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interfaces

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Volume 12, Fall 2016
The Unit Operations Lab

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Volume 12, Fall 2016
The Unit Operations Lab

Contents

About This Issue
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"It's where we first saw chemical engineering in action and theory and practice meet (or not!)"

Unit Ops Lab — Our Past and Our Future

EVEN THOUGH IT'S BEEN THIRTY-FIVE YEARS since I graduated from the undergraduate program at the Department of Chemical Engineering & Applied Chemistry (ChemE), memories of my time spent in the Unit Operations (Unit Ops) Lab, both as a student and teaching assistant, are still fresh. It's where we first saw chemical engineering in action and theory and practice meet (or not!), as well as where we worked as a team and developed long lasting friendships.

One of my favourite memories demonstrates how the lab is a place to problem solve, be creative, explore and think critically using fundamentals across our discipline. My team in third year was the first group to try the "leaching experiment," which had just been built. The best materials to leach out (e.g. dye) or to leach from (e.g. gypsum or sponges) were not clear. Neither was the best size, concentration, etc. to allow us to get "meaningful" data in a reasonable timeframe. This led to an exploratory lab, which got us to think about the physical/chemical processes involved (e.g. equilibrium, adsorption, kinetics, diffusion and fluid mechanics). We needed to determine what questions to ask and what experiments to design. I recall how this experiential learning was very inspiring and helped me to go from "understanding" to "knowing" by putting theory and exploration into practice. I later expressed this sentiment to the late, great Professor Diran Basmadjian who was so inspired that he added "surprise" experiments to his classes in future years.

As ChemE alumni, we possess diverse and unique skills/talents. However, we are bond by commonalities as well – one of them being Unit Ops. Since the late 1940's, we have each had the opportunity to grow and transform from our experiences in the lab – learning from those around us and those before us. Knowledge has literally been passed down from generation to generation.

Despite the fact that technology is changing the delivery of education in many exciting ways so that we can interact with material from anywhere, I believe that the physical spaces where we learn will be key differentiators for the future. The Unit Ops Lab is that kind of differentiator, with the potential to be an even greater advantage for us in the future, as it integrates with our curriculum, embraces technology, and provides a place for superb experiential learning and innovation. We still recognize the importance of having our students work with process-scale equipment before they enter the workforce. Every year in the Unit Ops Lab, over 200 students put key chemical engineering concepts into practice while gaining confidence and career-preparedness.

In this issue of *Interfaces*, you will hear from current and former students as they reflect on their time in the lab, and how it has influenced them. You will also learn about the changes coming to Unit Ops and the people making them happen.

I hope you enjoy this magazine and when you are done please feel free to share it with others, join us on Facebook, Twitter, Linkedin and now ChemE Connect (chemeconnect.ca) – our new alumni social networking platform.

Grant Allen (8T1, MASc 8T3)
Professor & Chair

Unit Ops

Departmental Feature

by Michael Freeman (MASc candidate)

A Space for Synthesis

Previous spread: Students studying pressure drop across valves.

The Unit Operations Lab – Unit Ops, as you will hear it called in Wallberg Memorial Building's rustic halls – is a place where aspiring chemical engineers come to meet chemical engineering for the very first time. A place where students at first stand in awe of intimidating scale and alien form, then gradually develop comfort controlling what boils and stirs inside of glass and metal. A place where the abstractions of blackboards and textbooks come to life, theory manifested in the rugged physicality of a centrifugal pump or a distillation column. Unit Ops is where it all comes together. Unit Ops is a space for synthesis.

A History of Evolution*

Stimulated by **Ida Wallberg's** 1933 donation of one million dollars – an echelon of philanthropy unparalleled during the Great Depression – a great swathe of College Street was to become a prodigious engineering building named in honour of Swedish-born industrialist **Emil Andrew Wallberg**, Ida's brother. The building itself was completed in 1948, its progress stymied by lack of funds until the conclusion of WWII. What came with it was Unit Ops in its original form, furnished with industrial-scale equipment like a gas absorption tower, a liquid-liquid extraction column, a climbing-film evaporator, and an evaporating still, Unit Ops represented the state of the art. As part of a steady evolution, the large room at the centre of Wallberg has seen a number of significant revisions through history. The Department of Chemical Engineering & Applied Chemistry (ChemE) welcomed the installation of its most memorable piece of still-standing equipment – the two-story, glass-walled distillation column – during the 1960s, and witnessed the coming and going of Canada's first subcritical nuclear reactor commissioned solely for teaching. Now, as the Department develops its vision for the future, Unit Ops will undergo its greatest changes yet, reaffirming it as Wallberg's beating heart.

* The information in this section was obtained from *The University of Toronto: A History* written by Martin L. Friedland published in 2002.

A Valve In Hand

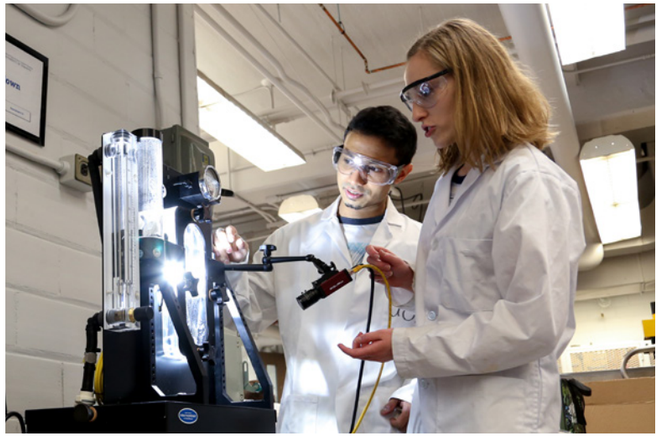
Unit Ops offers students an opportunity to get on the physical and cerebral level of the chemistry at play. To *feel* the guts of machinery through disassembly and assembly exercises. To *see* instrumentation readouts and actual fluid flow in the same breath. To *listen* to the sounds units make as a process runs.

"It is so important for students to get a feel for how real systems operate," explains Professor **Grant Allen** (8T1, MASc 8T3), Chair of ChemE. "If you went through a program without this kind of lab, you would be far less prepared for industry. Having students work with their hands is critically important, instead of just giving them the theoretical and launching them into the practical."

Associate Professor, Teaching Stream and past Associate Chair and Undergraduate Coordinator **Graeme Norval** (8T3, MASc 8T5, PhD 8T9) insists, "Good chemical engineers have a sense of how different units will work together. Much of this learning is experiential, and that is why we want the students to spend as much time as possible in the Unit Ops Lab."

True to the form of our digital age, some engineering schools use computer modelling alone to convey the experience of chemical process design and evaluation. Though the savings are doubtless and the virtual flexibility is without limit, the execution of this educational tact falls short.

"Would you want a civil engineer to design your bridge if they'd never walked across one? Would you want an electrical engineer to design your circuit if they'd never been zapped with 10 volts?" asks Professor **Timothy Bender**, Associate Chair and Undergraduate Coordinator. "In chemistry, there are serious safety concerns. *Serious.* If you don't place yourself beside that safety concern – so you can feel it, feel your heart rate go up – I think you would be lacking a skill set, an appreciation. While taking safety very seriously, I think this appreciation is critical."



Students studying flow visualization.

