, there should be an endless pool of cells within the human body that nourishes this restoration.

If this is actually the case, why is bone loss a major worldwide medical problem that represents 10 per cent of annual health care expenditures?

Professor Jane Aubin of Molecular Genetics has found that skeletal stem cells actually decrease with age and have intrinsic distinctions that cause the bone cells to behave somewhat as an older versus younger body.

“These two factors together sparked my interest in determining how to alleviate that disparity. There are so many people who suffer from arthritis and osteoporosis. The potential societal impact of finding an answer would be huge,” says Aubin.

To this end, Aubin and her team are trying to grow bone by approaching the problem from a number of perspectives.

First, they’re looking at three protein molecules related to the receptors that bind and produce estrogen effects. Hormones such as estrogen play an important role in bone turnover and strength. Specifically, as estrogen levels drop, bone begins to weaken.

“We know that two of the three protein molecules we’re investigating have completely opposite effects in bone and cartilage cells. Using drugs to turn one off and the other on in the right direction might bump up bone mass.”

The team is also looking to further enrich skeletal stem cells to do gene and biological profiling to better understand the differences between the older and younger cells. Without thorough profiling, trying to get old cells to act like young ones is made more difficult.

In 2009, Aubin and her team drastically enriched skeletal stem cells and identified whole populations of cells that could regenerate the entire bone, including bone marrow.

“Getting rid of extraneous cells within skeletal stem cells populations still remains our biggest challenge. Although we had great success in 2009, we still need to get them pure if we really want to understand how to get the older cells to act like younger ones.”

Isolating the cause of brain tumours

Peter Dirks uses old tricks to fight new battles by Jennifer Hsu

Brain tumours are among the most sinister cancers known to humans. The most common form, glioblastoma multiforme, has a survival rate of only 15 months, even after conventional treatments.

It’s a disease that has no age bias. After leukemia, brain cancer — as a group of different tumours—is the second most fatal disease experienced by children.

It’s also known to afflict many people under the age of 40 with increasing incidence after 40.

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In the early 1990s, John Dick (see above, Cancer fighter) identified cancer stem cells in specific forms of leukemia and discovered that cancer cells aren’t created equal. This finding led Peter Dirks, senior scientist at the Hospital for Sick Children and professor of neurosurgery at U of T, to question whether the same holds true for brain tumours.

His hunch proved fruitful. “We learned that there’s only a sub population of brain tumour cells that have the ability to maintain and initiate tumour growth. Most of the cells in the tumour actually lose that ability. Through our research, we’re now able to isolate the stem cells that cause brain tumours,” he says.

By studying these cells in succession, as well as the non-cancerous ones in isolation, Dirks and his team plan to pinpoint the driving factors of tumour growth and the solutions that will shut down the cancerous cells.

“They’re already getting close. The group realized that old drugs can have new purposes. One of the challenges with brain cancer is getting drugs past an existing natural barrier. The brain wants to maintain strict control over its environment and as a result restricts drugs from getting into the nervous system. By testing drugs with proven access to the nervous system, Dirks and his team noticed that specific drugs already on the market have a collateral effect on brain cancer stem cells.

“These drugs are already being used by people, they have existing safety profiles. I think we’re only three to four years away from a clinical trial. For new drugs, it can take 10 years plus,” says Dirks.

While this is a huge accomplishment, Dirks believes getting other researchers to apply stem cell thinking to their cancer research is an even greater triumph. “A lot of the methodology we developed is now being used worldwide to study not only brain cancer but other cancers as well.”

From L to R: Peter Dirks, Jane Aubin and John Dick.
Understanding what regulates stem cell growth and implementing this understanding using technologies can help advance medical research and translation.

Peter Zandstra, a scientist in U of T’s Institute of Biomaterials and Biomedical Engineering and Canada Research Chair in Stem Cell Bioengineering, feels a strong sense of duty to do just that.

