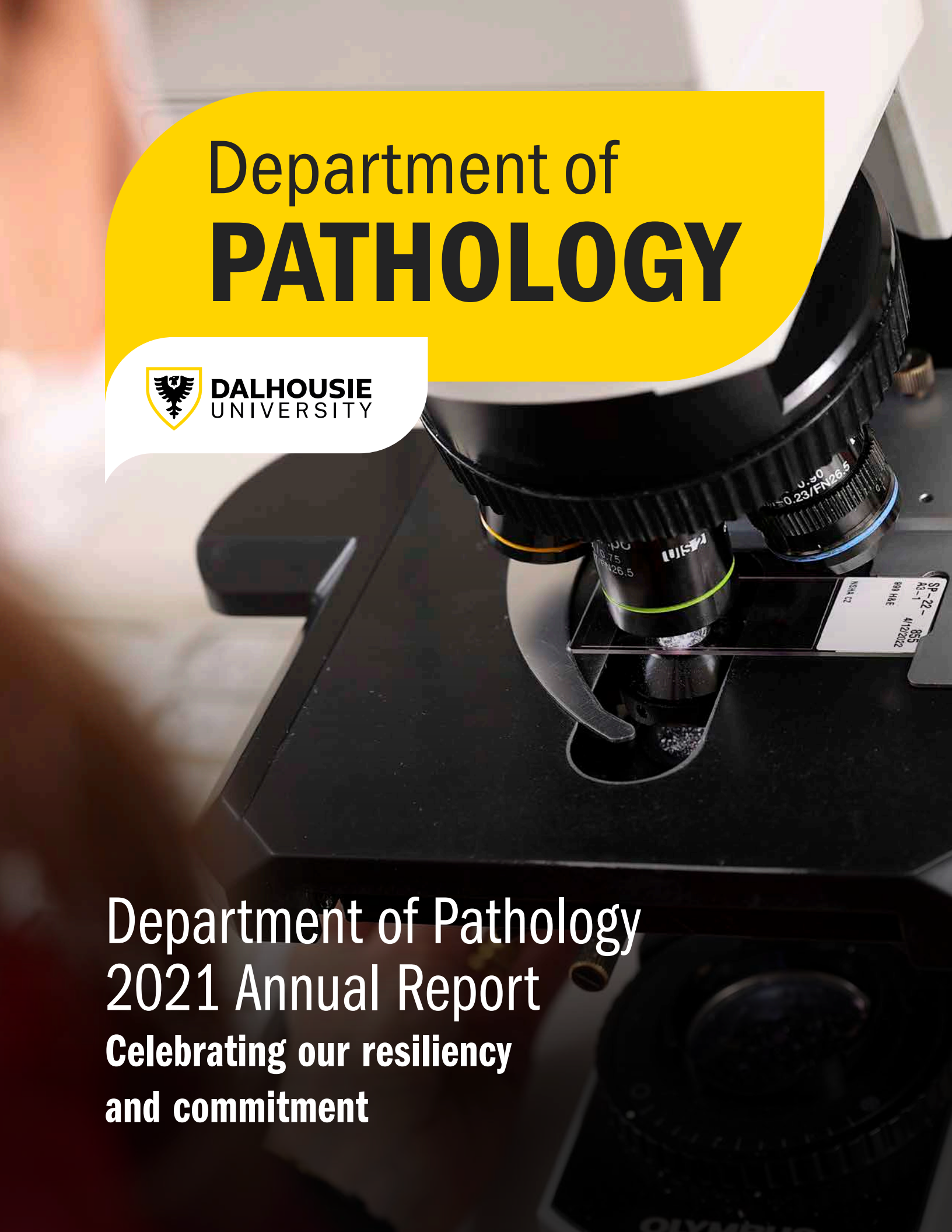
Department of
PATHOLOGY

DALHOUSIE UNIVERSITY



Department of Pathology 2021 Annual Report

Celebrating our resiliency and commitment

Message from the department head:

Celebrating our resiliency and commitment

IT IS NO EXAGGERATION TO REPORT THAT 2021 has been another extraordinary year for the Department of Pathology. The pandemic continued to make a profound impact, not only due to the massive demand for testing, but also to illness-related staff shortages and growing workloads overall. I have been so impressed with the resilience of our medical and technical staff in the face of ongoing challenges, and their willingness to cover for each other and take on extra duties for the sake of maintaining and improving patient care.

We have continued to progress in our quest for greater efficiency. This includes more automation in our laboratories and progress towards an online system for booking blood collection appointments. We look forward to its fruition in the months ahead.

The expansion of our laboratory facilities in the Dartmouth General Hospital is another major step forward. These expanded facilities support the increased clinical services offered at this location as well as the overall capacity of the department.

The Molecular Diagnostic Laboratory is expanding its capacity to meet the increasing need for molecular testing, moving us closer to precision medicine and individualized treatment for cancer patients. In addition to the purchase of high-throughput gene-sequencing equipment, we have created the new senior leadership role of medical director to meet the need for more medical oversight as the complexity of cases continues to increase. Dr. Michael Carter has stepped into this role, while Dr. Tanya Gillan has taken over as clinical director from Dr. Wenda Greer. I cannot express enough gratitude to Dr. Greer for her decades of leadership and service, especially since she has agreed to continue to support molecular services this year, post retirement, to help with the increasing workload.

I am also immensely grateful to Dr. Noreen Walsh, who is retiring later this calendar year. In addition to her work to establish our highly regarded Dermatopathology Fellowship Program, Dr. Walsh has been an outstanding clinician and capable administrator who contributed much to the success of the department over the last 30-some years.

I am pleased to welcome Dr. Ryan DeCoste, a recent graduate of the dermatopathology fellowship, to our medical staff, and to welcome Dr. Greg Fairn to our team of fundamental scientists. You will learn more about both talented individuals in the pages that follow.

Last but not least, I am delighted to see the expansion of our residency training program in New Brunswick. Our residents will be spending more time in different sites of the Horizon Health Network, expanding the teaching role of the medical faculty, broadening the residents' horizons, and enhancing their training experience. It is a true win-win-win scenario.

In closing, I offer my sincere thanks to our department's medical, technical and administrative staff for their hard work and dedication over this past year. While it has been challenging, we have kept our eyes on the future so that we can continue to provide the best possible and most innovative care to our patients.

Sincerely,

Dr. Irene Sadek
Head, Department of Pathology

CLINICAL WORKLOAD

12,493,506 TOTAL NUMBER OF TESTS PERFORMED

1,100,139 TOTAL BLOOD COLLECTIONS PERFORMED

PEOPLE

95 NUMBER OF PRIMARY FACULTY

30 CROSS APPOINTED FACULTY

5 ADJUNCT FACULTY

715 NSHA TECHNICAL STAFF

229 IWK TECHNICAL STAFF

220 NEW BRUNSWICK TECHNICAL STAFF

RESIDENTS

29 NUMBER OF RESIDENTS & FELLOWS

11 ANATOMICAL PATHOLOGY

7 GENERAL PATHOLOGY

7 HEMATO-PATHOLOGY

4 MEDICAL MICROBIOLOGY

GRADUATE STUDENTS

34 TOTAL NUMBER OF GRADUATE STUDENTS

11 PhDs

12 MSc

11 PDFs

RESEARCH STATISTICS

196 NUMBER OF PUBLICATIONS

$2,972,070 GRANT CAPTURE

Clinical Feature:

Molecular Diagnostics Lab evolves and expands to meet growing clinical need

^ *Dr. Michael Carter*

^ *Dr. Tanya Gillan*

> *"It's an incredibly exciting time to be in this field and to play a part in revolutionizing cancer care."*

OVER THE PAST TWO YEARS, the Molecular Diagnostics Laboratory has grown and evolved substantially—reflecting the increasing number and complexity of cases, advances in technology and treatments, and the resulting need for higher-level medical interpretation and direction.

"Almost all of the testing we do is for cancer, which involves so much more than diagnosing and staging the cancer these days," notes Dr. Michael Carter, an assistant professor in the Department of Pathology who was named the lab's first medical director in 2021. "We are now in a new era of personalized medicine and this demands more sophisticated testing and analysis to provide an accurate prognosis and guidance on the treatment approach."

It was necessary to establish the new role of medical director to accommodate the increasing complexity of the lab's role in cancer care. The 2021 retirement of Dr. Wenda Greer (PhD), a clinical molecular geneticist who ran the lab as its clinical director from 1990 to 2021, created a natural opening for a change in the leadership structure of the lab.