As the tides of modern education change, the hands-on, experiential learning that takes place in spaces like Unit Ops will remain integral to the U of T Chemical Engineering experience as it moves into the future.

The Present

Transformation to Synthesis

"The Unit Ops Lab, right now, is in a transitional period," explains Bender. "A number of faculty recognized that Unit Ops was focused on processes wherein no chemical reaction was taking place – physical transformations. For decades, our second-year students had been exposed to applied [bench top] chemistry, doing organic and inorganic chemical reactions, and never seeing them go bigger. I think it was a serious deficiency in the curriculum."

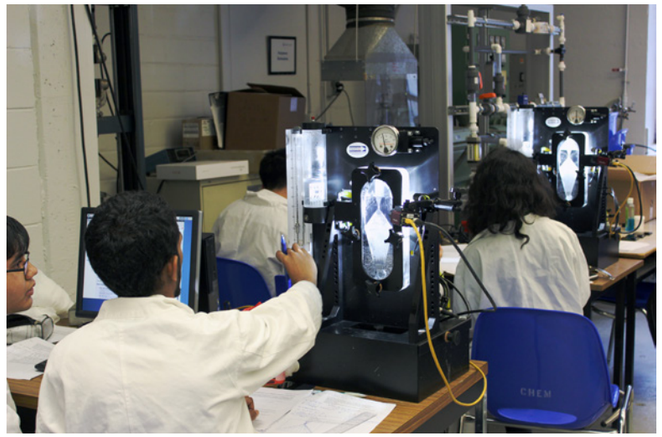
The Department's first inroads made in addressing this deficiency came in the form of the versatile batch reactor system (VBS) zone, which is now entering its fifth academic year in service. VBS comprises three batch reactors – 5L, 50L, and 100L volumes – each fitted with heating-cooling jackets and control systems. Set beside the steadfast two-story distillation column's upper reaches, the juxtaposition between old and new is clear. The smartly scaffolded apparatus with its complementing process automation desk reminiscent of a spaceflight mission control centre was, indeed, carefully designed and assembled, but the secret to the new zone's magic is in its 'V' for 'versatility.'

"VBS is not *firmly* installed," says Bender, "the system can be redesigned to take on nearly any batch chemical process. From hydrometallurgy to biofuels...we could probably even make beer in there." As for now, the transformable process rig is optimized for the production of octyl acetate by Fischer esterification. The sequence, running as a three-day lab, provides an elegant demonstration of how VBS can be a one-stop shop for pilot-scale batch processes. The next incarnation of the VBS zone is just an idea away.

Importantly, with the incorporation of VBS, Unit Ops now functions not only as a vehicle for knowledge synthesis, but also as a vibrant setting for the synthesis of fine chemicals.

Integration

Professors **Edgar Acosta** and **Vladimiros Papangelakis** have recently developed a set of integrated unit operation experiments to explore the refrigeration cycle. The units will allow students to compare real compressor efficiencies with values calculated for an ideal case, and will push students to understand better the sources of thermodynamic inefficiency. The apparatus will include



Top: Students looking at flow patterns.
Bottom: Unit Ops Lab during its current renovation.

the instrumentation necessary to conduct mass and energy balances in dynamic conditions and will incorporate start-up and shut down stages – some of the most challenging scenarios in chemical process engineering.

Visualization

Professor Graeme Norval has led the development of new laboratory experiments that explore concepts in fluid dynamics. First, Norval and his team assembled three flow visualization units that allow students to view and record flow patterns around obstructions at various flowrates. What does laminar, intermediate and turbulent look like in situ? This year's cohort of students is about to find out. Second, a test rig fitted with a spectrum of common flow measurement devices – their outputs ranging from dials to displays to digital data loggers – was constructed in order to bridge an observed gap in students' familiarity with process instrumentation. This lab will be run in concert with courses leading students through the development of piping and instrumentation diagrams (P&IDs), helping to bring elements of the diagrams to life.

The Future

Across his desk, ChemE Chair Grant Allen slides an 11×17 sheet marked with crisply printed matrices and tables expertly fitted with reflections on the Department's past and guiding philosophies for its future. The centre of the large, colourful document is emblazed with the Department's refreshed vision statement: *Through leading edge research and education, we integrate chemistry, biology and engineering to drive solutions to global challenges in energy, the environment and health.*

"This is where we're going," Allen explains, beaming, "And one of the ways we will get there is by embracing experiential learning to a greater extent."

> "And one of the ways we will get there is by embracing experiential learning to a greater extent."

The Department is looking closely at Unit Ops and considering how the experience might evolve, allowing the space, and its user, to achieve its greatest potential. Recognizing the Unit Ops experience as a curricular focal point rivalling even the capstone design project, the Department aims to provide as much student exposure to the space as possible. Instead of having Unit Ops labs concentrated in the winter semester of third year, as is done now, the Department aims to make these experiential learning opportunities available to second-year students, and eventually have them trickle down to first.

The last time the Department engaged in such significant laboratory reform was during the amalgamation of the experiments from all second-year classes into one dedicated course, CHE204. Using this model, students would learn concepts in the classroom and immediately test their understanding with tandem laboratory experiences. The course's success will likely encourage the installation of a similar program in the third-year curriculum, and Unit Ops may soon play a larger role therein.

Taking the helm of CHE204 this year, and leading the Department's charge toward a fully integrated laboratory-lecture plexus, is Assistant Professor, Teaching Stream **Jennifer Farmer**. A chemist by training, Farmer is passionate about bridging the gap between chemists and chemical engineers, an attitude that aligns beautifully with a program that takes pride in its hallmark duality of *Chemical Engineering* and *Applied Chemistry.*

The Department intends on spreading the Unit Ops wealth. Understanding well that engineering disciplines intermingle in industry, engaging in Unit Ops lab sharing and course amalgamation with other engineering departments could represent a natural progression in the evolution of the space. Also, recognizing the value Unit Ops equipment may provide graduate courses and graduate research projects, the Department aims to incorporate graduate 'scale-up' labs – beyond the few currently offered to beginner MASc and MEng students – and will begin inviting proposals for graduate research in the space.

