CHEMICAL ENGINEERING
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CATALYST FALL|WINTER 2017

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THIS IS UW CHEME – INSPIRING THE NEXT GENERATION TO CREATE KNOWLEDGE AND SOLUTIONS FOR A CHANGING WORLD

CHEMICAL ENGINEERING
UNIVERSITY of WASHINGTON
Knowledge and solutions for a changing world

FALL|WINTER 2017

Catalyst

IN THIS ISSUE

ENABLING CHEMICAL ENGINEERING WITH DATA SCIENCE

By Professor David Beck

From high-throughput experimentation to large-scale observational studies and massive simulations, there has been an unending succession of advances in our ability to generate large data sets. These advances have been made possible by the commoditization of robotic instrumentation, the increasing availability, decreasing cost, and improved accuracy of sensing and imaging technologies, and the continually declining cost of scalable computation and data storage. However, large data sets are often synthesized from several sources, resulting in heterogeneity and complexity that requires reconciliation. They may also contain noise or other challenging features. As a result, knowledge extraction has been limited. Data Science is meant to address this bottleneck. At its core, Data Science is the intersection of statistics, data management, visualization, Machine Learning and software engineering. It is at its most powerful when overlaid onto the fabric of substantive domain expertise.

The challenges of data management begin the moment data is collected. In the case of a large-scale streaming sensor network, do we save all the data–potentially billions of samples–or just time-windowed statistical summaries? What implications do these decisions have on our ability to use the data effectively in downstream analyses? In a high-throughput imaging experiment, how should the data be stored to be most effectively used by image processing software? In all cases, we wrestle with what metadata to record so that data is correctly interpreted and its provenance captured. Working effectively with data sets requires knowledge and understanding of databases and data management strategies.

David Beck is a Research Associate Professor of Chemical Engineering, Director of Research for the UW eScience Institute, and Associate Director of the National Science Foundation Research Traineeship DIRECT program

Chemical engineering is an ideal environment to deploy Data Science methodologies. For example, chemical plants are highly automated settings in which sensor networks provide continuous streams of data. However, traditional model predictive control techniques often fail due to process complexity or a mismatch between the speed of computation and the response rate required for high performance. In such instances, Machine Learning methods can be used to learn process control rules with a high level of accuracy and millisecond run times.

Machine Learning is often broken down into supervised and unsupervised. In supervised learning, a model designed to predict the behavior of a system is trained with data labeled by domain experts and careful experimental design. For example, to identify order or disorder in a microscopy image, a Machine Learning model may be trained with hundreds of labeled images. Unsupervised learning does not have the benefit of labels and tries to discover meaningful relationships and structures within the data. An example would be the clustering of gene expression data to design an industrial microbe that produces massive amounts of a commercially valuable compound.

Data Science is equally powerful when applied to hybrid pipelines that couple high-throughput characterization experiments to data driven modeling. These pipelines tend to be "virtuous design-build-test cycles" where experimental data are used for model building, models are used to design experiments that test model accuracy, and results are fed back into models. With this cycle repeating until the model is accurate, it becomes possible to create new materials or medicines with unique properties.

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MESSAGE FROM THE CHAIR

Chemical engineers have long used probability and statistics to assess uncertainty, design experiments, and make industrial processes safer, more profitable, and more environmentally friendly. An explosion in the sheer amount of data available to the average engineer combined with a rapid increase in the processing power of cloud-based computing platforms is about to change the rules of the game.

What we now refer to as Data Science has potential for transforming the jobs that our graduates hold, and is already ushering in a new paradigm in the way we conduct research. In the cover article of this issue of *Catalyst,* Prof. Beck provides an introduction to Data Science and Machine Learning, and explains why chemical engineering is the ideal field to deploy these powerful new tools. In our feature story, alumnus, Advisory Board member, and NVIDIA VP of Business Development Rick Hyman, provides an industrial perspective on the transformational nature of Data Science, Machine Learning, Deep Learning, and Artificial Intelligence. He also challenges you to educate yourself on the topic.

With many of the global leaders in Data Science (Microsoft, Amazon, Tableau, Zillow…) in our backyard, an Advanced Data Science Option for doctoral students approved in 2015, a graduate training program in Data Science in clean energy funded by a $3M National Science Foundation award (see side article by Prof. Pfaendtner), and the impending roll-out of a strategic initiative that places Data Science as a foundational piece of the department's educational and research efforts, UW Chemical Engineering is well ahead of the pack. I look forward to reporting on our progress in future issues of *Catalyst*.