"We've made the shift to involving a pathologist in a leadership role, to interpret the molecular data within the clinical context and convey that information to the oncologists and surgeons," Dr. Carter says. "I work in close collaboration with the lab's new clinical director, Dr. Tanya Gillan."

Dr. Tanya Gillan (PhD), a clinical molecular geneticist and cytogeneticist, joined the Molecular Lab as its new clinical director and associate professor in the Department of Pathology in June 2021, stepping into the shoes of her former mentor, Dr. Wenda Greer.

"I feel honoured to be taking on my former supervisor's role," says Dr. Gillan, who completed her MSc under Dr. Greer's supervision in 1997 and then spent many years in western Canada furthering her graduate studies and clinical training, and then working, before returning east to St. John's in 2016. "Now I feel like I've come full circle to be back in Halifax. I'm excited, it's a great group of people in the lab, working together in the exploding field of molecular medicine."

Dr. Carter and Dr. Gillan work closely together to interpret the results of patients' genetic sequencing tests.

"It's a challenge, because new biomarkers are being identified all the time, and the number of requests for molecular analyses continues to rise," says Dr. Gillan. "For example, the lab conducted about 1,200 high complexity next-generation sequencing (NGS) analyses of patient blood or bone marrow samples in 2021, compared to 200 in 2017. Solid tumour NGS analyses increased from about 1,100 to 1,600 in the same period."

The Molecular Lab's capacity to run multiple gene-sequencing panels at a time will be doubled in the near future, with the installation of an Illumina NextSeq2000 next-generation sequencer, purchased in 2021 with funding from the QEII Foundation.

"The Illumina NextSeq2000 is 40 times more powerful than our current instruments and in the future will allow us to conduct comprehensive genomic profiling," Dr. Carter says. "Rather than 50 or so genes of interest, we will be able to sequence 500-gene panels, or even the entire exome of 22,000 protein-coding genes."

Fred Li, Molecular Lab technician ›

The vast quantity of data—gigabytes per tumour—can take days to process through the custom pipeline overseen by the lab's clinical bioinformatician and then requires manual review and analysis. This is why machine learning and artificial intelligence hold promise in making the data more accessible for interpretation. The Molecular Lab is also in the process of hiring a genomic analyst who will play a crucial role in identifying genetic mutations and determining their clinical significance.

"We look for specific mutations that respond to targeted therapies," explains Dr. Gillan. "For example, in lung cancer there are several well-characterized, recurrent genetic mutations for which targeted small-molecule therapies are available. When we identify one of these mutations, we know there is a good chance for an improved outcome. When we identify other genetic mutations, we know those individuals will respond poorly to certain therapies."

While therapies designed to neutralize the effect of a single, specific genetic mutation have only been available within the past 20 years, their number and variety are exploding, transforming the landscape of cancer care.

"The testing we do to identify genetic mutations in cancers is crucial to correctly diagnosing a cancer and matching it to the right targeted therapy," Dr. Carter says, adding, "These therapies are quite different from chemotherapy. Not only can they improve survival, from modest gains in some cases to striking results in others, they can also dramatically improve quality of life because the side effects tend to be much milder."

In addition to the detailed analysis that goes into diagnosing a cancer by its precise genetic mutation, predicting its course and identifying the right personalized therapy, staff in the lab also monitor the patient's response to treatment.

"We do PCR assays to monitor specific cancer gene fusions in patients with leukemia," Dr. Gillan explains. "Gene fusion levels will go down if they are responding to the treatment. We monitor them for years, so we get an early indication if they've stopped responding and can alert the oncologist."

So far, there are targeted therapies for lung, breast, ovary, prostate and colon cancers, as well as melanoma and some leukemias. Meanwhile, therapies for other cancers are coming along and the mutations they harbour will need to be captured in updated testing protocols. "We are working to grow the lab's capacity to meet the growing demand," says Dr. Carter. "We have 12 on staff now and will be hiring more technologists and analysts as time goes on. It's an incredibly exciting time to be in this field and to play a part in revolutionizing cancer care."

EDUCATION Feature:

Dalhousie Dermatopathology Fellowship Program pioneers subspecialty in Canada

Dr. Noreen Walsh

IN ORDER TO JOIN DALHOUSIE'S Department of Pathology as a dermatopathologist in 1989, Dr. Noreen Walsh first had to complete fellowship training in the subspecialty in New York City. There were few opportunities to pursue this training in Canada at the time.

In 2012, after serving two terms as head of the Division of Anatomical Pathology, Dr. Walsh decided to launch a fellowship training program in dermatopathology at Dalhousie.

"There were very limited training opportunities in Canada for this badly needed subspecialty," remarks Dr. Walsh. "There was a program in Toronto, and a sporadic program in Calgary, but most Canadians still had to go to the States for training. I hoped to do something to correct this deficit."

Dr. Walsh was able to gain the support she needed from the Department of Pathology and the Division of Dermatology to establish a dermatopathology subspecialty fellowship, but that was only part of the equation.

The Royal College of Physicians and Surgeons of Canada had not—and still hasn't—officially recognized any dermatopathology programs in Canada. In order for graduating fellows to receive an official credential, Dr. Walsh approached the International Committee for Dermatopathology-European Union of Medical Specialists (ICDP-UEMS) to seek approval of the Halifax site as a registered training centre in this discipline. After a site visit and comprehensive evaluation of the quality of the learning opportunity, ICDP-UEMS officially approved the Halifax program. It was the first and remains the only ICDP-UEMS-accredited fellowship in Canada.

"This was really important, as it meant that fellows who completed our program would be eligible to sit for the ICDP-UEMS examination and thereby gain international certification in the discipline," says Dr. Walsh. "It has since become a popular fellowship and word of its merits has been spread by our graduates to other potential trainees."

The first fellow joined the program in 2013, Dr. Jonathan Lai, followed by seven more in the years since. These highly qualified subspecialists are now working all across Canada, in British Columbia, Saskatchewan, Manitoba, Ontario and Nova Scotia.

"Our program is helping to fill a national gap," Dr. Walsh says, adding that, "there is a great need for well-trained dermatopathologists, given the rising rates of skin cancers, especially in Nova Scotia."

In addition to skin cancers and other kinds of skin growths, dermatopathologists examine biopsies of rashes caused by autoimmune diseases and allergic reactions—including reactions to cancer treatments and even COVID vaccines.

The pandemic brought an unexpected change in 2021, when senior Dalhousie pathology resident Dr. Ryan DeCoste was unable to pursue a fellowship at the Memorial Sloan Kettering Cancer Center in New York as planned. There was already a fellow in the program for 2021, Dr. Glenda Wright, but the Department of Pathology moved quickly to find a way to accommodate Dr. DeCoste as well, training two dermatopathology fellows at once for the first time ever.

"Like pathology as a whole, dermatopathology is the perfect intersection of clinical medicine and fundamental science."

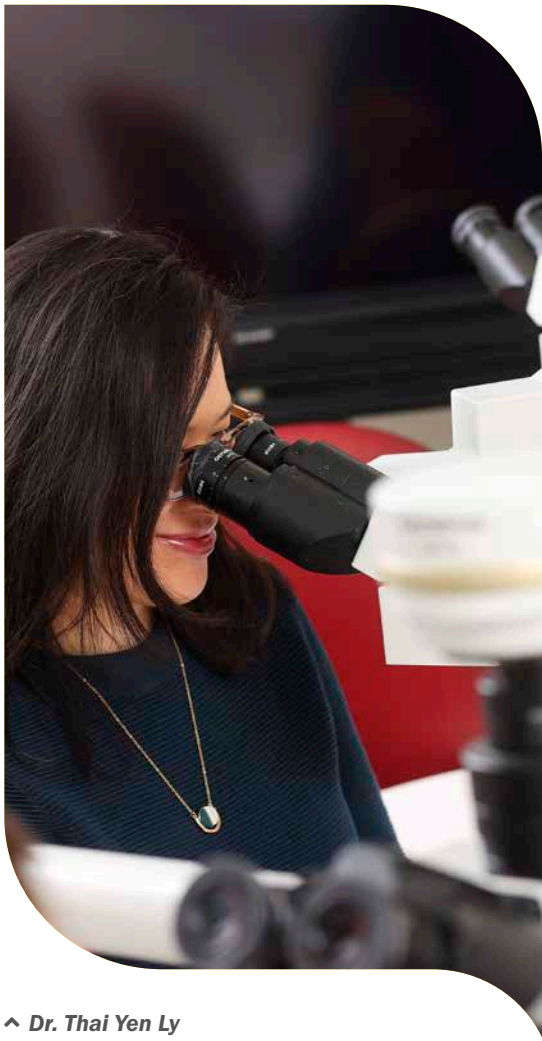
^ *Dr. Ryan DeCoste*

"Even though I didn't end up going to Sloan Kettering, it was a relief to be able to pursue my fellowship in Halifax and know that I was in a place where I would receive comparable training," says Dr. DeCoste, who has since joined the Department of Pathology as a staff dermatopathologist and assistant professor. "The department was very gracious in finding office space and a microscope for me."