Fresh Lungs

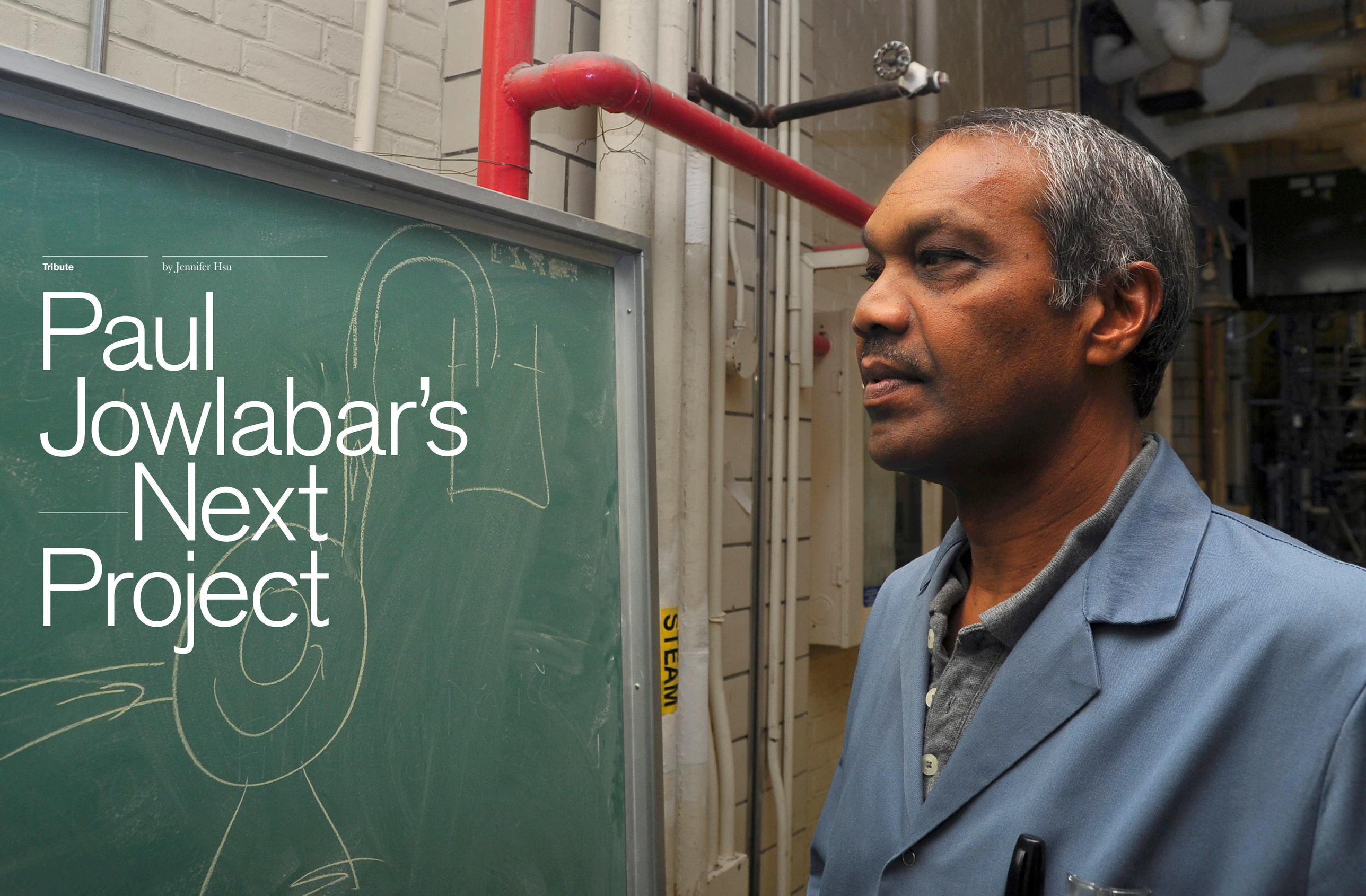
To broaden the spectrum of experimental capability in the Unit Ops Lab, the need for modifications to the room's infrastructure stands out in bold. The much-anticipated shift toward reactive processes necessitates enhanced ventilation, an endeavour for which the Department is currently raising funds. Providing walk-in fume hoods, scrubbing units and improved make-up air capacity would do the work of adding that all-important 'V' for 'versatility' to the Unit Ops space, present and future. Once installed, the list of experiments that could be performed within the walls of WB25/125 will expand at a rate limited only by human imagination.

With new lungs, Wallberg's heart will beat ever stronger.

A Synthesis of Experience

For nearly 70 years, Unit Ops has been providing a practical complement to the theoretical concepts stockpiled in the minds of aspiring chemical engineers. From the date of its launch, the space has been evolving to provide learning experiences relevant to the ever-changing chemical engineering landscape. The Department of Chemical Engineering & Applied Chemistry aims for Unit Ops to exist as a cross-section of what is available to graduating chemical engineers *today*. For this, the Department draws on its vast pool of practicing alumni for its input and support, to synthesize and distill present-day industrial expertise in order to continue building a world-class education experience at the University of Toronto.

Unit Ops is a space for synthesis. We invite you to contribute to our enduring process of refinement. i



Tribute

by Jennifer Hsu

Paul Jowlabar's Next Project

"The educational experience gained through Unit Ops and Paul's teaching is invaluable."

Previous spread: Paul Jowlabar explaining the centrifugal pump project to third-year students.

Photo by Michael Freeman (MASc candidate)

Professor **Paul Jowlabar** is best known throughout the Faculty of Applied Science & Engineering for his longstanding commitment to the Unit Operations (Unit Ops) Lab in the Department of Chemical Engineering & Applied Chemistry (ChemE). Come May 2017, as students emerge from study-hibernation to embrace the sun and summer fun, Jowlabar will be prepping for a very special day – his retirement. 2016–17 marks the last official academic year of Jowlabar's outstanding 44-year career in ChemE.

Born on January 8, 1951 in Guyana, Jowlabar – one of 11 siblings – relocated to Toronto by himself at the young age of 19 to escape the political unrest of his home country. His interest in chemical engineering sparked much later in life than one would assume. Jowlabar studied various programs including welding, machine shop, business and ultimately completed his Bachelor in Arts (Honours) in economics from York University in 1982. Single, alone and in a foreign country with no money he found employment at ChemE as a Storekeeper. In the subsequent years he went through eight different job titles culminating with his current one, Associate Professor, Teaching Stream. During his role as Laboratory Supervisor in the organic and first-year laboratories, the Department offered him a position in the Unit Ops Lab. He gladly accepted this opportunity, as he recognized the career growth potential available to him in what was referred to as the 'big lab.' Jowlabar began self-educating himself on chemical engineering in his spare time to take full advantage of this opportunity.

Through his fortitude and guidance from his mentor **John Bradnam**, who was instrumental in the development of Unit Ops from its genesis, Jowlabar feverishly reviewed all the pilot-scale experiments. Sadly in the late 1980s, Bradnam took ill, but seeing the potential in Jowlabar began grooming him to become his successor as Unit Ops' Lab Supervisor. In 1990, Bradnam retired and shortly there after passed away, but his contributions to the building and diversity of pilot-scale experiments in the lab, such as the plate distillation unit, will forever be remembered.

Having big shoes to fill, Jowlabar stepped into the position of Lab Supervisor for Unit Ops while continuing his other miscellaneous duties. In 1999, he was promoted to Senior Lecturer and in 2015 Associate Professor, Teaching Stream. In 2008, Jowlabar (while still a Senior Lecturer) was awarded the Wighton Fellow by the Sanford Fleming Foundation and the National Council of Deans of Engineering and Applied Sciences. This annual fellowship recognizes innovative, distinctive and exceptional instruction in relation to undergraduate engineering laboratory courses.

"When Paul won the award he was teaching four courses, ranging from first to third year; all of them were core to our curriculum. In addition, he was instrumental in developing new labs for the Department's first-year course that demonstrates the relevance of chemical engineering in the real world. His students, who were all on a first name basis with him, regularly referred to his ability to educate them through Socratic questioning.

Students regularly remarked that Paul never fed them answers, but instead guided them through discussions so they could arrive at the answers on their own. This challenged them to think critically and creatively to find the proper responses," says **Doug Reeve** (MASc 6T9, PhD 7T1), Chair of ChemE when Jowlabar won the Wighton Fellow.