“I’m a chemical engineer by trade but I became interested in stem cell research during my PhD work. I was drawn to the complexities of stem cells and observed that engineering strategies and tools could be applied to develop a better understanding of how stem cells work and how new technologies could be created to move stem cell research forward,” he says.

To illustrate the complexity, Zandstra points to the use of stem cells to generate cardiac cells for heart therapy. “To treat heart attacks, doctors may need to replace damaged heart cells (cardiomyocytes) with several grams of heart tissue, requiring billions of cells. This cell amount is difficult to produce using current technologies. Our bioreactors produce cell environments that are carefully measured, controlled and designed to grow stem cells in the required amounts of cardiomyocytes.”

Zandstra and his team approach their work from a bioengineering perspective, incorporating mathematical modelling and microfabrication strategies—techniques not often used by stem cell biologists to reveal the underlying principles that regulate stem cell function.

The significance: mathematical models allow researchers to run simulations of many different experimental conditions at the same time. This, in turn, allows for the testing of several possible hypotheses and the selection of the most promising one. Zandstra and collaborators are using this approach to understand how transplanted cardiac cells and host cells communicate with each other to properly integrate and promote tissue healing.

What does this mean for the future? “Instead of growing cells and then transplanting them into a patient for treatment, which is where most of the field is going right now, we’re investigating if it’s possible to modify the stem cells already in our body using drugs that induce regenerative healing from inside,” says Zandstra.

U of T’s Associate Vice President, Research, Professor Peter Lewis notes that U of T’s Innovations and Partnerships Office and MaRS Innovation are working with U of T scientists including Zandstra to develop stem cell applications.

“One of the exciting things about conducting our research in Toronto is that it’s home to so many stem cell researchers studying different aspects of stem cell biology,” says Zandstra. “All the various pieces needed to solve the stem cell puzzle are in place. We provide the bioengineering discovery and translation part, while others provide a development or genetic engineering perspective. You can go right from discovery to therapy all in the same place.”
A roadmap to solving blood shortage

Julie Audet’s family tree model explains cell fate by Jennifer Hsu

This story is about a subject you literally cannot live without—blood. It carries oxygen and other vital nutrients to every part of your body. Unfortunately, there’s an annual shortage of 22 million units worldwide.

The global population is growing and a huge percentage of that population needs access to blood, such as cancer, surgery, trauma, burn and chronic disease patients. One of the biggest problems is that donated blood only lasts 42 days and it has to be refrigerated, without which it would spoil.

One of the big things we’re interested in now is where do brains come from in the embryo? How does the embryo actually decide to produce a brain? To do this, van der Kooy and his team have isolated a ‘primitive neural stem cell that we think is the very first brain cell in the developing embryo. And we think this cell gives rise to the definitive neural stem cell, which lasts from the moment the embryo is formed right up into adulthood.

With the translational work, van der Kooy’s team has been able to conduct some interesting applications. One of them is with the eye. The eye is known to grow out of the brain, so this has been a natural extension of our work. The eye is actually neural tissue. We’ve been able to isolate retinal stem cells. We started our research using mice, but we have recently been able to use human adult eyes (donated when people have died to the Eye Bank of Canada). As long as we can get the eye within 24 hours of death, we can isolate 10,000 stem cells and expand them to millions of cells. That means we can grow all kinds of new retinal cells from human eyes.

And with those cells, the van der Kooy team has been able to actually restore some sight in mice that have been bred to be born blind. “We can give the mice just a miniscule amount of vision, but even that is exciting.”

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The essence of this work—and that of stem cell research and application in general—is that it means scientists have to do the most difficult task imaginable—truly understand the genius of nature in creating this force we call life.

Derek van der Kooy’s stem cell research functions as a roadmap leading to the maximum yield.”
The cell maker
For Gordon Keller, collaboration is the key by Paul Fraumeni

Just as the interview for this article is about to start, Gordon Keller, Canada Research Chair in Embryonic Stem Cell Biology, asks, “Have you ever actually seen a stem cell in a dish?”