You will also find in this issue an update on the graduates of our entrepreneurial capstone design program, and a celebration of the achievements of our students, alumni, and faculty. From Ph.D. candidate Matt Murbach's success as a Forbes 30 under 30 in Energy to Warren Wilder's (B.S. '79) selection as the 2017 R. Wells Moulton Distinguished Alumnus in Industry, Prof. DeForest's prestigious NSF CAREER Award, and Prof. Jiang's 2017 AIChE Braskem award for Excellence in Materials Engineering and Science, we are proud of all of the accomplishments of the past year, and, as always, deeply grateful for your support.

François Baneyx, Department Chair and Charles W.H. Matthaei Professor of Chemical Engineering

KNOWLEDGE AND SOLUTIONS FOR A CHANGING WORLD

TWO BIRDS WITH ONE STONE: ENABLING DATA INTENSIVE RESEARCH IN CLEAN ENERGY AND PREPARING OUR GRADS FOR WHAT'S NEXT

By Professor Jim Pfaendtner

Discovering new materials to generate and store renewable energy is one of the most important technological challenges facing society today. However, all phases of this scientific process – design, synthesis, and characterization – are routinely stymied by the same challenge: researchers are not equipped to handle the deluge of data coming from their labs and high-performance computations. DIRECT (Data Intensive Research Enabling Clean Technologies), a training program for graduate students at UW funded by the National Science Foundation, teaches the next generation of energy researchers how to handle the massive data sets that arise at all stages of materials discovery. At the same time, students learn valuable data science skills and a credential for their degree, helping them compete for the many 'data scientist' jobs that companies seek to fill.

In its 2nd year, DIRECT just welcomed a new cohort of master's and doctoral students from ChemE and partner departments (Materials Science and Engineering, Chemistry, Molecular Engineering and Electrical Engineering). In their year long program, students will receive Data Science training, apply new tools and skills in a project-based learning environment, and work with industry on a capstone project that matches student teams with employers to provide real-world experience.

Students take two courses developed last year by Prof. Beck and Prof. Pfaendtner: *Software Engineering for Molecular Data Scientists* and *Data Science Methods for Clean Energy Research.* The courses provide students with software engineering skills to do research in Data Science fields and to be successful technical professionals. We also provide students with a survey of Machine Learning methods, including supervised and unsupervised methods, while they participate in hands on, interactive and collaborative learning.

There has been a high demand for the program which has grown from 30 to over 50 students. We plan to expand DIRECT to other fields of chemical engineering research to help our graduate students become highly sought after, data-intensive researchers.

PROFESSOR POZZO TAKES STUDENT GROUP TO PUERTO RICO TO SURVEY HURRICANE DAMAGE AND ASSIST WITH ENERGY NEEDS FOR HEALTH CARE

This November, on the first of several trips, an interdisciplinary team of engineers visited homes and clinics in Jayuya, PR to assess energy needs for health care in the aftermath of hurricane Maria. The team will return to bring more efficient and afforable energy solutions to those in need.

(l-r) Chanaka Keerthisinghe (EE), Erin Palmisato (Global Health), Mareldi Ahumada (EE), Wesley Tatum (MSE), Marvi Matos (Blue Origin), Prof. Lilo Pozzo, Lauren Kang (Chemistry), Chester Pham (ChemE) | Students participate in the installation of solar fridges donated by *Seattle for Puerto Rico Organization*. Installations were carried out with help from Borintek, a local solar installation company. | In the Jayuya clinic, students performed interviews and conducted an energy audit of the medical instrumentation.

CHEME'S ENTREPRENEURIAL DESIGN PROGRAM PAYS BIG DIVIDENDS

The Entrepreneurial Design program was developed and launched in 2011 by Professor Dan Schwartz to provide a year-long alternative to traditional capstone design, and since its inception, has produced some big dividends.

CEO and co-founder of PolyDrop, Volha Hrechka started her company as a ChemE student in 2013. She was one of the first to participate in Entrepreneurial Design. Her interdisciplinary team developed and manufactured a lightweight conductive polymer additive for coatings that formed the basis of her company, and just this year, Volha was recognized as one of *Puget Sound Business Journal*'s 2017 40 under 40.

In 2015, Matt Murbach developed and co-founded Battery Informatics as a graduate mentor in Entrepreneurial Design. Matt's company is now leading the way in battery diagnostics, and he was recently selected as one of *Forbes Magazine*'s 30 under 30 for 2017.

Andy Liu, CEO and founder of startup DeCafino, shared how the program contributed to his growing success. "The biggest strength of the program is that it helps students to identify a real-world problem and apply the skills they have learned in ChemE right away."