Reeve also points to Jowlabar's own creativity, which was constantly integrated into lab demos and hands-on projects. "In order to teach how a fluidized bed functions, which is a common method used in industry to mix solid particles with gases or liquids, Paul used rubber duckies. He showed how when fluid is injected into sand it becomes loose, which allowed the duckies to float on the sand as though it were water. He then encouraged students to put their hands into the sand, where they found little or no resistance," recalls Reeve.

Paul Jowlabar running student project presentations in Unit Ops.

Unit Ops, which Jowlabar helped grow over the years, is one of ChemE's key teaching facilities and the largest lab in the Department. It is the place where students see the link between what is described in the classroom and what is used in industry. Until this day, Jowlabar continues to add new components, as equipment becomes available and finds new ways to present concepts.

"Paul's use of hands-on exercises definitely helped me visualize what real unit operations would look, smell and feel like. The value he provides to students is irreplaceable. Most universities today have gone to simulation software, which is not nearly the same thing. Paul has a great way about him, making students feel at ease and hence making learning much easier," says **Sonia De Buglio** (9T4, MASc 9T8) a former student of Jowlabar and current Director of Alumni Relations and Annual Giving for the Faculty of Applied Science & Engineering.

De Buglio's comments are mirrored by hundreds of ChemE alumni. Here are just a few from past students:

"The educational experience gained through Unit Ops and Paul's teaching is invaluable since it provided us with hands-on applications encompassing process units, fluid dynamics, separation processes as well as heat transfer and process control. Such tangible exposure enabled us to apply engineering principles to real-life operation of equipment and auxiliaries, thus bridging the gap between the theoretical and the practical, and conditioning us towards effective team work and on-site problem solving. The knowledge gained through Unit Ops was a great asset to have and apply upon joining the engineering work force post graduation," says **Gus Edmond** (9T6, MASc 9T8), Project Manager at Brevitas Consulting – Pharmaceutical Division.

"This is what the Units Ops lab and Paul offers, training future chemical engineers with practical experience"

Opposite page: Paul Jowlabar in the Unit Ops Lab in 1985.

"I have very fond memories of Units Ops and Paul. It is the one lab that abstract concepts learned in textbooks become meaningful and realistic. In today's age when engineers exceedingly rely on computer simulations, the physical reality can be under-appreciated. There's nothing like looking at a pressure gauge and appreciating the physical force and risks behind the pressure, compared to looking at some number on a computer screen. This is what the Units Ops lab and Paul offers, training future chemical engineers with practical experience," says **Rami Abouatallah** (9T7, PhD 0T2), Manager of Advanced Stack Technology at Hydrogenics Corp.

"Second year was very challenging for me. In particular, the heat and mass transfer course which is a fundamental part for the program. I remember feeling horrible after finishing the exam for that course. After leaving the exam room I found myself questioning my place in the program. I saw Paul in the Unit Ops Lab and we started chatting about what had happened. He walked me through the lab and described to me the heat and mass transfer elements, as they pertained to the equipment. I'll never forget the moment when it all clicked in for me. From then on I always went to the lab when I had trouble understanding something theoretical and never again did I question my place in program. Simply put, the lab offers a practical dimension to the theories taught in class and Paul helps students navigate the theories safely and confidently," says **Arjang Tajbakhsh** (1T3), Process Safety Consultant at WS Atkins.

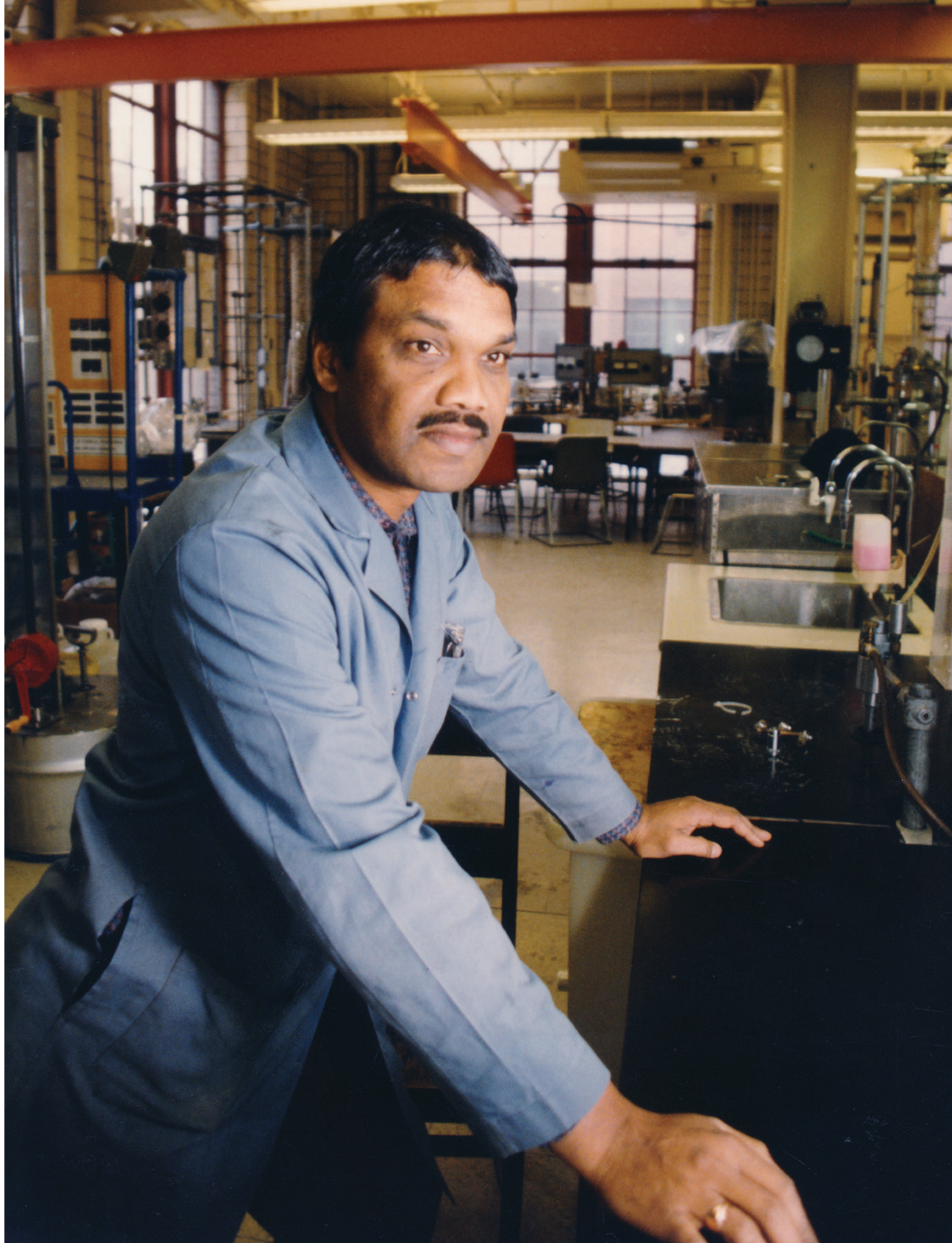
Jowlabar shows great care and concern for his students. He regularly speaks with students about their career goals and provides sage advice. Past and present students continually remark how they find Jowlabar to be super approachable and less intimidating than many other professors. That he is known simply as "Paul" in ChemE is evidence of the close relationships he has built with students in his years as a lecturer/professor in the Department, and this goes beyond undergraduate students.