That’s what he leads you through a series of hallowed halls to his lab situated in the Toronto Medical Discovery Tower at the MaRS Centre. He gathers members of his research team and asks them to set up slides under microscopes.

“Go ahead,” says one of the team. “Take a look.”

And there they are – the magical and mysterious stem cells you’ve heard about, the potential source of the elusive cures for conditions like heart disease and diabetes, right before your eyes. But why are they pulsing?

“Because we’ve generated heart cells from them,” says Keller. “So they beat like a heart.”

Back in his office, Keller, also director of the University Health Network’s McEwen Centre for Regenerative Medicine and a professor of medical biophysics at U of T, illustrates the science of stem cells and his own web of work. It’s a complicated, but Keller – a superstar in this field, named by New York Magazine as one of the six doctors New York City couldn’t afford to lose when he was director of the Black Family Stem Cell Institute at the Mt. Sinai School of Medicine – would have made a great high school science teacher. He makes stem cell science sound simple.

A major goal of his work is to use the stem cell-derived heart cells for transplantation to treat damaged hearts. This is a very long-term goal. There are more immediate applications, specifically using these cells for what he calls “predictive toxicology” or, the testing of drugs. “At the present time there is no method to test the effects of new drugs on human heart cells. With our ability to generate these cells from stem cells, we will have a constant supply of heart cells for evaluating potential toxic effects of new drugs, long before they are developed for the market. We believe this type of screening will eventually be used by pharmaceutical companies as part of their drug screening platforms.”

In another part of the lab, Keller’s team is using the same stem cells to create pancreatic cells that may one day be transplanted into diabetic patients, so they don’t have to rely on manually injecting insulin or using an insulin pump. “The possibility of using pancreatic cells to treat diabetes is likely a sooner-better option than using the heart cells to treat heart disease because there is still work to be done there as well.”

Collaboration is common in all of Keller’s work.

“What we do is totally collaborative. We are not experts in pancreatic or heart function. We can make different cell types, but then we need help. I could show you these beating cells all you want, but the question is, ‘What are you going to do with them?’”

So we collaborate. If you don’t collaborate, you don’t progress. That’s our overall focus at the McEwen Centre. “This collaborative spirit extends beyond the local community as Keller distributes the heart cells he creates to scientists in other countries including England, Germany and the US. And that’s why he came back to Canada. “When the opportunity came to direct the McEwen Centre, I thought, ‘U of T has a great stem cell community and the opportunity came to direct the McEwen Centre, I thought, ‘U of T has a great stem cell community and with the hospitals, a very large research enterprise. Here’s an opportunity to make things better and to do exciting things.’”

He’s doing just that.

Your skin: the answer to a healthy nervous system?

Freda Miller explores the reality by Jennifer Hsu

The nervous system is made up of the central nervous system (our brain and spinal cord) and the peripheral nervous system (the wiring that activates our five senses). It is a complex net through which the brain coordinates and controls all bodily functions; therefore, the nervous system is the network that relays messages back and forth from the brain to different parts of the body. It does this through the spinal cord, which branches out to every organ and crevice through the skin, which contains elements of the peripheral nervous system (PNS). These stem cells are able to regenerate if treated with cells derived from the peripheral nervous system. The obvious question arising from this is: Where could we obtain these cells without injuring the nervous system itself?

A team led by Freda Miller, senior scientist at the Hospital for Sick Children, professor of molecular genetics at U of T and Canada Research Chair in Developmental Neurobiology, discovered exactly where.

“The stem cells my team and I identified are from the second layer of the skin, which contains elements of the PNS. These stem cells are able to generate the cells that Aguayo showed could promote brain and spinal cord regeneration,” says Miller.