Dr. DeCoste enjoys the consulting role of the dermatopathologist and the opportunity to investigate rare cases that require his level of expertise. He is particularly interested in Merkel cell carcinoma, a rare and aggressive form of skin cancer.

"Dr. Walsh has fostered a long-term study of Merkel cell carcinoma that is advancing our proficiency in diagnosing this disease," says Dr. DeCoste, adding that he would like to carry this work forward after Dr. Walsh retires in July 2022.

He also enjoys working on melanoma cases, especially now that there are targeted therapies that have transformed this once extremely deadly disease into something highly treatable. "It's exciting to watch the targeted treatments being developed, and to see how the tumours respond. It really is a fascinating perspective, to be able to stare at a disease at the microscopic level and understand how it is affecting the surrounding tissues," he says. "Like pathology as a whole, dermatopathology is the perfect intersection of clinical medicine and fundamental science."



^ *Dr. Thai Yen Ly*

RESEARCH Feature:

Dr. Gregory Fairn brings a wealth of new expertise to Dalhousie

^ *Dr. Gregory Fairn*

THE DEPARTMENT OF PATHOLOGY welcomed an internationally renowned researcher back to Dalhousie in 2021, after 15 years at SickKids and St. Michael's hospitals in Toronto.

Dr. Gregory Fairn, originally from Bear River, N.S. and a PhD graduate of Dalhousie University, returned to Halifax to accept a new faculty position in the Pathology department—complete with a Tier 1 Canada Research Chair in Multiomics of Lipids and Innate Immunity, and additional funding from the Faculty of Medicine and the Dalhousie Medical Research Foundation.

Dr. Fairn is known for the multi-faceted nature of his work, which spans the disciplines of cell biology, biochemistry, genetics and immunology, with many applications to human health.

"In the past few years, I have been moving more and more into the realm of translational research," notes Dr. Fairn. "In addition to studying the mechanisms of disease, my work is now exploring and testing countermeasures to these mechanisms."

Dr. Fairn is particularly interested in the role of genetic defects, lipid metabolism and immune cells in the development of inflammation.

"We've learned how lipids control the ability of the immune system to kill bacteria, and how defects in lipid metabolism contribute to inflammation in such pathologies as Crohn's disease," explains Dr. Fairn. "For example, if lipids are not being synthesized properly, the body is not able to rid itself of unfriendly bacteria, which can lead to disease-causing imbalances in the microbiome. Conversely, inappropriate protein lipidation can lead to such disorders as Blau Syndrome, which causes terrible inflammation in the eyes, skin and joints of children."

Several mutations in the NOD2 gene result in proteins that are not properly lipidated. Dr. Fairn and his team are searching for ways to "fix" defective NOD2 variants, in order to restore the ability of the immune system to detect bacteria and to potentially stop the progression of Crohn's disease. At the same time, they are exploring the possibility of stopping Blau Syndrome in its tracks by regulating NOD2 to turn the overproduction of lipids off.

"We are testing candidate molecules in human cell lines, to see if we can restore the balance in both directions," Dr. Fairn says. "We have already found some that are able to correct the defect in NOD2 in vitro. Our next step is to move into animal models."

Dr. Fairn and his team are also studying how salmonella bacteria are able to hijack host lipid-synthesis pathways during infection and how this can lead to the development of gallbladder cancer.

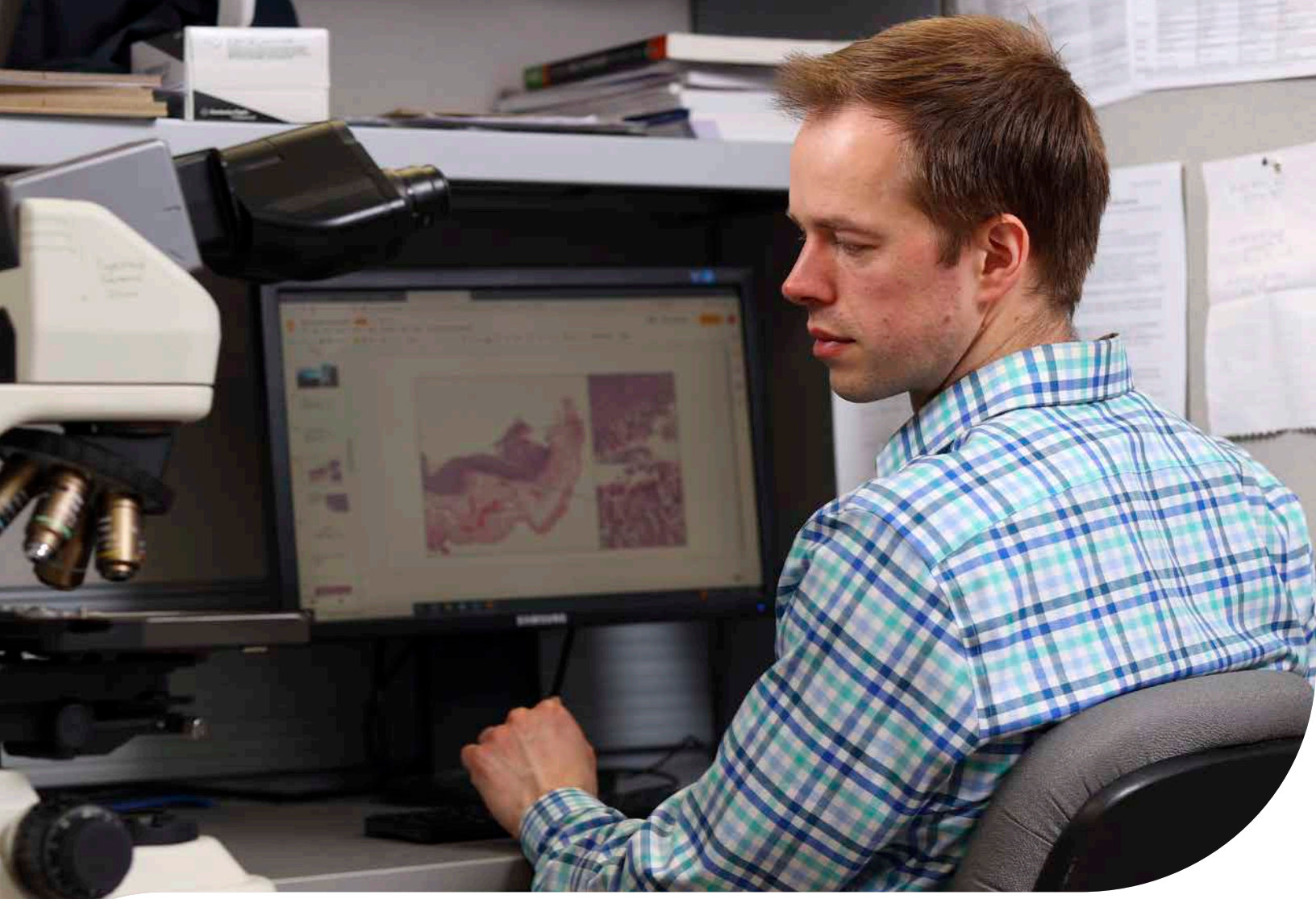
"When salmonella injects proteins into the host cells it reprograms some of the lipid-synthesis pathways for its own benefit. Specifically, it is able to invade the host cells through the generation of membrane ruffles to gain access to the cell where it takes over and replicates," he says. "Re-wiring of these lipid biosynthetic pathways also turns on the cell's survival mechanisms and they begin producing growth factors and apoptosis-blockers, allowing the compromised cells to survive and proliferate in the gut. It starts with food poisoning and, for those with chronic recurring infections, leads to cancer. We are searching for a way to prevent the salmonella from re-wiring the host lipid-synthesis pathway and put a halt to this process."