"Paul has been an extraordinary help to me and the research group that I work with. He's always willing to aid in concepts and constructions that help us fine-tune our engineering and machinist skills. It's been an honour to learn technical and soft skills from such a valued U of T faculty member, and I am lucky to be able to consider him as a friend," says **Steven Le**, Protocol Engineer for U of T's Reinventing the Toilet Challenge team.

In 2007, Jowlabar received the inaugural Professor Bill Burgess Teachers of the Year Award that recognizes excellence in teaching large classes within ChemE. He was selected on the basis of his teaching evaluations and enthusiastic comments of support from students. When the award was announced at the 22nd Annual Chemical Engineering Dinner, students, faculty and staff cheered in unanimous agreement to honour Jowlabar.

"I believe Paul to be a fine example of teaching within our Department and Faculty. He has earned it through the students he has inspired, the enthusiasm he provides and the grateful graduates who have reached higher because of his efforts," says Professor **Grant Allen** (8T1, MASc 8T3) and Chair of ChemE.

When asked what he will miss most about ChemE come retirement, Jowlabar simply replied, "my students." i



by Michael Freeman (MASc candidate)

Applied Creativity

How World-Leading Plant Makers Nurture a Culture of Excellence

Opposite page: A Pyrolysis Oil Production Plant.

IN A DARKENED CONFERENCE ROOM, a team of engineers gather around an illuminated screen. The largely jeans-clad group, sipping Cokes and working away at catered chicken parmesan, watch with interest as a colleague leads them through the nuances of pressure relief valve design, this meeting's topic of interest. A young man with scruffy hair and dark-rimmed glasses explains allowable nozzle pressure drop values in a variety of conditions with a casual Australian lilt. "Now, do we use a 1.1× or a 1.21× multiplier here?" Responses fly in from all corners of the room. To the ultra-sharp engineers of Zeton Inc., the design minutiae of pressure relief valves, and thousands of other components incorporated into their unique chemical processing plants, are not mere theoretical abstractions, but important parameters firmly embedded in reality.

A One-Stop Shop for Scale Up

The Zeton name is synonymous with excellence in the design and manufacture of modular laboratory scale systems, pilot plants, demonstration plants and small modular production plants. Over the past 30 years, Zeton has worked across a broad

"If you can relate something you see in a book to something that is real, that connection becomes instant."

array of industries to bridge the gap between laboratory scale chemistry and scaled-up continuous processes, helping clients to realize commercial ambitions. With over 750 successful projects completed in 35 countries, Zeton has become the largest company in the world that specializes in this niche. "We have developed a reputation as the go-to company for high quality plants," says Zeton's President and CEO **David Beckman** (MASc 8T1). "From design engineers through to the people in our shop, quality of work is inherent in the culture of this company."

Zeton's plants are shipped across the globe with relative ease as a result of the company's policy to assemble the systems in-house and organize each into modules. Their modular approach is critical, as most projects the company takes on are unique, requiring the fabrication of custom equipment – an exceedingly difficult task to accomplish with precision at remote sites. In this way, Zeton keeps installation costs low and project schedules tight.

Applied Creativity

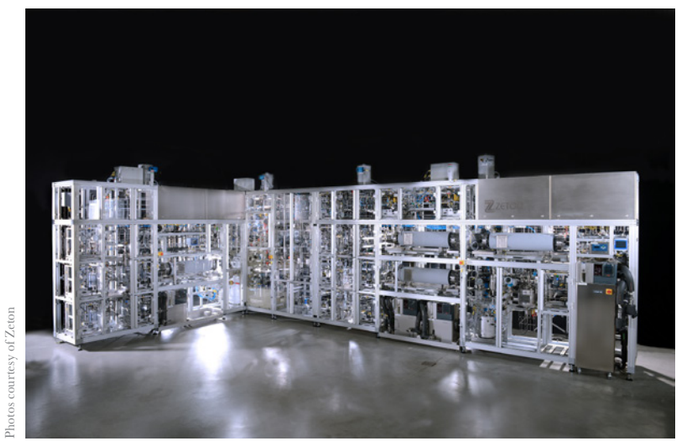
The near-constant stream of novel solutions pouring from Zeton's offices requires what Zeton's Vice President of Operations, **Leisl Dukhedin-Lalla** (8T8, MASc 9T0, PhD 9T6), calls 'applied creativity.' "Sometimes we build things where our client doesn't even know what they want…and at certain scales, commercial equipment isn't available, so we will do our own testing and build our own equipment. Being creative is what we thrive on."

With process design know-how developed and distilled over the course of three decades, Zeton draws from a deep pool of expertise and works hard to acquaint its newer engineers with this valuable resource. On any given day one can see this knowledge transfer in action as veteran staff work alongside novices, and twice each month the company runs 'Zeton University' sessions, where pertinent process design topics (e.g. pressure relief valves) are discussed amongst the age- and experience-diverse crowd. Zeton also maintains an internal database – 'Learning Points' – where lessons learned and expertise developed through projects are collected and made available across the organization. As a company that puts heavy emphasis on providing superior process design on compressed schedules, its collective memory is critically important, so Beckman, Dukhedin-Lalla, and other senior staff often act as project reference directories, pointing employees who are new to a certain design challenge toward those familiar with the scenario. "David is the kind of guy whose door is always open. He's the president of the company and people just walk into his office all the time," Dukhedin-Lalla says of Beckman, demonstrating the value Zeton sees in experience sharing.

A Union of Theoretical and Practical: Making the Connection Instant

Beckman and Dukhedin-Lalla, U of T Chemical Engineering alumni, understand well the importance of learning classroom concepts, then quickly marrying them with real-world practicality. "Things don't always happen the way they do in theory. [As a new engineer,] you need to learn this pretty quickly," says Beckman. The alumni saw the Department of Chemical Engineering & Applied Chemistry's Unit Operations (Unit Ops) Lab as a profoundly conducive environment for this connection to be made. Both Beckman and Dukhedin-Lalla pursued graduate studies in the Department, where they, separately, built pilot-scale operations as part of their projects, further supporting a cerebral union of theory and practice.

"If you can relate something you see in a book to something that is real, that connection becomes instant," says Dukhedin-Lalla. From there, true creativity and critical thinking take over. As advice to students, Dukhedin-Lalla explains, "If you're doing these [Unit Ops] labs, find out how you can break them. How could you do damage? That's how I approached things. I asked, 'What could go wrong? What are my protections in place?'" Incorporating process troubleshooting into current experiments would be a beneficial exercise, she suggests. By seeking out and correcting process issues, one may begin to truly understand the system.



Photos courtesy of Zeton

Top: A Polyolefins Pilot Plant.
Bottom: A Modular Flow Chemistry API Production Plant.

Bridging the Academic-Industrial Gap

Zeton recently began working with the Department of Chemical Engineering & Applied Chemistry to identify and fill voids in the current Unit Ops space, the most obvious among them being the laboratory's absence of continuous chemical reactions. "In my career, people would come to me with requests for pilot plants based on one of three types of reactors: fixed bed, fluidized bed, or stirred tank," Beckman says, drawing on that all-important depth and breadth of alumni experience. "Exposure to any of these would provide a great learning experience."

Initial plans have been drawn up for a small fixed bed reactor system furnished with a heat exchanger and process instrumentation that would allow students to look deeper into the flow properties, reaction kinetics and heat transfer characteristics of the process at hand. The project is on hold for the time being as the Department works to organize space, curriculum and funds, but the academic-industrial pairing is anxious to explore this exciting new avenue.