Under Professor Lilo Pozzo's guidance, seniors in Andy's group were asked to find an innovative use for extracting water from food using zeolites. From this starting point, Andy and his team came up with several product ideas, including a household kit for dry-aging steak and removal of water from coffee to make a more intense brew. Part of the program teaches students how to perform market research, and the team soon realized that they needed a more practical, innovative and marketable product. "We thought that extracting water from coffee essentially gives us espresso, and that is already out there." The team began to take a closer look at the coffee industry, then the idea materialized. "Decaffeination is a big problem for the industry, there are harsh chemicals, high energy use and inconsistent results in current processes. What if we could extract caffeine from coffee after the coffee is brewed, while reducing the environmental and health impacts of traditional decaffeination methods?" Andy and his group now had a compelling problem to which they could directly apply their ChemE skills.

Andy Liu, Co-Founder, DeCafino

The team went on to develop a business plan and a unique product, and Andy's company, DeCafino became a reality. Currently, DeCafino is working on further development of their patented decaffienation process, and improvements to efficiency and manufacturing methods. "Today, we have coffee roasters and restaurants lined up and waiting for our products. Our challenge right now is to scale up production to meet market demand. DeCafino will not only serve larger customers, but also has a product line for individual consumer use.

Andy commented about the program, "ChemE's Entrepreneurial Design program is a valuable experience because it gives students the tools that activate the engineer mind."

-Stephanie Ashby

ALUMNI UPDATES

DONOR SPOTLIGHT *By Jessie Muhm*

For the past five years, **James (BS '61) and Katherine McClain** have provided scholarship support to chemical engineering students.

"We decided to make this gift out of a desire to give a leg up to young students. With this financial support, we hope we're taking away one of the various burdens that face incoming college students."

Jim and his family moved from California to Seattle right after his high school graduation. As a newcomer to the area, Jim found friendship when he joined the Phi Sigma Kappa fraternity in his freshman year, where he and his new friends explored the greater Seattle area. Jim remains friends with some of his original roommates today, and he and Kay want to ensure that current students can similarly devote time to developing friendships while getting beyond campus to see all that Seattle has to offer. The McClain Scholarship offsets tuition expenses for one student, ensuring that he or she can focus time and energy on these explorations rather than having to add a part-time job to a very full plate. Fortunately, for future chemical engineering students, the McClains have recently renewed their commitment and will continue providing this wonderful support. *Photo: Jim McClain with current McClain Scholarship recipient, Hannah Hertz*

CHEME CLASS OF 1967 RETURNS TO UW FOR 50TH REUNION *By Kaitlin Colleary*

ChemE Department Chair François Baneyx and Professor John Berg greeted alumni from the class of 1967 as they gathered to commemorate their 50th year class reunion in Benson Hall. The reunion was celebrated along with the Chemical Engineering Graduation ceremony on June 9, 2017.

From the class of 1967, Om Agarwala, Donald Anderson, Robert Burmark, Christian Haussmann, Lino Niccoli, Richard Perry and Eugene Skoglund were in attendance, along with spouses Fran Anderson, Marilyn Burmark and Priscilla Skoglund. Will McKean, a friend from the class of 1968, also joined the festivities. ChemE Emeritus Prof. Charles Sleicher, Emeritus Prof. Bill Heideger and spouse Janet were also there to welcome the group.

Chair Baneyx hosted a tour of Benson Hall, and pointed out new and familar spaces, including the Bindra Innovation Lab and the Berg Colloids and Surfaces Lab. The tour concluded in the Temple Conference Room where alumni mingled over snacks and looked at photos from their time as students when the building first opened its doors. Professor John Berg surprised the group with photos of the alumni from their time in the department.

Chair Baneyx shared remarks and a departmental update with the group. Then, in recognition of 50 years of accomplishments, he presented members of the Class of '67 with commemorative "stoles of gratitude." Several alumni wore the stoles proudly during the graduation ceremony that followed.

It was a joyful reunion, and a great time was had by all. ChemE looks forward to continuing this tradition next year when we welcome the class of 1968.

(left): Chair François Baneyx presents Om Agarwala with a ChemE "Stole of Gratitude" ; (l-r) ChemE's class of 1967 alumni Eugene Skoglund '67, Donald Anderson '67, Richard Perry '67, Christian Haussmann '67, Lino Niccoli '67, Robert Burmark '67, William McKean '68, Om Agarwala '67, Emeritus Prof. Charles Sleicher, Emeritus Prof. Bill Heideger and Professor John Berg gather for a reunion photo.