Results of Dr. Fairn's recent work on salmonella were published in the May edition of *Nature Cell Biology*, adding to his long and impressive list of publications in such high-impact journals as *Science*, *Nature Microbiology*, *Leukemia*, *Proceedings of the National Academy of Science*, *The Lancet*, *Journal of Cell Biology*, *eLife*, and *Nature Communications*.

Dr. Fairn is delighted to be back at Dalhousie, continuing to explore research themes that began during his doctoral studies in lipid metabolism with Dr. Chris McMaster, with easy access to advanced microscopy, proteomic/lipidomics analysis platforms, and genomics core facilities.

"Together, lipids and macrophages affect pretty much any disease imaginable," says Dr. Fairn, who is also exploring how modifying host lipids may be able to block Ebola and SARS-CoV2 infections. "Our work provides a foundation of knowledge that can be applied to advance many others' work."

He is equally happy to be back in Halifax, where his commute is measured in minutes rather than hours. "We were seeking a slower pace of life now that we have children," he says. "It's really been a great move, both professionally and personally."



RESIDENT Feature:

Dr. Sean Rasmussen follows father's footsteps into pathology career

^ *Dr. Sean Rasmussen*

IT WAS AN EASY DECISION for Dr. Sean Rasmussen to choose residency training in pathology upon completing his medical degree at McMaster University. While this choice was not a given, the fact that his father is a pathologist had primed him to be aware and curious about the field and to seek elective experiences in pathology early in his medical training.

"I never looked back after my first elective," says Dr. Rasmussen, who used to go with his father to the lab sometimes and watch him preparing specimens. "I appreciated my electives in other fields, but nothing appealed to me as much as pathology, it's such a fascinating intellectual pursuit. Perhaps it's a genetic tendency to enjoy this kind of endeavour? We both enjoy sitting with puzzles, musing and mulling them over, and there is a lot of that in pathology!"

Dr. Rasmussen is in his fourth year of residency training in anatomical pathology at Dalhousie, and loving every minute of it—although he prefers his days in the lab to his days in the frozen section suite near the operating room, where once a week he examines frozen sections of resected tumours as they are removed from the patient.

"Many of my peers prefer the fast pace and excitement of working in the OR," he says, noting that this is incredibly important work for patients undergoing cancer surgeries, to ensure the surgeon is getting all the cancer without cutting into any vital and delicate structures. "For me, the greatest joy comes from taking my time with a mystery, looking and looking at the specimen and doing the research, the thinking, the consultation, to get to the bottom of it."

The bulk of specimens Dr. Rasmussen and his colleagues examine are tumours, many of which are cancerous. While some cases can be diagnosed accurately in minutes, others can take hours, days or even weeks to figure out. In any case, the investigation always begins with an examination of the gross anatomy of the specimen, followed by the microscopic examination of paraffin-fixed sections, sliced to a thickness of just four microns.

"It is really mentally engaging to examine the subtleties, to look beyond the immediately obvious," Dr. Rasmussen says, adding that no two tumours are exactly the same and each one needs to be approached with fresh eyes. "It's surprising how much a pathologist can determine about the dynamic progression of a disease, even though the specimen is fixed in time. We see features that offer predictive clues about the type of disease and how it's likely to progress—for example, vascular invasion of the tumour or infiltration of cancer cells along a nerve."

Sometimes the microscopic examination does not reveal the necessary prognostic information and this is where molecular pathology comes into play, revealing the genetic variants underlying the disease. "Molecular pathology is part of our training, although we do not work with it every day," Dr. Rasmussen says. "Fortunately, our mentors are well-versed and we work together to prepare the detailed reports for the oncologists."

Dr. Rasmussen enjoys the collegial atmosphere at Dalhousie and the willingness of people to share their time and their knowledge. "All of the pathologists are in one building, there is always an expert down the hall, and they are always willing to share their expertise," he says. "And as teachers, they are so enthusiastic."

When he is not in the lab, Dr. Rasmussen can be found in the kitchen, making homemade bread and pizza (a pursuit he picked up during the pandemic lockdown), or climbing boulders near Peggy's Cove.

> *"All of the pathologists are in one building, there is always an expert down the hall, and they are always willing to share their expertise."*

NEW BRUNSWICK Feature:

Saint John clinical chemistry lab plays vital role in public health

Dr. Jennifer Shea

CHEMISTRY IS THE LARGEST DIVISION of the clinical laboratory at the Saint John Regional Hospital (SJRH), employing one clinical chemist and 34 medical lab technicians to perform approximately three million tests on about 500,000 specimens a year. In addition to testing for biomarkers of kidney dysfunction, cardiac disease, celiac, certain cancers, autoimmune diseases and more, staff in the lab perform chemistry and toxicology testing on post-mortem specimens brought forward by the province's chief coroner.

"Whenever someone dies outside the hospital or shortly upon arrival at the hospital, the chief coroner may get involved to determine the cause of death," explains Dr. Jennifer Shea (PhD), division head of Clinical Chemistry at the SJRH and assistant professor in the Department of Pathology. "We receive specimens from the eight New Brunswick hospitals that perform autopsies, 600 to 700 cases a year."

With the opioid crisis running out of control in New Brunswick, the Clinical Chemistry Lab has an important role to play. In fact, Dr. Shea recently established a special interest group in the Saint John area, bringing together physicians, pharmacists and administrators to tackle the problem collectively. The group plans to expand to involve officials in law enforcement, public health and the coroner's office in the future.

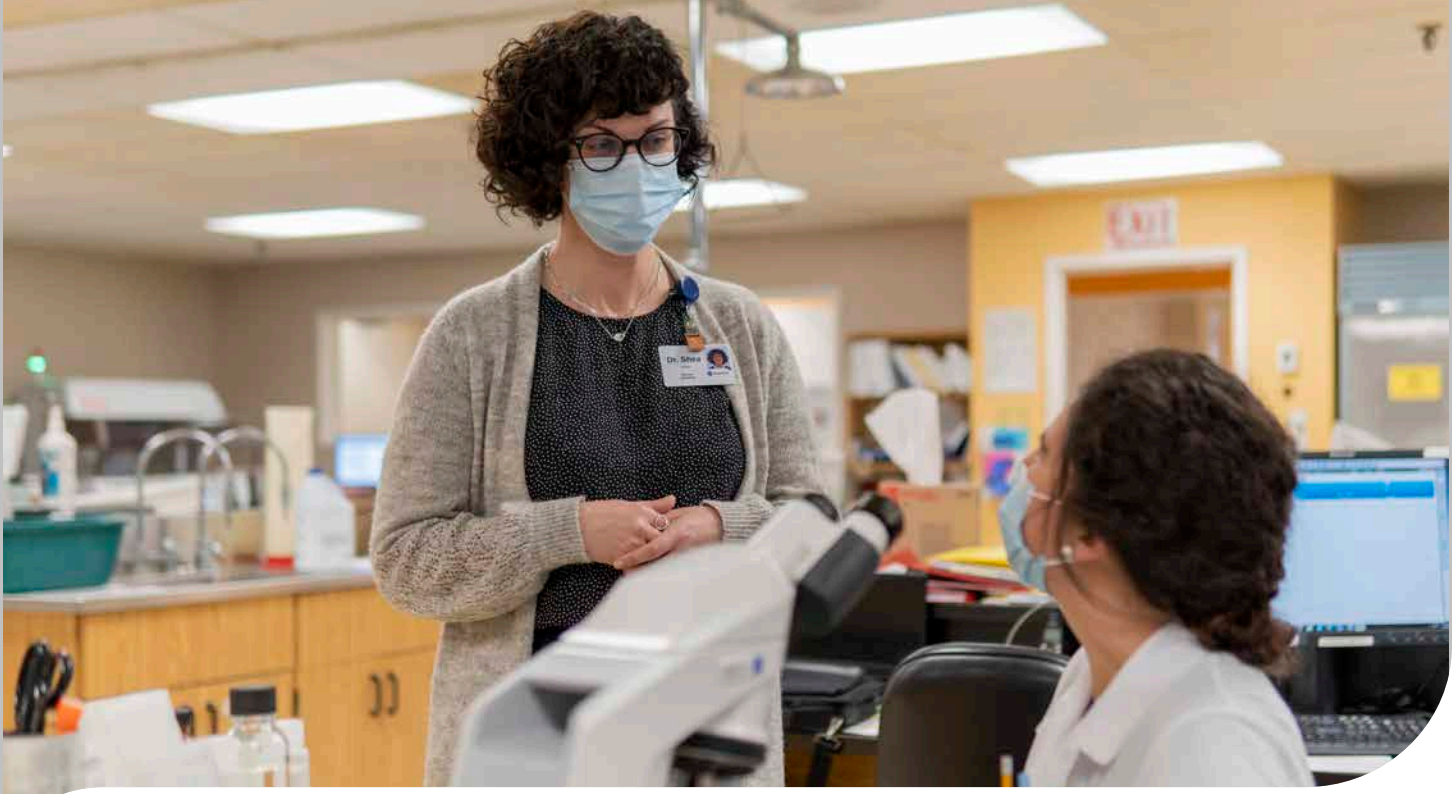
"We conduct regular urine tests on people with opioid use disorder who are in a methadone program, to confirm that they are not taking other drugs that could interact dangerously with the methadone," says Dr. Shea. "We are also able to monitor the safety of the illicit drug supply through urine tests. This is important because there is a growing problem with tainting. For example, we have found fentanyl where we only expected to find methamphetamine or cocaine. Ultimately, I would like to establish a drug-checking program to ensure a safe supply of street drugs. It is all about harm reduction."