Asked to sum up her perspective on Unit Ops' value to the U of T Chemical Engineering program, Dukhedin-Lalla, after a long, searching pause, explained, "No engineer should leave an undergraduate program and not know what a valve or a pump looks like. That's what Unit Ops is for. Taking the theory being put on the board and bringing it to a practical level. This is why Unit Ops is so important." i

Student Profile

by Andrew Connolly

Industrial-Scale Experience

Unit Ops Lab Gives Students Memorable Opportunities

Previous spread: Students exploring plate distillation column.

During the school year the Unit Operations (Unit Ops) Lab buzzes with activity as six different courses use the lab for experiments. In the summer, however, things are much quieter.

The first thing you see when you enter the upper level of the Unit Ops Lab in the middle of August is a bubbling fermentation tank. Beyond that, two-story distillation columns stretch down to the lower level. The lab is filled with industrial-scale equipment that students use.

Four students on fellowships crowd around a computer in the corner of the lab's top level on this warm summer day. One of the students, **Adel El Tannir** (1T7), says he could barely contain his enthusiasm when he first entered the lab."I felt very excited that I was going to run a real-world system and integrate theory from class," he says.

This is what the Unit Operations Lab offers students: the opportunity to put the theoretical principles they learn in their courses into practice on a larger scale, a scale they might encounter once they graduate and enter the workforce.

"The Unit Ops Lab is part of what makes U of T Chemical Engineering unique," explains Department Chair **Grant Allen**. "Most schools only offer computer-based simulations whereas we offer essential hands-on education and experience that students can use when they begin their careers."

Students appreciate the opportunity that lab provides for them.

"U of T Chemical Engineering students are lucky," says **Rosten Role** (1T8), another student working in the lab over the summer. "It is important for us to get a glimpse of what chemical engineering in industry looks like and this lab gives us a firsthand view of that. It gives us practical skills that are essential for our future career plans."

The lab is specially designed to help students develop those skills. For example, the controls for the tube and shell heat exchanger are on the opposite end of the lab from the machine itself.

"That is by design," explains the Lab Supervisor and Associate Professor, Teaching Stream **Paul Jowlabar**. "In an industrial setting, the controls are often in a different room. Students learn how to communicate and work together, not just how to use the equipment."

Students also have the opportunity to scale-up experiments that they run in chemistry labs.

For example, this past summer students worked on an esterification project using the 5L, 50L and 100L batch reactors sit at the very back of the lab's top level. When an alcohol is mixed with an acid (and often a catalyst to speed up the reaction) it produces an organic chemical compound called an ester. Esters have unique fragrances and are used in perfumes and essential oils. Students normally perform esterification projects on the micro-scale, but the Unit Ops Lab gives them the opportunity to work on a scale that companies would use in the production of commercial products.

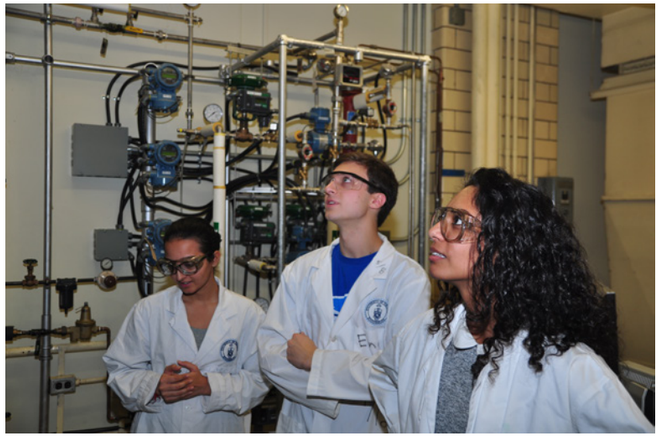
"The process of moving between these scales is known as the 'scale-up' and it is the most challenging aspect of the project," explains **Julia Lobo** (1T8), "The chemistry does not perfectly translate from a 250mL reaction vessel to a 5L/50L/100L reactor without certain considerations."

Students had to account for different surface areas and temperatures as they experimented with different chemical ratios, different catalysts and different catalyst ratios for each scale. In the end, students were able to see how the theory they learn in classroom translates to real, large-scale environments.

"I learned that chemistry theory does not translate perfectly from paper into practice without perfecting the necessary conditions," says Lobo. "Working in the Unit Ops Lab is a diversified learning experience."

"It is important for us to get a glimpse of what chemical engineering in industry looks like and this lab gives us a firsthand view of that."

Photos by Michael Freeman (MASc candidate)



Students tracing piping lines for heat exchangers going to the process control unit in the background.

Students not only had an opportunity to use industrial-scale equipment for their products, they also learned how to maintain it. That led to some memorable experiences.

"My favourite memory of working in the Unit Ops Lab was when myself, the other summer students and Paul, the Lab Supervisor, cleaned the big plate distillation column," says Lobo.

The process of cleaning the column takes several days, and includes scrubbing with snakes and a CLR solution. In order to make their work easier, the group planned to let the CLR sit in some hard to reach areas of a re-boiler over night.

"The flanges on one of the bottom openings was not secured tightly enough," recalls Lobo. "Ten minutes after we poured the re-boiler full of CLR, the flange came loose and all of the grimy green liquid came gushing out in front of us. Our silence that followed still tickles me when I think about it."

"I will look back at these wonderful lifetime memories and appreciate them," says Tannir. "They will be forever engraved on my mind."

While students gain skills and memories from their experiences in the lab, the Department of Chemical Engineering & Applied Chemistry benefits from the lab in other ways. For example, the work students did on the esterification project has a direct impact on what undergraduate students will do in class in the coming years; they will use ratios and catalysts which best mimic the kinds of reactions students achieve on an industrial scale.

Students in the Unit Ops Lab were also encouraged to identify different ways the equipment in the lab could be improved. For example, the four summer students designed a Dean-Stark trap for the 5L reactor that would enable future students to collect both liquid and gas samples safely without cross-contamination. The pride shows on their faces as they demonstrate where it fits on the reactor and how it will work.

"I felt really excited because there were design-based assignments that had a real impact on students' academic learning experiences," says **Omar Hamdy** (1T8). "We get to take part in what happens behind the scenes and it gave me a true sense of fulfillment."

Role agrees. He says his experience in the lab has been rewarding. "As a U of T Chemical Engineering student, there is something very special and exciting about getting to operate this massive set of equipment and do something to help improve it," he says. "It felt as if I was already an engineer when I got to work on it; that's how awesome it is." i

Selected Honours & Awards

Members of the Department of Chemical Engineering & Applied Chemistry at U of T help set us apart from the rest.

We are extremely proud of the number of awards and acknowledgements received by our alumni, faculty and students since Fall 2015. Congratulations to each of them on their major achievements.