2017 DISTINGUISHED ALUMNUS IN INDUSTRY, WARREN WILDER *By Jessie Muhm*

We are pleased to honor Warren Wilder (BS '79) with the 2017 R. Wells Moulton Distinguished Alumnus in Industry Award. Since 1993, the Moulton Award has been presented to alumni who have made exceptional contributions in industry, academia, government or public service.

Warren Wilder's career in the global chemical and refining industry spans 30 years. In 2013, he joined Saudi Aramco and was appointed Vice President of its chemicals business in 2014. In that capacity, he led some of the company's most strategically critical operations, including its global growth initiatives and its world-scale domestic joint-ventures, Petro Rabigh and Sadara. Sadara, a $20 billion joint venture with Dow Chemical Company, is the world's largest chemical complex ever built in a single phase.

Prior to joining Aramco, he served as Managing Director for Titan Chemicals in Malaysia, President and CEO of Reliance Industries in Mumbai, and Vice President, Olefins & Styrene at Westlake Chemical Corps in Houston. His career began at Exxon where he held roles in refinery process engineering, financial planning, business development and strategic planning.

Warren also serves on the Board of Directors of the Gulf Petrochemicals and Chemicals Association (GPCA), a 240-member association that represents the downstream hydrocarbon industry in the Arabian Gulf.

He holds an MBA from The University of Chicago and a BS in Chemical Engineering from the University of Washington.

We congratulate Warren on joining our prestigious cohort of Moulton award recipients.

ASHUTOSH CHILKOTI ('91 Ph.D.) RECEIVES 2017 DIAMOND AWARD FOR DISTINGUISHED ACHIEVEMENT IN ACADEMIA *By UW College of Engineering*

Ashutosh Chilkoti, '91 Ph.D. Chemical Engineering, and currently the Alan L. Kaganov Professor of Biomedical Engineering and Chair of the Department of Biomedical Engineering at Duke University, received the UW College of Engineering 2017 Diamond Award for Distinguished Achievement in Academia. The Diamond Awards honor outstanding alumni and friends who have made significant contributions to the field of engineering.

Ashutosh "Tosh" Chilkoti is one of the world's leading biomolecular engineering researchers focused on cancer diagnosis and treatment. His expertise in protein engineering and molecular manipulation of biomaterials for diagnostics and drug delivery has led to therapeutics and devices that impact patients and doctors worldwide.

At Duke University, Tosh leads one of the top biomedical departments in the country. He has written more than 260 publications in top-tier journals and has been cited more than 21,500 times. His current and former students praise him as a skilled, caring and invested mentor, and he has graduated close to 50 doctoral students who have carried his legacy into their own careers.

Tosh received the CAREER award from the National Science Foundation and the Robert Pritzker Distinguished Lecture award, the Biomedical Engineering Society's highest honor. In 2015, he was inducted into the National Academy of Inventors.

CLASS OF 1968 50TH REUNION **Calling all members of the Chemical Engineering Class of 1968! We hope that you will join us for your 50th reunion which will be celebrated in conjunction with the 2018 Chemical Engineering Graduation. Come back to campus to reconnect with classmates, visit with faculty, and be formally honored during the graduation ceremony. An official invitation with all of the details will be mailed in early spring but please contact Kaitlin Colleary, Assistant Director of Advancement at kaitcoll@uw.edu or 206-685-6192 with any immediate inquiries.**

DATA SCIENCE: POWERFUL TOOLS TO TRANSFORM CHEMICAL ENGINEERING By Rick Hyman

DATA SCIENCE, ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND DEEP LEARNING ARE BECOMING THE PRACTICAL TOOLS OF ENGINEERING, AND THEY ARE ABOUT TO CHANGE EVERYTHING.

Chemical engineers who are skillful with the tools of data science and the science of chemical engineering will be the engineers that drive our industry forward.

At the core of chemical engineering is physics modeled by differential equations. Tools like slide rules and calculators were once sufficient to solve these equations, but modeling increasingly complex systems required the development and use of new tools. The introduction of computers for calculations, simulations, and modeling enabled significant breakthroughs in engineering. In the 1970's, ANSYS and MATLAB allowed differential equations to be linked and solved in complex systems, enabling us to build space shuttles and smartphones.

While computer simulations use our knowledge of engineering to create data, the cutting edge tools of Data Science, including Artificial Intelligence, Machine Learning and Deep Learning, use data to create knowledge. This is a profoundly powerful difference.

WHY IS DEEP LEARNING SO IMPORTANT?