The Clinical Chemistry Lab will soon be able to expand the scope of its drug testing efforts thanks to the imminent arrival of a mass spectrometer. "This equipment will allow us to test for the presence of hundreds of compounds, compared to our current capability of eight classes of drugs," Dr. Shea says. "We were so fortunate to receive the funding for this as the result of our participation in the annual Lion's Den competition put on by the SJRH Foundation."

The impact of cannabis legalization on public health and safety is another topic of keen interest to Dr. Shea. She supervised Alexander Jordan, a medical student at Dalhousie Medicine New Brunswick, to conduct an analysis of New Brunswick toxicology reports from 2014 to 2020, to identify if there were any changes in the number of cannabinoid-positive blood samples seen in deceased individuals post-legalization.

"We found that those who died following legalization had an increased likelihood of having cannabinoids present, with those dying by suicide and or accidental causes showing the largest increase in positive cases," reports Jordan, noting that, pre-legalization, 18 per cent of autopsy cases identified as suicide showed the presence of cannabinoids, while post-legalization that figure increased to 30 per cent. Similarly, among those who died by accidental means, the detection of cannabinoids increased from 26 per cent to 36 per cent. "These findings are important to consider given existing literature

"This is an important safety signal that points to the need for additional research and potential public health measures to support at-risk groups who may be adversely impacted by recreational cannabis legalization."



Alexander Jordan

highlighting the potential for negative mental health outcomes in those who start using cannabis early, as well as the effects acute intoxication can have on driving."

The results of this study (Identification of cannabinoids in post-mortem blood samples from the province of New Brunswick before and after recreational cannabis legalization) were published in the *International Journal of Drug Policy* in early 2022, adding to a growing body of literature that suggests there are health and safety implications of legalizing the recreational use of cannabis.

"This is an important safety signal that points to the need for additional research and potential public health measures to support at-risk groups who may be adversely impacted by recreational cannabis legalization," says Jordan, who has an interest in harm reduction in public health, with his sights set on pursuing family medicine residency once finished medical school.

"Legalization shifted the public's perception of the harms of cannabis use," notes Dr. Shea. "Now we are seeing that it is not as harmless as many people have thought, particularly in reference to driving under the influence of cannabis or using cannabis when you have a mental health condition such as depression or schizophrenia. This study highlights the importance of clinical chemistry and toxicology studies to shed light on real-world realities versus popular perceptions."

DALHOUSIE UNIVERSITY

Department of Pathology
DIVISIONAL REPORTS

CLINICAL WORKLOAD

7,467,857 NS HEALTH TESTS

813,655 NS HEALTH BLOOD COLLECTIONS

43,008 NS HEALTH TISSUE COLLECTION

Anatomical Pathology

The Anatomical Pathology team comprises 29 subspecialist pathologists, one fellow, 10 anatomical pathology and six general pathology residents, and four technical and clerical managers and staff members.

THE DIVISION'S CORE VALUES INCLUDE FOSTERING the wellness of laboratory pathologists and staff, high-quality patient care, excellence in education and research, and sustainability.

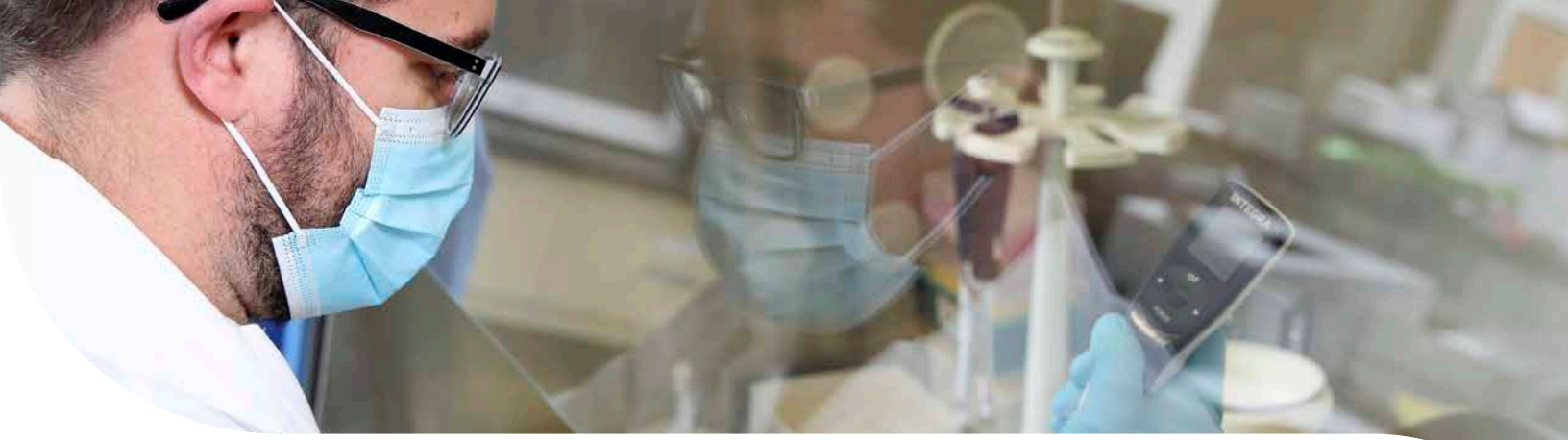
The division provides subspecialist anatomical pathology investigations, including immunohistochemistry, immunofluorescence and electron microscopy, cytopathology and autopsy pathology services to the Central zone, and consultation services across the Atlantic region and beyond. Members also participate in the Department of Pathology's growing molecular laboratory. They provide intraoperative consultation services at the Victoria General Hospital, Halifax Infirmary and Dartmouth General Hospital sites.

In the coming months, Anatomical Pathology will be implementing liquid-based cytology and automated screening to improve cervical cancer screening. The division is also expanding its digital pathology capabilities and supporting several developments in the molecular pathology laboratory to enhance personalized medicine.

The Anatomical Pathology team has a strong commitment to education at all levels. Its pathologists are heavily involved in the Medical Sciences Program and Dalhousie Medical School at the undergraduate, graduate and postgraduate levels. The Anatomical Pathology and General Pathology residency programs received highly positive reviews from the Royal College. Dr. Penny Barnes coordinates the National Resident Review Course, while Dr. Martin Bullock chairs the Royal College Anatomical Pathology Specialty Committee. The Dermatopathology Fellowship Program, led by Dr. Noreen Walsh, is nationally acclaimed. And, the division has been offering a distance continuing professional development program across Atlantic Canada for close to 15 years.

Despite its heavy clinical commitment, Anatomical Pathology also excels in research. Pathologists in the division are widely represented on editorial boards of leading scientific journals. The Divisional Review Report, March 31, 2021, reported a total of 292 peer-reviewed publications and 21 other publications, including book chapters, over the previous five years. There were 58 publications from division members in 2021. Division members have held 49 grants as principal or co-applicants for a total of $5.5 million over the past five years.

A great deal of research activity is conducted in collaboration with residents, who frequently receive awards at local, national and international meetings. Drs. Sid Croul and Zhaolin Xu co-lead the NS Health/Dalhousie Biobank, a member of the Atlantic Canada Biobank Consortium, which houses a significantly greater number and diversity of banked specimens than any single provincial biobank. The lung bank, led by Dr. Zhaolin Xu and surgeon collaborator, Dr. Drew Bethune, has been active for more than 10 years, and continues to support basic science and clinical research.