Miller’s research has drawn international and national attention. Her lab now collaborates with specialists in spinal cord damage at the University of British Columbia’s UBC Rick Hansen Institute.

“We grow all the cells in Toronto and then ship them to Vancouver where UBC transplants them into animal models. The results have been very exciting. The anatomical and functional locomotive recovery truly substantiates our ideas,” says Miller.

This partnership, which recently secured funding from the Canadian Institutes of Health Research and the Canadian Stem Cell Network, is currently moving towards implementing its ideas in humans.

“We’re at the point in our work where we’re asking ourselves: important questions to determine if we’re ready to move to clinical trials and to prepare for the process if and when the time actually comes. It’s possible we might be ready in as little as three years.”
Rare disease sheds light on common illness

William Stanford examines progeria and its heart-related complexes by Jennifer Hsu

In 1996, actor Robin Williams starred in the movie JACK – a story about a 10 year old boy suffering from an accelerated form of aging. Many of us may see this as pure fiction. But for the few, this is pretty close to their reality. Progeria is an extremely uncommon childhood disease that makes the body age 10 times faster than usual. Children suffering from this ailment will lose their hair and develop wrinkles and age spots, as well as respiratory, cardiovascular and arthritic conditions all before turning 10. Many pass away before the age of 13. There is no cure for this disorder, but it has given rise to scientific discoveries about heart disease. While progeria patients suffer from many health problems, they often die from either a heart attack or stroke. Through our work, we can develop a better understanding of heart disease and possibly develop new therapies,” says William Stanford, a professor at U of T’s Institute of Biomaterials and Biomedical Engineering and Canada Research Chair in Stem Cell Bioengineering and Functional Genomics.

Along with James Ellis (see below), Stanford co-directs the Ontario Human Induced Pluripotent Stem Cell Facility. The institute was established as a joint venture with Ryerson University and Shinya Yamanaka (see page 3), the scientist who created induced pluripotent stem cells (iPS cells) – reprogrammed skin cells that function like embryonic stem cells.

Through the facility, heart ailments have been replicated onto culture dishes by Stanford using iPS cells from progeria patients. Stanford believes better heart treatments for both progeria sufferers and the general public can be developed by learning more about the biological make-up of cardiovascular disorders. In Canada, someone dies every seven minutes from heart disease or stroke. Finding more effective treatments will have a positive impact on people suffering from these illnesses and on the Canadian health care system.

“The Progeria Research Foundation currently has several clinical trials underway. Our hope is to utilize the drugs the foundation will be testing on progeria patients to see if they have a favorable response to the cells we’ve created. If they do, there might be new treatments for heart disease soon. If the drugs don’t work, we will perform our own drug screens using the vascular cells derived from progeria patients to identify therapeutics for these children and other patients suffering from cardiovascular disease.”

Changing gears with safety in mind

James Ellis enters a new stem cell world by Jennifer Hsu

Switching professions for most of us can be frightening. For stem cell scientists like James Ellis, senior scientist at the Hospital for Sick Children and associate professor of molecular genetics at U of T, it’s a welcome situation. “When you’re working with stem cells, it’s liberating to take your research in a completely new direction,” says Ellis, who began his career by studying gene targeting, a process that directs genes to specific sites in the chromosome. During his postdoctoral fellowship, Ellis decided to adjust his focus and examined instead how to apply gene targeting, a process that directs genes to specific sites in the chromosome.

Today, Ellis’s research has transformed entirely. In 2008, he and his team were presented with the opportunity to work on a new technology called induced pluripotent stem (iPS) cells, and have already made huge scientific strides in the field. “By delivering a new reporter gene into skin cells, we’re able to see when the skin cells become iPS cells because they glow green,” says Ellis.

iPS cells are similar to embryonic stem cells, in the sense they can produce all cell types in the body. By making iPS cells from patients, the mechanisms of disease can be studied and the effectiveness of drugs or their toxicities can be evaluated in a petri dish. Although iPS cells come from reprogrammed skin cells, the innate danger of embryonic stem cells persists onto culture dishes by Stanford using iPS cells from progeria patients. Stanford believes better heart treatments for both progeria sufferers and the general public can be developed by learning more about the biological make-up of cardiovascular disorders. In Canada, someone dies every seven minutes from heart disease or stroke. Finding more effective treatments will have a positive impact on people suffering from these illnesses and on the Canadian health care system.