Alumni

11th International Conference on Industrial Ventilation, Outstanding Career Award
2015 — Howard Goodfellow (6T4, MASc 6T5, PhD 6T8)

ACGC, Top 30 Under 30
2016 — Yazan Kawar (1T0, MEng 1T1)

CAE, Fellow
2016 — William Breukelman (5T5)

EC, Meritorious Service Award for Community Service
2016 — Marisa Sterling (9T1)

FASE, EAA Engineering Alumni Medal
2016 — David Colcleugh (5T9, MASc 6T0, PhD 6T2)
2015 — Frank Dottori (6T3)

FASE, EAA Hall of Distinction
2016 — Ali Khademhosseini (9T9)
2015 — William Breukelman (5T5)

OSPE & PEO, Citizenship Award
2016 — Valerie Davidson (PhD 8T3)
2015 — Claire Kennedy (8T9)

OSPE & PEO, Engineering Excellence Medal
2015 — Jeanette Southwood (8T6, MASc 8T8)

OSPE & PEO, Gold Medal
2016 — Larry Seeley (6T6, MASc 6T8, PhD 7T2)

U of T, Arbor Award
2016 — Michael O'Dwyer (8T4)
Sid Olvet (5T9)
Ravindran Thuraisingham (MASc 9T4)
2015 — Angela Tran Kingyens (MASc 0T7, PhD 1T2)
Marisa Sterling (9T1)
Stanis Yu (0T0)

WXN, Canada's Most Powerful Women: Top 100
2015 — Siobhan Robinson (0T9)
Jeanette Southwood (8T6, MASc 8T8)

Donor-Sponsored ChemE Student Awards

Colcleugh Family Award
2015 — Roham Dorakhan (1T8)
Yalun Li (1T6+PEY)
Shankavi Sivakumaran (1T9)
Minh Long Tran (1T7+PEY)

Diran Basmadjian Graduate Scholarship in Chemical Engineering & Applied Chemistry
2016 — Olivia Molenda (PhD candidate)

Eco-Tec Founder's Fellowship
2016 — Jon Obnamia (PhD candidate)
Naz Orang (PhD candidate)
Shirley Lam (PhD candidate)

Edward Jarvis Tyrrell Fellowship
2016 — Locke Davenport Huyer (PhD candidate)
David Josey (PhD candidate)
Nimalan Thavandiran (MASc 1T2, PhD candidate)

Helen L. Cross Memorial Graduate Scholarship
2016 — Hanya Hemasian Ettefagh (MASc candidate)
Sable Reid (MASc candidate)

Howard Guest Bursary
2016 — Darren Rodenhizer (1T3, PhD candidate)
Alinaghi Salari (PhD candidate)

Irving P. Shoichet Graduate Scholarship
2016 — Stephanie Fisher (PhD candidate)
Anastasia Korolj (1T4+PEY, PhD candidate)

Professor William F. Graydon Memorial Graduate Fellowship
2016 — Mabel Wong (PhD candidate)

R. E. Jervis Award
2016 — Antonie Boyer (MASc candidate)
Numaira Obaid (PhD candidate)
Silvia Zarate-Munoz (PhD candidate)

R. W. Missen Memorial Prize in Thermodynamics
2015 — Cullen Hunter Adam (1T6+PEY)
Kishan Modi (1T6+PEY)
Shi Miao Yu (1T9)

The Class of 5T9 Leaders of Tomorrow Award
2016 — Katie Dritsas (1T7)

The Class of 8T2 Emerging Leaders Award in Chemical Engineering
2016 — Molly Gorman (1T8)

The ERCO Worldwide Leaders of Tomorrow Award
2016 — Nikola Andric (1T5+PEY, MEng candidate)

The Professor Douglas Reeve Leaders of Tomorrow Award
2016 — Jeremy Dang (PhD 1T6)
Locke Davenport Huyer (PhD candidate)

The Professor James W. Smith Leaders of Tomorrow Award
2016 — Tyler Choi (1T8)

The Troost Family Leaders of Tomorrow Award
2016 — Oyinkansola Romiluyi (1T5+PEY)

W. H. Rapson Memorial Award
2016 — Geanna Hovey (MASc 1T6)
Eric Jin (1T1, MASc 1T3, PhD candidate)

Faculty

AAAS, Fellow
2015 — Greg Evans (8T2, MASc 8T4, PhD 8T9)

CAE, Fellow
2016 — Milica Radisic
Honghi Tran (PhD 8T2)

CCA, Killam Prize
2016 — Elizabeth Edwards

Chatelaine, Women of the Year List
2016 — Molly Shoichet

ChemE, Bill Burgess Teacher of the Year Award for Large Classes
2016 — Cathy Chin

ChemE, Diran Basmadjian Teacher of the Year Award for Small Classes
2016 — Chris Ambidge

CRC, Tier 2
2016 — Cathy Chin
Elodie Passeport

FASE, Hart Early Career Professorship
2016 — Alison McGuigan (PhD 0T5)

MetSoc of CIM, Environmental Award
2015 — Charles Jia

NAE, Foreign Member
2016 — Molly Shoichet

OCUFA, Teaching Award
2015 — Greg Evans
(8T2, MASc 8T4, PhD 8T9)

RCI Science, Fleming Medal & Citation
2015 — Molly Shoichet

RSC, Fellow
2015 — Levente Diosady
(6T6, PhD 7T2)

SCN, Till & McCulloch Award
2016 — Molly Shoichet

TERMIS, Lifetime Achievement Award
2016 — Michael Sefton (7T1)

Terumo, Global Science Prize
2016 — Michael Sefton (7T1)

U of T, Honorary Degree
2016 — Venkatesh Mannar

Other Student Awards

2016 Canadian University Chess Championship, 1st Place
2016 — Sowjanya Sowrirajan
(MEng candidate)

ChemE, Chemical Engineering Plant Design Award
2016 — Jiawei Du (1T5+PEY)
Stephanie Fata (1T5+PEY)
Madona Khalil (1T5+PEY)
Hyeok Lee (1T6)
Tianwen Tao (1T6)

ChemE, Environmental Engineering Plant Design Award
2016 — Devika Jain (1T5+PEY)
Karan Nathwani (1T6)
Ribhu Rampersad (1T5+PEY)
FuYuan Tee (1T5+PEY)
Minyue Zheng (1T6)

ChemE, Graduate Student Life Catalyst Award
2016 — Jeremy Dang (PhD 1T6)
Geanna Hovey (MASc 1T6)
Naomi Zimmerman (PhD 1T6)

ChemE, Sustainable Engineering Plant Design Award
2016 — Siyan Guo (1T5+PEY)
Shiva Nandlal (1T6)
Akhil Patel (1T6)
Helia Safaee (1T5+PEY)
Prithvi Sinha (1T7)
Manning Shu (1T6)

ChemE, Undergraduate Student Life Catalyst Award
2016 — Nikola Andric
(1T5+PEY, MEng candidate)
Carol Choi (1T5+PEY)
Madona Khalil (1T5+PEY)
Peter Murphy (1T5+PEY)

CIC/SCI, Canada Merit Award
2016 — Hui Huang Hoe
(1T5, PhD candidate)

OPE Foundation for Education, Undergraduate Scholarship
2016 — Kun Yi Antonio Juan Ding
(1T7)

Pan-American Intercollegiate Chess Championship, 2nd Best International Team
2016 — Sowjanya Sowrirajan
(MEng candidate)

U of T, Gordon Cressy Leadership Award
2016 — Nikola Andric
(1T5+PEY, MEng candidate)

UnERD, Chemical Engineering Poster Competition, 1st Place Medal
2016 — Onasvi Kharsikar (1T8)

UnERD, Overall Competition, 3rd Place Medal
2016 — Onasvi Kharsikar (1T8)

In Memoriam

It is with regret that we have learned of the passing of the following ChemE graduates since the last issue of *Interfaces* in Fall 2015.