Clinical Chemistry

Following the acquisition and validation of three state-of-the-art liquid chromatography-mass spectrometry/ mass spectrometry instruments in the previous year, the Toxicology Laboratory has improved testing for anti-rejection drugs (ARD) for transplant patients, and urine drugs screening (UDS), in which the test menu has been expanded to include new drugs in demand by pain clinics and addiction centres.

IMPORTANTLY, WITH THESE ENHANCED TESTING platforms, the forensic UDS service was reclaimed in July 2021. This provides a crucial service for the Department of Social Services, assisting in decisions related to child safety. It also generates over $700,000 of annual revenue for the Department of Pathology, which had been going to laboratories in the U.S. over the previous three years.

During the fiscal year 2019-2020, the Toxicology Section performed 6,668 medical urine drug screens (MUDS). Samples came from across Nova Scotia and were ordered and performed without a review process at an annual cost of $57,544.84 ($8.63 reagent cost per test). However, since January 2021, a new utilization initiative implemented a review process requiring the ordering service to justify the testing and for it to be approved by the medical director of the section. As a result, the volume of tests performed from January 29, 2021 to January 28, 2022 has been reduced to 902 tests at a total cost of $7,784.26. This has led to total reagent (true) savings of $49,760.58 per annum.

In 2021 Clinical Chemistry completed a project to enhance curriculum development for chemistry rotations. This project incorporated new lectures and interactive educational activities and built them into Brightspace. Three general pathology residents, one off-service endocrinology resident, one medical student and two observers were on service during that time and were first to benefit from this novel structure. Clinical Chemistry also participated in the continued development of the “Transition to Discipline” rotation for first-year residents and contributed to that teaching in July 2021. The cross-listed undergraduate and graduate course Biochemistry of Clinical Disorders (BIOC 4/5813 PATH 5013) was successfully completed in the fall of 2021, online, following a comprehensive build-in of the course. Division members are enthusiastic about plans in the works to launch a second semester of this course and expand the repertoire of topics covered. Finally, faculty members continue to contribute to Med I and Med II tutorials.

Awards

» **Dr. Bassam Nassar:** Outstanding Contribution to Medical Biochemistry Award, from the CAMB/AMBQ National Committee in November 2021

Foundational Science

The Department of Pathology's foundational scientists were awarded $4 million in basic research funding from a number of regional, national and international agencies in 2021. These agencies include Research Nova Scotia, Dalhousie Medical Research Foundation, the Natural Sciences and Engineering Research Council of Canada (NSERC), Canadian Institutes of Health Research, Canada Foundation for Innovation, Canadian Cancer Society, and the U.S. National Institutes of Health.

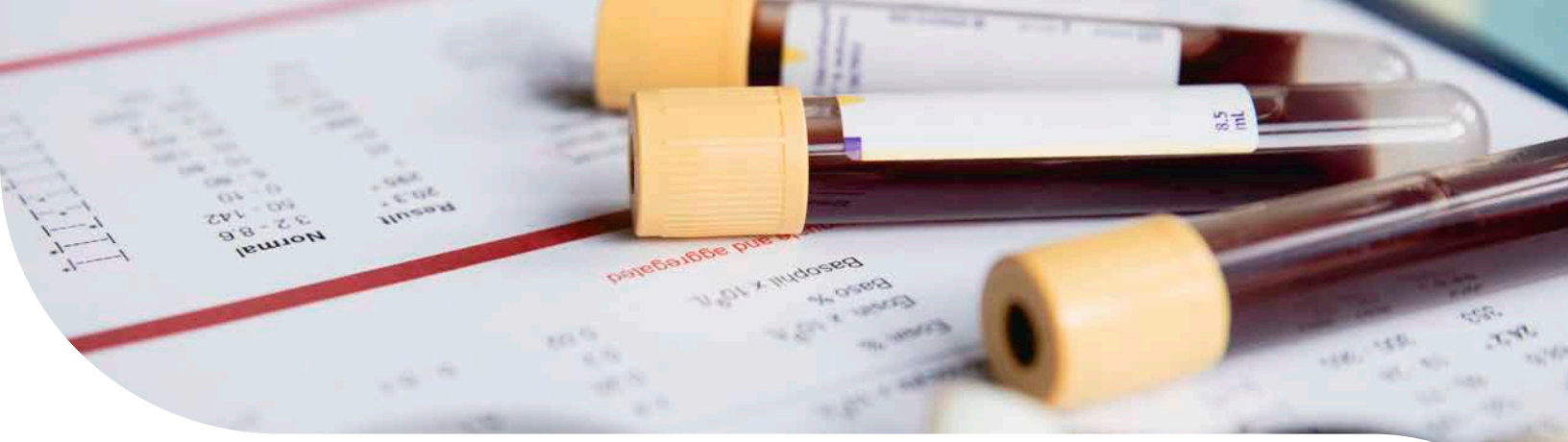
THANKS TO THIS FUNDING, SCIENTISTS IN THE department were able to complete numerous studies and report their findings in 44 peer-reviewed publications in 2021, published in well-respected journals including *Cell Reports*, *Journal of Cell Biology*, *Faseb Journal*, *Human Genetics*, *Cancers*, *Cancer Immunology*, *Journal of Methods in Molecular Biology*, *Molecular Therapy*, *American Journal of Cancer Research*, *Molecular Therapy Oncolytics*, *Cancer Immunology Research*, *BioEssays*, *Viruses*, and *Science of the Total Environment*.

The division welcomed Dr. Gregory Fairn, who joined the department from St. Michael's Hospital in Toronto, in 2021. He studies a variety of aspects related to vesicular and non-vesicular transport of lipids, membrane dynamics, innate immunity, and cell biology.

Overall, the average H-index of the department's scientists is 37 (range 51 to 23) and their works have been cited more than 39,000 times. The collective research outputs of Pathology's six basic scientists have been highly cited and recognized for their excellence through a number of awards and accolades.

Awards

- **Dr. Jeanette Boudreau** and **Dr. Shashi Gujar** each received a 2021 President's Research Excellence Award for Emerging Investigators from Dalhousie University. The President's Research Excellence Awards for Emerging Investigators were created to honour those who, early in their careers, have made noteworthy contributions to Dalhousie's research culture.
- **Dr. Paola Marcato** and **Dr. Graham Dellaire** were each recipients of a 2021 Faculty of Medicine Award for Excellence. Dr. Marcato, currently serving as acting assistant dean of graduate and postdoctoral studies, received her award for her excellence in research mentorship of trainees. Dr. Dellaire received his award for his excellence in research mentorship of faculty members.
- **Dr. Gregory Fairn** received a Tier 1 Canada Research Chair in Multiomics and Innate Immunity from the Government of Canada to pursue his research at Dalhousie.



Hematopathology

This past year was a busy one for the Division of Hematopathology, as the division continued to maintain high-quality diagnostic services in hematology.

CLINICALLY, THE FOCUS THIS YEAR HAS BEEN ON improving the efficiency of diagnostic services. Some highlights include the implementation of automated cell counts for cerebrospinal fluid specimens to improve accuracy and decrease the turnaround time by more than 90 per cent when compared to the manual method.

Hematopathology also reviewed and updated its critical test values. This initiative led to a significantly more streamlined notification process to physicians and/or patients in cases of urgent and emergent laboratory test results

Finally, with the expert guidance from Dr. Anna Greenshields, assistant HLA director, the division successfully implemented next-generation sequencing (NGS) technology in its tissue-typing (HLA) laboratory. This greatly improved the quality and resolution of the HLA typing for patients in Atlantic Canada who are in need of solid organ or stem cell transplants.

On the education front, faculty, residents and technical staff have worked very hard on improving and enhancing the hematopathology residency training program. The leadership of residency program director, Dr. David Conrad, and Dr. Tish O'Reilly, the associate program director, has been pivotal in guiding these efforts. Following the recent Royal College accreditation review, the program received full accreditation, with follow-up to take place by regular accreditation review.

Under the leadership of Dr. Jason Quinn and Dr. Calvino Cheng, the division's transfusion medicine laboratory team has been working on computer-based digital interventions in collaboration with Dr. Raza Abidi in the Faculty of Computer Science at Dalhousie University. All transactions in blood transfusion are tracked in the laboratory information system. As a result, this area of medicine is very amenable to the application of modern data-analysis techniques, including software and artificial intelligence-based interventions. This research has been productive, receiving grant funding in each of the last three years from Canadian Blood Services, NSERC and MITACS. As a result of this research, software has been created for the blood transfusion service. This is currently being implemented. Members of the Hematopathology division have also published two papers, one book chapter and three conference abstracts on this topic. The research with Dr. Abidi has facilitated collaborations with other specialties including large, funded projects with the ICU (NSERC) and Nephrology (Research Nova Scotia).