To understand why Deep Learning is so important, one needs to understand the basics of how Deep Learning is different from other approaches. Previous Machine Learning approaches required people to embed their knowledge inside the algorithm, in the form of programmed instructions on how to extract meaning from data. For example, computer vision algorithms have subroutines that look for edges, shapes, and colors. People crafted the algorithm to recognize objects (like faces) in the combinations of shapes. This is very labor intensive and requires skilled programmers with knowledge of computer vision.

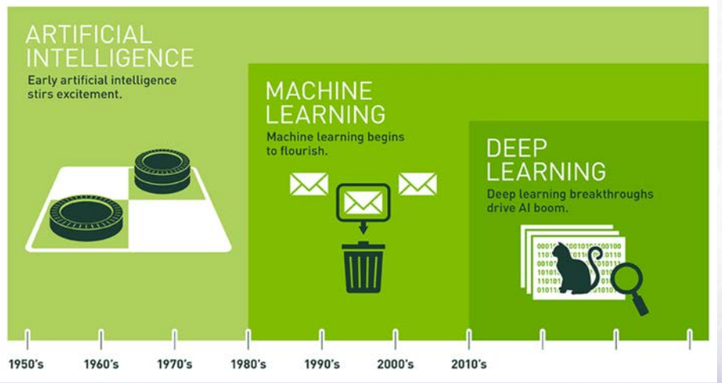
With Deep Learning, the computer learns from the data and builds its own algorithm. A neural network is created by humans, and then "trained" with data. The trained network now has intelligence. It can make judgments (called inference) on new data it is tasked to analyze. As computing power increases and the training data set increases, the size and complexity of the neural network also increases. Thus, Deep Learning networks are constantly increasing their "intelligence" and performing more complex tasks. With DL, the human labor of programming is no longer a limit to AI adoption. Adoption is limited only by a combination of computing power, data, and imagination.

In 2012, the significance of Deep Learning materialized with two breakthroughs, ImageNet[1] and Google Brain. The ImageNet Challenge compared the capabilities of computer vision algorithms to identify and classify the contents of photographs. Historically, the winning algorithms had always been created by humans, until Deep Learning won the competition in 2012. In 2015, both Microsoft and Google had used DL to surpass humans in both image recognition and classification[2]. The second breakthrough for DL was the Google Brain project[3]. Google Brain was first deployed on YouTube videos where it learned to recognize cats, and was later used to perform the seemingly different task of speech recognition.

ARTIFICIAL INTELLIGENCE IN INDUSTRY

Deep Learning based Artificial Intelligence is deployed in many industries. Adoption is happening first in industries that have huge data sets and software expertise. Companies like Apple, Microsoft, Google, Facebook, Amazon, Baidu, and Alibaba are leading the AI revolution. Deep Learning based AI is also deployed in medicine, finance, climate science, security, self-driving vehicles and many other fields. This five year old technology is rapidly becoming pervasive.

Where systems are complex, maybe too complex for humans to grasp, AI is the tool of choice. A company using AI to tackle a problem too large for human understanding is GRAIL. Their mission is to detect cancers before there is any physiological effect of the disease. Their website states[4] they are embarking on one of the largest clinical trials in history with data from hundreds of thousands of people. A study this large is well beyond the capability of human intelligence but perfect for AI.



To understand the relationship of AI, Machine Learning and Deep Learning, think about three nested boxes. As you progress deeper inside the boxes, the balance shifts from human sourced intelligence to computer sourced intelligence.

AI IN CHEMICAL ENGINEERING

While chemical engineering has been slower to adopt AI, this is changing rapidly. It will be a central foundation of the UW Chemical Engineering curriculum going forward. AI and ML are currently being used to solve complex chemical engineering problems like catalytic processes and process control.

SLAC recently published a paper using ML to understand and improve catalytic processes[5]. In the paper, Zachary Ulissi, a postdoctoral researcher at SUNCAT comments, "In this case there are thousands of possible reaction pathways – an infinite number, really – with hundreds of intermediate steps. Usually what would happen is that a graduate student or postdoctoral researcher would go through them one at a time, using intuition to pick what they think are the most likely paths. This can take years." The complexity of the catalytic processes makes ML the perfect tool for analysis and understanding.

Flutura[6] is using Machine Learning to gain insights from huge data sets in refineries and industrial plants to improve the efficiency of operation. Fueltrax[7] is using DS and ML to improve the fuel efficiency of shipping fleets. These are great examples where the complexity of process control makes AI the perfect tool.

WHAT CAN CHEMICAL ENGINEERS DO WITH AI?

First, consider AI as a tool. The more proficient we are with our tools the better we are at our craft. But knowing the tool is no substitute for knowing the craft. Future engineers should be experts in chemical engineering science and proficient with AI.