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iPS cells are similar to embryonic stem cells, in the sense they produce all cell types in the body. By making iPS cells from patients, the mechanisms of disease can be studied and the effectiveness of drugs or their toxicities can be evaluated in a petri dish. Although iPS cells come from reprogrammed skin cells, the innate danger of embryonic stem cells persists onto culture dishes by Stanford using iPS cells from progeria patients. Stanford believes better heart treatments for both progeria sufferers and the general public can be developed by learning more about the biological make-up of cardiovascular disorders. In Canada, someone dies every seven minutes from heart disease or stroke. Finding more effective treatments will have a positive impact on people suffering from these illnesses and on the Canadian health care system.

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The role of stem cells in plant growth is the focus of study for two researchers at the University of Toronto Scarborough (UTSC) – work that advances scientific understanding of plant development and may also have implications for agriculture and crop yields.

Biological sciences professors Daniel Riggs and Sonia Gazzarrini of UTSC study the genetics and molecular biology of Arabidopsis thaliana, a plant closely related to canola, from adjacent labs in UTSC’s new Science Research Building.

Riggs focuses on the genetics of various aspects of plant development, working to identify and characterize mutants. “Most people think of plants as food,” observes Riggs. “Modern agriculture has selected for crops that feed the world. We know of mutants that alter the architecture of plants, and of course in some cases, more branches mean more flowers on a plant, which means more fruit. Plant architecture also influences how effectively crops can be harvested.”

Many plants like wheat and canola are subject to lodging – flattening by wind and rain of seed-bearing stalks. This lodging renders the plants uncollectible by the harvesting machines that cannot reach stalks on the ground. “Traditional plant breeding approaches and/or genetic engineering to decrease a plant’s surface area or height can prevent lodging and enable a more effective harvest,” he says.

A large number of genes control stem cell maintenance, keeping the cells in a state in which they have the capacity to become any type of cell. He examines how mutants differ from normal plants and then aims to map and clone the genes responsible for these alterations to try to determine the signaling pathways that underpin the changes observed.

Gazzarrini studies the molecular mechanisms in plants that regulate their transition from embryos to vegetation, and looks at the effects of stem cells on the plant’s developmental processes. She focuses on seed development in genes that regulate the transition from seed dormancy to germination and play a major role in the accumulation of seed storage proteins.

“I’m interested in seed development because 60 per cent of the world’s food intake comes from grains – rice, wheat and corn – and yet very little is known about the mechanisms that regulate the accumulation of major nutritious compounds in seeds such as carbohydrates, proteins and lipids,” she says. “Furthermore, the mechanisms that control dormancy, dryness tolerance and germination in seeds are also poorly understood, yet these things greatly affect crop yields worldwide.”

The timing of seed germination is a major problem in agriculture, Gazzarrini says. In a humid environment, for instance, some dry seeds may germinate too early, while the bag of seeds is still stored in the barn or while the young seed is still attached to the plant. This results in wasted seeds – an economic loss as well as a decline in crop quality and yield.

Research is all about discovery and any lessons learned will serve to advance scientific knowledge, even if the applications are not immediate, they say. “We’re trying to fill in the pieces in the puzzle of plant development,” says Riggs. “Our reward is the expansion of our knowledge. Strategies we employ today often generate data that determine what we do tomorrow.”

Plants the focus of U of T Scarborough stem cell research

If you think stem cell research relates only to humans, think again by Mary Ann Gratton