Awards

- **Dr. Robert Liwski** received the Doctors Nova Scotia 2021 Distinguished Service Award for improving care for organ and stem cell transplant patients.
- **Dr. Allam Shawwa** received the Canadian Association of Pathology Award for Leadership in Education for his contributions to hematopathology education.

Microbiology

The Division of Microbiology performed 1,645,361 tests in 2021, an increase of 187 per cent over the previous year. SARS CoV-2 continued to dominate testing.

THE QEII LABORATORY HAS IMPLEMENTED A genomic-sequencing program to support Canada's surveillance of viral variants of SARS-CoV-2. Enhanced public health laboratory infrastructure can be used for other important surveillance programs, including enteric bacteria causing diarrheal illness.

Division members published 23 manuscripts in 2021, several of them related to SARS-CoV-2 diagnostic testing. For example, when Omicron became the dominant circulating virus, the internet was rife with anecdotes that nasal swabs used in rapid testing were not as good as throat swabs. There was, however, a lack of data to support these claims. The Microbiology team was able to compare the effectiveness of self-collected throat and nasal swabs, or a combination of both, in detecting Omicron. The resulting iSNOT project (investigating Sensitivity of Nose or Throat swabs) showed a combination of both sites is most effective, influencing the conduct of rapid antigen testing in Nova Scotia and across Canada.

The QEII laboratory has changed the Lyme disease testing algorithm to the modified two-tier algorithm, which has decreased the turnaround time for Lyme disease serology results and increased the sensitivity for detecting early infection. In addition to Lyme, last year saw an increase in other tick-borne infections, including Anaplasma and the first case of Babesia infection. Members of the division also helped develop and implement a provincial Antimicrobial Resistant Organism (ARO) program to detect emerging resistant pathogens like Enterobacteriaceae and Candida auris.

Tuberculosis (TB) has seen a resurgence in Nova Scotia. To better support clinical and public health management of these cases, the Microbiology laboratory has implemented GeneXpert Ultra®, a molecular method with increased sensitivity for detecting TB and identifying the genetic markers of resistance to rifampin, one of the core medications used for treating TB.

Other initiatives that had been delayed during COVID have been implemented including: supporting the tissue bank and organ transplant programs with molecular testing on high-risk donors; implementing total laboratory automation in bacteriology; and rapid identification of MRSA in bloodstream infections using molecular methods.

Microbiology members teach in a number of undergraduate and graduate level courses and both oversee and coordinate three undergraduate courses. In addition, the division was successful in renewing the accreditation of the Medical Microbiology Program through the Royal College and preparing to implement Competence By Design in 2024.

Awards

- **The Nova Scotia Pathology & Laboratory Medicine** team received the NS Health Award for its response to the COVID-19 pandemic.
- **Dr. Todd Hatchette** received the NS Health Leadership Excellence Award for his leadership during the pandemic, as well as the Dalhousie Faculty of Medicine Award of Excellence in Clinical Practice.

CLINICAL WORKLOAD

2,425,649
IWK TESTS

170,484
IWK BLOOD COLLECTIONS

IWK Pathology & Laboratory Medicine

Pathology & Laboratory Medicine at the IWK Health Centre went through many changes in 2021, to facilities, equipment, processes and personnel, all in the service of improved patient care and outcomes. For example, the renovation of the outpatient specimen-collection facility will alleviate congestion in waiting areas, while the acquisition of a NextSeq2000 Next Generation Sequencer in the Clinical Genomics Division is dramatically increasing its capacity to conduct large-panel genome- and exome-sequencing studies locally, rather than sending specimens out to laboratories in the U.S.

CLINICAL GENOMICS ALSO ADDED A LAB-BASED genetic counsellor to its service to improve testing algorithms and utilization, to provide guidance related to genetic testing for health care providers, and to ensure a patient focus is embedded in the service. Another important change that will help ensure quality and patient safety is the division's acquisition of a three-year accreditation package, specific to clinical genomics laboratories, from Accreditation Canada. This will further develop the IWK as a training site, a referral centre for specialized testing, and as a participant in clinical research collaborations.

Local expertise in pediatric hematopathology and maternal-fetal transfusion medicine has also been expanded, with a shift in the staffing model for the Division of Hematopathology. Instead of one hematopathologist handling all cases, three hematopathologists now collectively provide 1.0 FTE in coverage. This expands the range of expertise to optimize both service coverage and resident teaching. Hematopathology division staff are also key members of Nova Scotia's provincial Massive Hemorrhage Working Group. In 2021 they contributed to the development of provincial guidelines for the management of massive hemorrhage.

The IWK Division of Anatomical Pathology is employing its specialized expertise to provide comprehensive technical support in perinatal and placental pathology and autopsy investigation of perinatal deaths. Staff in the division are working with IWK Women's Health to standardize the handling and diagnostic work-up of pregnancy-related specimens, and to provide compassionate post-mortem care for families.

Microbiology staff implemented a new process, Lucira molecular testing, to provide pre-operative and admissions COVID testing for all IWK patient populations.

In terms of equipment upgrades, IWK Pathology & Laboratory Medicine acquired multiple new pieces, including:

- **Kryptor GOLDs** for consolidating maternal serum testing for the Maritime Maternal Serum Screening Service onto high-throughput, open-access instrumentation with full back-up to limit service disruptions, gain workflow efficiencies and minimize patient safety risk
- **GC–MS/MS** system replacement/upgrade for urine organic acids, allowing essential and timely diagnostic testing of inborn errors of metabolism used by Biochemical Genetics and the Maritime Newborn Screening services
- **X-ray irradiator** for Transfusion Medicine to improve blood-inventory management and the quality of blood components for transfusion
- **Cytopro slide centrifuge** has increased cell yield by two to three times, compared to the earlier equipment, improving morphologic detection of neoplastic cells in body fluids
- **miniiSED ESR** analyzer for hematology allows onboard QC monitoring and provides faster results (20 seconds versus 60 minutes) compared to the equipment it replaced
- **BD Phoenix Identification** and antimicrobial susceptibility instrumentation in Microbiology will allow transition from recording QC manually to recording in Meditech, as well as paperless reporting
- **CryoStarNX50** new histology instrumentation in Pathology

In the realm of research, members of IWK Pathology & Laboratory Medicine's Clinical Genomics group, led by Dr. Victor Martinez, implemented new sequencing technologies intended to improve the analysis of genetic variants in complex genomic regions. Funded by the Beatrice Hunter Cancer Research Institute, this work also involves the training of research staff and medical students. Clinical Genomics also collaborated with Hematology (Dr. Amy Trottier as principal investigator) to acquire a TRIC grant (Translating Research Into Care) to develop testing and become a referral centre for inherited hematological malignancies. Additional funding for an automated extractor to support this project is pending through the Nova Scotia Health Innovation Catalyst Fund. This project will also support a graduate student to be co-supervised by Drs. Gaston and Martinez.

As part of a Canada-wide research study funded by the Public Health Agency of Canada through the COVID-19 Immunity Task Force, IWK was the Nova Scotia site in a pan-Canadian COVID-19 serological survey using antenatal serum samples to determine seroprevalence.

In the realm of children's cancer, two division members were recently invited to join the Children's Oncology Group (COG). Dr. David Conrad, interim head of the IWK Division of Hematopathology, and Dr. Craig Midgen, pediatric anatomical pathologist, are both now registered members of COG.

New Brunswick

In addition to providing diagnostic services to a catchment area extending approximately 80 km around Saint John, the laboratory at the Saint John Regional Hospital serves as a training site for learners from Dalhousie Medicine New Brunswick (DMNB) and a sister site for advanced rotations as part of the Pathology Residency Training Program.

The Saint John lab performs over two million tests every year and is staffed by 10 anatomical and general pathologists, two hematopathologists, a clinical chemist, a medical microbiologist and a molecular geneticist. The lab also receives about 20,000 pathology accessions, 20,000 cervical screening cases and more than 3,000 non-gynecological cytology specimens a year.