Second, keep learning. AI is a dynamic tool, not a static tool, because it is constantly evolving. As computing hardware becomes more powerful, the technology of AI will progress. Breakthroughs will happen every year for the foreseeable future. A useful place to start learning about DL is the NVIDIA website[8]. The University of Washington has created an online course in Machine Learning [9]. NVIDIA has partnered with Amazon to provide GPU cloud computing resources specifically for Deep Learning [10]. There are many resources, just go learn.

Third, since chemical engineering is early in the AI adoption process, exciting opportunities abound for young engineers. Use your imagination and knowledge of chemical engineering science to utilize AI on the complex problems that human minds can't solve. You may change the world.

Rick Hyman (BS 1978) serves on the UW Chemical Engineering Advisory Board. Rick began his chemical engineering career at Exxon Nuclear in Hanford, WA. and Alcoa in Wenatchee, WA. He moved to Silicon Valley in 1981 with roles in engineering, sales, marketing and management. Rick has spent the last 15 years of his career as VP of Business Development at NVIDIA working on programs from autonomous vehicles to game consoles.

Special thanks to NVIDIA for supplying key concepts and Images in this article.

(1) *2012, Krizhevsky, Sutskever, and Hinton: https://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks*

(2) *https://www.eetimes.com/document.asp?doc_id=1325712*

(3) *2012, https://research.googleblog.com/2012/08/speech-recognition-and-deep-learning.html*

(4) *https://grail.com/clinical-studies/*

(5) *https://www6.slac.stanford.edu/news/2017-04-24-machine-learning-dramatcally-streamlines-search-more-efficient-chemical-reactions*

(6) *https://www.flutura.com/industries.php?oil-and-gas*

(7) *http://www.fueltrax.com*

(8) *https://www.nvidia.com/en-us/deep-learning-ai/*

(9) *https://www.coursera.org/specializations/machine-learning*

(10) *https://www.nvidia.com/en-us/gpu-cloud/*

DS **Data Science (DS) seeks to provide meaningful information from large amounts of data. Data Science combines different fields of work in statistics, science, and computation in order to interpret data for the purpose of decision making, and includes Artificial Intelligence, Machine Learning and Deep Learning**

AI **Artificial Intelligence (AI) is programming computers to perform tasks that require intelligence. It has been around since the beginning of computing.**

ML **Machine Learning (ML) Machine learning is an application AI that provides systems with the ability to automatically learn and improve from experience without being explicitly programmed.**

DL **Deep Learning (DL) is an approach to Machine Learning using an architecture inspired by the neural networks of the human brain.**

ALUMNI UPDATES

IN REMEMBRANCE OF DR FERNANDO ORÉ, CLASS OF 1959 *By Kaitlin Colleary*

Chemical Engineering Alumnus, Dr. Fernando Oré passed away on June 17, 2017 at the age of 93. Known for his outstanding contributions to Chemical Engineering, Dr. Oré was born in Peru, and from humble beginnings, went on to earn his BS in Lima, Peru, and his MS (1954) and Ph.D. (1959) in Chemical Engineering at the UW. He worked closely with Dr. Moulton while he was a student, and always credited Dr. Moulton for encouraging him to pursue a PhD.

Fernando began his career as a Research Engineer at American Potash Company, later known as Kerr-McGee Chemical Corporation, and went on to work in phosphate research at Occidental Chemical Corporation, where he took on management responsibilities. He also contributed articles to many professional journals and held several patents in the field.

Dr. Oré was the recipient of *Chemical Engineering Magazine*'s Award for Outstanding Personal Achievement in Chemical Engineering, and the Kirkpatrick Award for the development of the Boric Acid Process by Solvent Extraction, among others.

In 1990, Dr. Oré retired as Vice President of Occidental Chemical Corporation to take care of his wife as she battled cancer. Throughout his career, he continued to give back to the UW. Fernando also included the department in his estate plans, and left a generous gift that will benefit Chemical Engineering students and faculty for years to come.

2017 BRUCE A. FINLAYSON LECTURE FEATURES DR. GARY LEAL, UCSB

Prof. L. Gary Leal earned a BS degree in chemical engineering from the UW, followed by an MS and Ph.D. from Stanford. He then spent two years as a postdoctoral student at Cambridge, prior to returning to faculty positions at Caltech (1970-89) and UCSB where he is a Research Professor and the Schlinger Professor of Chemical Engineering (Emeritus). He is a Fellow of the National Academy of Engineering and Fellow of the American Academy of Arts and Sciences. Prof. Leal's honors include the Fluid Dynamics Prize of the APS; the Bingham Medal of the Society of Rheology; and the Allan P. Colburn, William H. Walker and Warren K. Lewis Awards of AIChE. He has published more than 250 papers on fluid dynamics, and has directed 55 Ph.D. theses in various topics in fluid dynamics.