T B. Adams (5T0)
Aug 29, 1926 – Jan 13, 2016

Maurice Bryson (5T0)
Sep 26, 1916 – Aug 11, 2016

Paul G. Complin (6T8, MASc 7T1)
Jul 28, 1945 – Sep 8, 2015

Donald Cullingham (5T0)
Aug 9, 1928 – Oct 16, 2015

Mark J. Ernsting (PhD 0T5)
Unknown – Dec 15, 2015

Donald E. Fleet (4T8)
Dec 23, 1925 – Mar 6, 2016

John R. Hall (3T9)
Mar 1, 1916 – Feb 23, 2016

George T. Harrap (5T6)
Dec 1, 1932 – Oct 24, 2015

John D. Hisey (4T7)
Sep 14, 1919 – May 5, 2016

Donald B. Hislop (4T9)
Jan 9, 1927 – Dec 3, 2015

John W. Holland (5T8)
Oct 18, 1935 – Aug 29, 2015

John J. C. Klauke (5T6)
Feb 4, 1935 – Nov 13, 2015

Donald R. Lambert (5T1)
Jun 15, 1929 – Oct 14, 2016

Edgar Lavergne (MASc 5T3, PhD 5T6)
Jan 23, 1928 – Nov 6, 2015

James E. Lightfoot (5T4)
Aug 30, 1931 – Oct 21, 2015

Elwood A. MacDonald (3T9)
Mar 27, 1916 – Feb 23, 2016

David K. Matsunaga (6T6)
Jun 18, 1944 – Dec 9, 2015

Ian M. McArthur (4T9)
Mar 22, 1926 – Oct 30, 2015

Robert W. McCullough (6T1)
Dec 28, 1938 – Dec 18, 2015

Mark K. Nagata (5T2)
Aug 7, 1925 – Apr 27, 2016

Akio Oda (5T8)
Jan 10, 1929 – Feb 11, 2016

Frederick E. Punnett (4T8)
Unknown – Jan 15, 2016

Allan G. Pyatt (4T9)
May 12, 1921 – Feb 11, 2016

John L. Smart (3T9)
Aug 15, 1916 – Jul 14, 2016

Bruce P. Wallace (5T7)
Oct 10, 1933 – Nov 14, 2015

John B. Watts (4T1)
Unknown – Jan 6, 2016

Richard E. Watts (4T5)
Apr 21, 1922 – Oct 12, 2015

by Peter A. Stevens

Profiting From Renewal

Opposite page: Scale-up reactors in Unit Ops.

DR. LARRY SEELEY (ChemE 6T6, MASc 6T8, PhD 7T2) knows all about the value of renewal. During his 45-plus years in the mining and metals industry, he has transformed himself from a Scientist, to a Senior Executive of Falconbridge, to the globe-trotting CEO of the world's foremost metallurgical testing, research and development firm, Lakefield Research Limited. He chuckles when reflecting on his days as an eager young engineer, running experiments and testing theories in the Unit Operations (Unit Ops) Lab of U of T's Department of Chemical Engineering & Applied Chemistry. Never did he imagine, back then, that he would have such a wide-ranging and rewarding career.

"Graduate school does two things for you," Seeley declares. "It opens doors to various career aspects and it teaches you how to think and get results. It's one thing to have theories and ideas, but quite another to do experimentation and prove those theories as fact." As a graduate student, Seeley immersed himself in the Department's research environment, working as a demonstrator in the Unit Ops Lab and making his own contributions to the field of fluid mechanics. For his PhD project, Seeley designed a five-story apparatus that measured laminar and turbulent flow in the boundary layer around a sphere. His research represented the first time that the velocity in the boundary layer had been measured using a non-disturbing technique.

Industry soon came calling. Hired by Falconbridge to run a pilot plant in Sudbury, Seeley quickly made a name for himself devising solutions to environmental problems that also helped the company's bottom line. Amidst growing public concern over acid rain, Seeley led the development of a new smelting process that increased productivity and improved plant safety while also reducing sulphur dioxide emissions by over 50%. He led similar success with a new slag cleaning system, proving that

"The problem we increasingly face in industry is that many engineers are entering the workforce with little hands-on experience"

efforts at environmental renewal could also pay dividends for business. "We achieved many objectives by redeveloping the process," he explains. In addition to fighting acid rain, "that project produced tens of millions of dollars within five years."

Seeley would go on to spend nearly 25 years with Falconbridge, rising through the managerial ranks and eventually becoming the corporation's first Vice President of Environmental Services. Under his direction, the company undertook a variety of environmental initiatives, including site remediation, tree-planting programs, and the creation of environmental codes of practice and responsibilities that ultimately were adopted internationally. To Seeley, this is just one example of how Canadian mining expertise has benefited the industry worldwide. "There's a tremendous lack of public understanding about how important the metals industry is. But the fact is that, globally, Canadians have been the primary drivers of this business."

In 1995, Seeley left Falconbridge to become owner and President of Lakefield Research, a small, Peterborough-area company that provided technical and research services to the mining industry. Over the next nine years, he grew Lakefield into the largest organization of its type in the world, with some 1,000 employees, and operations in Canada, South America, Australia and South Africa. Closer to home, Lakefield emerged as a leading water-testing company, with its labs testing more than half of the municipal water sources in Ontario. This new direction was in keeping with Seeley's belief that there needn't be a conflict between resource extraction and the environment. "Stopping any contaminants from getting into the water is absolutely critical," he asserts. While acknowledging past mistakes, he argues that "We can't blame our forefathers, because that's the way it was done. But the industry has evolved and part of that evolution has been to sustainable development."

Seeley has continued to reinvent himself since selling Lakefield in 2002. Today he heads the Seeley Group, a private company with interests in real estate, solar energy and the production of protein from canola. As he explains, this variety of challenges keeps him fresh: "I can't be in a box. I can't do the same thing all the time."

For his service to industry, Seeley has been showered with awards from the Professional Engineers of Ontario and other professional organizations. He also has served on the boards of several educational institutions, including Science North, Trent University and the University of Ontario Institute of Technology. At U of T, he has served as a Board of Advisor member for the Department of Chemical Engineering & Applied Chemistry.

Seeley is excited by plans to modernize the Unit Ops Lab where he once spent so much time and he's convinced that the Department and its graduates will profit from the lab's renewal. "The problem we increasingly face in industry is that many engineers are entering the workforce with little hands-on experience," he says. "Just using a computer, or textbooks, or models – it's not good enough. We need engineering students to be running equipment, getting the numbers, analyzing them and figuring out what's going on. And that's what that lab is all about." i

Save the Date!

The **32nd Annual Chemical Engineering Dinner** will take place on **Friday, April 7, 2017**.

This "must-attend" event draws in hundreds of attendees each year consisting of alumni, industry friends, students, faculty and staff. To better engage with our growing guest list, we're expanding our program this year to begin in the afternoon with an industry talk and research-poster session.

We will be sending out email invitations within the next few months. If you wish to attend, please make sure we have your current email address on file by sending an email to address.update@utoronto.ca.

Hope to see you then!

Upcoming Events

For information on upcoming events visit chem-eng.utoronto.ca.