Besides providing services to the local population, the lab also serves as the site for multiple provincial programs. These include tuberculosis testing, enteric organism surveillance, the provincial toxicology lab, the forensic autopsy service and a stem cell bank. The department also has a busy molecular pathology service which has become an indispensable service supporting personalized cancer care.

CLINICAL WORKLOAD

2,600,000
NB TESTS

116,000
NB BLOOD COLLECTIONS

Undergraduate learners are taught basic tissue structures and lessons on disease processes requiring pathologic examination. Undergraduate students from DMNB have also been involved in research in the lab through the Research In Medicine (RIM) program.

The Saint John lab provides senior residents with advanced rotations where they have greater autonomy and prepares them for functioning as independent consultants. The training program will soon start hosting hematopathology trainees as well. Residents from other disciplines also learn in the lab during multidisciplinary clinical rounds, which provides them with an understanding of pathological processes and reports and their implications on patient management.

Members of the Saint John laboratory are integrated partners in various Dalhousie committees, ensuring that the training programs are focused on serving the needs of all four Atlantic provinces.

OUR FACULTY

Dr. Thomas Arnason
Dr. Penny Barnes
Dr. Gillian Bethune
Dr. Martin Bullock
Dr. Michael Carter
Dr. Mathieu Castonguay
Dr. Sidney Croul
Dr. Kelly Dakin Hache
Dr. Alexander Easton
Dr. Emily Filter
Dr. Laurette Geldenhuys
Dr. Jennette Gruchy
Dr. Thai Yen Ly
Dr. Jennifer Merrimen
Dr. Joanne Murphy
Dr. Shawn Murray
Dr. Saul Offman
Dr. Sylvia Pasternak
Dr. Heidi Sapp
Dr. Sorin Selegean
Dr. Ashley Stueck
Dr. Andrea Thoni
Dr. Noreen Walsh
Dr. Cheng Wang
Dr. Ryan DeCoste
Dr. Zhaolin Xu
Dr. Philip Moss
Dr. Lisandra Cubero Herrera
Dr. Manal Elnenaei
Dr. Amy Lou
Dr. Bassam Nassar
Dr. Calvino Cheng
Dr. David Conrad
Dr. Daniel Gaston
Dr. Allam Shawwa
Dr. Robert Liwski
Dr. Jason Quinn
Dr. Mahboubeh Rahmani
Dr. Irene Sadek
Dr. Deitrich Werner
Dr. Tanya Gillan
Dr. Tish O'Reilly
Dr. Anna Greenshields
Dr. Ross Davidson
Dr. Ian Davis
Dr. David Haldane
Dr. Glenn Patriquin
Dr. Todd Hatchette
Dr. Jason LeBlanc
Dr. Lori Beach
Dr. Jo-Ann Brock
Dr. Robert Fraser
Dr. Zaiping Liu
Dr. Tim Mailman
Dr. Craig Midgen
Dr. Erica Schollenberg
Dr. Karen Bedard
Dr. Kathryn McFadden
Dr. Helene Arts
Dr. Victor Martinez
Dr. Jeanette Boudreau
Dr. Thomas Issekutz
Dr. David Waisman
Dr. Graham Dellaire
Dr. Shashi Gujar
Dr. Paola Marcato
Dr. Gregory Fairn
Dr. Behram Cenk Acar
Dr. Yu Chen
Dr. Tsetan Dolkar
Dr. Mojgan Ebrahimi
Dr. Sameh El Bailey
Dr. Ron Francis
Dr. Tarunendu Ghose
Dr. Marek Godlewski
Dr. Samina Mansoor
Dr. Ather Naseemuddin
Dr. Ken Obenson
Dr. Tarek Rahmeh
Dr. Lakshmi Rajappannair
Dr. Hasini Reddy
Dr. Yu Shi
Dr. Mehgana Toal
Dr. Jaime Snowdon
Dr. Imran Umar
Dr. Mohammad Hossain
Dr. Jennifer Shea
Dr. Nancy Carson
Dr. Matthew Bowes
Dr. Erik Mont
Dr. Marnie Wood
Dr. Alison Edgecombe
Dr. David Hoskin
Dr. Godfrey Heathcote
Dr. Wenda Greer

OUR RESIDENTS AND FELLOWS

Dr. John Loggie
Dr. Nafisa Shandi
Dr. Valerie Taylor
Dr. Paul Zamiara
Dr. Laura Marie McDonell
Dr. Sean Rasmussen
Dr. Alexandre R. Corriveau
Dr. Priyanka Y. Ravi
Dr. Allison Maybank
Dr. Aleksandra (Ola) Kajetanowicz
Dr. Maggie Maung
Dr. Maci Ricketts
Dr. Richard Wood
Dr. Eniko Holo
Dr. Ashlyn Fong
Dr. Ibrahim Elsharawi
Dr. Tessa Boyer
Dr. Manal Al-Aufi
Dr. Buthaina Al-Maashari
Dr. Richard Xiang
Dr. Carley Bekkers
Dr. Ian Sarty
Dr. Yahya Shabi
Dr. Ziad Allehebi
Dr. Buthaina Al-Maashari
Dr. Farhan Khan
Dr. Alexi Surette
Dr. Jake Yorke
Dr. Manal Al-Aufi

OUR GRADUATE STUDENTS

Bassel Dawod
Michael Giacomantonio
Mark Hanes
Namit Holay
Youra Kim
Edwin Leong
Leah MacLean
Sabateeshan Mathavarajah
Lauren Westhaver
Hanan Aljamei
Justin Brown
Allyson Cook
Samuel Cutler
Kateryna Kratzer
Marie-Claire Wasson
Zara Forbrigger
Vishnupriyan Kumar
Olivia Walker
Hannah Cahill
Elias Habib
Meghan McLean
Morgan Pugh-Toole
Freyja Verth

OUR ACADEMIC STAFF

Kimberlea Clarke
Julie Griffith
Kelly Leights
Michelle Sampson
Victor Martins Madeira
Patricia Colp
Dr. Gopal Pathak
Dr. Alamelu Bharadwaj
Dr. Jayme Salsman
Dr. Pei-Lin Chen
Dr. Rashmi Shah
Joyce Chew
Cheryl Dean
Emma Kempster
Erica Allen
Angelita Alcos
Dr. Jenny Liu
Dr. Haggag Zein

OUR POST DOCTORAL FELLOWS

Dr. Wasundara Fernando
Dr. Jaganathan Venkatesh
Dr. Raj Pranap Arun
Dr. Dharmapal Burne
Dr. Seke Keretsu
Dr. Michael Salsaa
Dr. Mahlegha Ghavami Nodeh
Dr. Charneal Dixon
Dr. Meg Dahn
Dr. Jasmine Barra
Dr. Youra Kim

ANNUAL DEPARTMENT AWARD WINNERS

2020-2021 DAVID T. JANIGAN TEACHING AWARD:
Dr. Erica Schollenberg
Dr. Ashley Stueck

2021-2022 DAVID T. JANIGAN TEACHING AWARD:
Dr. Jeanette Boudreau
Dr. Manal Elnenaei

WENDA GREER PRIZE FOR RESEARCH EXCELLENCE:
Dr. Meg Dahn

PATH FORWARD COLLABORATION AWARD:
Dr. Alexi Surette

BEST PAPER CLINICAL RESEARCH:
Dr. Glenn Patriquin

BEST PAPER FUNDAMENTAL RESEARCH:
Dejan Vidovic

DR. TOM ARNASON UNDERGRADUATE PRIZE:
Carley Bekkers

RESEARCH DAY WINNERS

JUDGES' CHOICE:
Edwin Leong and Morgan Pugh-Toole

GRADUATE STUDENT AWARD FOR TEACHING, OUTREACH AND MENTORING:
Dr. Meg Dahn

RESIDENT TEACHING AWARD:
Drs. Paul Zamiara, Sean Rasmussen

GUPTA TRAVEL AWARD:
Drs. Richard Wood, Sean Rasmussen

BEST TALK BY A PATHOLOGY GRADUATE STUDENT:
Lauren Westhaver

BEST TALK BY A PATHOLOGY RESIDENT:
Dr. Richard Xiang

BEST TALK BY AN EXTERNAL PARTICIPANT:
Adam Nelson

BEST ABSTRACT BY A PATHOLOGY GRADUATE STUDENT:
Edwin Leong

BEST ABSTRACT BY A PATHOLOGY RESIDENT:
Dr. Richard Wood

BEST ABSTRACT BY AN EXTERNAL PARTICIPANT:
Morgan Pugh-Toole

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