Professor Leal presented two lectures, entitled *"The Dynamics of Polymeric Solutions: Polymer Migration and Inhomogeneous Flow Effects"* and *"Fluid Mechanics: Some Topics of Special Relevance to ChemEs"*.

Named in honor of Dr. Bruce A. Finlayson, Rehnberg Chair Professor Emeritus of Chemical Engineering, the lecture series is now in its fifth year and features distinguished chemical engineers who demonstrate exceptional scholarship, teaching, and service in their field.

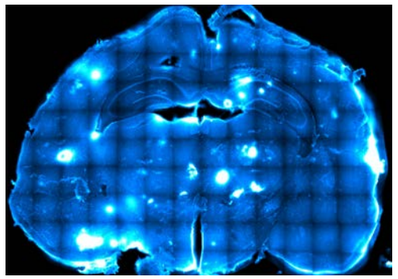
CHEMICAL ENGINEERING LEADERSHIP SEMINAR SERIES

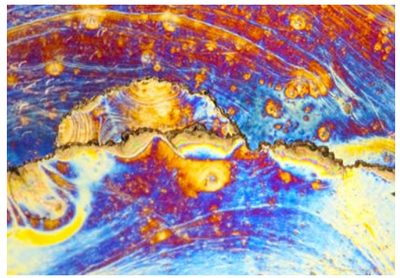
For eleven years, the Leadership Seminar Series (LSS) has provided chemical engineering students with the opportunity to learn from alumni leaders whose careers have spanned across a variety of industries and sectors. Through their lectures, alumni offer students helpful insights, lessons learned and advice for succeeding in today's professional working environment. LSS explores the depth and breadth of a ChemE degree and the careers that follow. Thank you to the alumni who participated in the 2017 LSS!

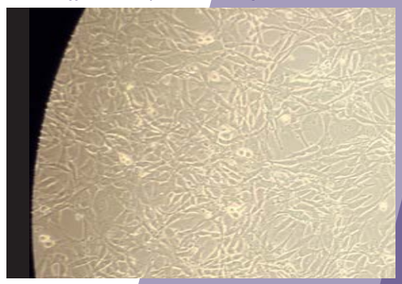
Keegan Wincewicz, B.S. ChemE '04 - Global Infrastructure Business Development, Amazon Web Services
Matt Hinck, B.S. ChemE '93, M.S. CEE '95 - Environmental Manager, Calportland
Dave Zimmer, B.S. ChemE '90 - VP, Consumer Electronics, Amazon
Rick Brouns, B.S. ChemE '78, PhD '93 - Chief Technology Officer, NSD, PNNL (retired)
George Johnson, B.S. ChemE & Paper and Pulp, '81 - Porfolio Manager, Alessandra Capital Management
Stacey Lawson, B.S. ChemE '92 - Executive Vice Chairman, Ygrene Energy Fund
Nedra Albrecht, B.S. ChemE '98 - SDE, BI & Big Data, Zillow
Brian Christin, B.S. ChemE '10 - CMC Lifecycle Management Lead for Domestic Operations, Juno Therapeutics
Lucas Chang, PhD ChemE '98 - Sr. Partner, Morgan, Lewis & Bockius LLP (Retired)

STUDENT UPDATES

SCIENCE & ENGINEERING AS ART COMPETITION *By Nicole Minkoff and Stephanie Ashby*







2017 Winners (l-r): "Braniac" - Rick Liao (3rd) ; "Space Chip" - Brittany Bishop (1st); "Full Moon" (detail) - Payam Farahani (2nd)

ChemE held the department's Second Annual Science & Engineering as Art competition this spring. Thanks to the Bowers Endowed Fund, this art competition has grown and flourished. Sixteen students submitted artwork created through the course of a wide range of research, and winners were honored at the 2017 Annual Awards Day Luncheon. The winning images will be added to the growing collection of Science and Engineering as Art on view year round in Benson Hall.

Four ChemE's were among the select group of 2017's Husky 100. The Husky 100 actively connect what happens inside and outside of the classroom and apply what they learn to make a difference on campus, in their communities and for the future. Through their passion, leadership and commitment, these students inspire all of us to shape our own Husky Experience.

Congratulations to **Kayla Sprenger, Holly Sullivan, Gabriella Tosado, and Grant Williamson** on this tremendous honor.

THE HUSKY 100

STUDENT HONORS & ACHIEVEMENTS

Our ChemE students are among the best and brightest at the University of Washington. Here are some of their outstanding achievements of this past year

HONORS & ACHIEVEMENTS

MATT MURBACH, PhD student and CEI Fellow (Prof. Dan Schwartz Group) was named one of ***Forbes Magazine's*** 2017 30 under 30 in Energy for his leadership at his company Battery Informatics

JESSICA SOTO-RODRIGUEZ (Baneyx group) was awarded a GO-MAP Dissertation Fellowship from the Graduate School

ChemE Team **RAYNA TILLY, DORSA TOGHANI AND CARA MISCHINSKI** (Beck, Nance and Carothers labs) win **first place for overall presentation and poster scores at the WiSE Up Bridge Summer Research Symposium.**

NSF GRADUATE RESEARCH FELLOWSHIP
Awardee: **PAYAM FARAHANI**
Honorable mention: **ANGELA KIMBER**

2017 PACIFIC NORTHWEST AICHE STUDENT CHAPTER CONFERENCE RESEARCH PAPER COMPETITION
1st place: **PAYAM FARAHANI**
3rd place: ANDREW AVERKIOU

2017 BOWEN DESIGN AWARD WINNERS
BINH DANG, MIGUEL HERNANDEZ, AND AUSTIN WRIGHT-PETTIBONE

GRADUATE STUDENT AWARDS

TL-1 FELLOWSHIP, ITHS - CHAD CURTIS

UW COE STUDENT RESEARCH AWARD
KAYLA SPRENGER

2017 FACULTY LECTURE AWARD
BARRY BADEAU

2017 MCCARTHY AWARD FOR EXCELLENCE IN GRADUATE STUDENT TEACHING - JONATHAN WITT

2017 HONORABLE MENTION FOR EXCELLENCE IN GRADUATE STUDENT TEACHING - STEVEN ADELMUND

2017 KRIEGER-BROCKETT TRAVEL AWARD
MONICA ESOPI

2017 CHEMICAL ENGINEERING GRADUATE STUDENT SYMPOSIUM AWARDS

2017 FACULTY LECTURE AWARD - BARRY BADEAU

2017 HIGH IMPACT PUBLICATION AWARD -
PENG ZHANG

2017 MCCARTHY AWARD FOR EXCELLENCE IN GRADUATE STUDENT TEACHING - MANAN PATHAK

DR. COLE DEFOREST WINS NATIONAL SCIENCE FOUNDATION 2017 CAREER AWARD *By Shoko Saji*

Assistant Professor Cole DeForest was recognized as one of the recipients of the 2017 Faculty Early Career Development (CAREER) award from the National Science Foundation (NSF). The prestigious award recognizes teacher-scholars for outstanding research and a dedication to the integration of educational and research activities.

DeForest's project, "User-programmable hydrogel biomaterials to probe and direct 4D stem cell fate" will receive $500,000 over five years from the Biomaterials (BMAT) Program of the NSF Division of Materials Research (DMR).

"Human tissue undergoes constant change. Though such alterations are critical in combating disease, promoting healing, and allowing us to live happy, healthy lives, the specifics of how these changes affect cell behavior remain largely unknown," said DeForest. "We seek to address this knowledge deficiency through the development of biomaterials that can be modified reversibly and on demand with bioactive signaling proteins, thereby mimicking the dynamic biochemical properties of native tissue." These advanced materials will be used to study and direct stem cell function in response to changes in local signaling, providing new insight into disease/healing processes and a clear path towards the engineering of complex 3D tissues.

DeForest also looks forward to creating a multidisciplinary education program involving new laboratory classes and to providing research opportunities for students to learn the fundamentals of polymer chemistry, reaction engineering, and biomaterial science. The award will support the development of open-source biomaterial-based modules in collaboration with local outreach programs that encourage under-represented groups to pursue careers in engineering. Modules will be made freely available online for others to use and help encourage a diverse community of future engineers with a passion for biomaterials. In partnership with the Society for Biomaterials, an inclusive support network will be built for young scientists, further ensuring their lifelong interest and a thriving future for the field of biomaterials.

"In a little over 3 years, Cole has built a highly innovative research program in regenerative medicine, biomolecular engineering, biomaterials and single cell proteomics. I am delighted that NSF recognized his remarkable potential through a CAREER award," said Department Chair François Baneyx.

Cole's monumental achievement comes on the heels of recent awards in research and education that include the 2017 American Chemical Society PMSE Young Investigator, the 2017 Emerging Investigator Award from the Journal of Materials Chemistry B, the 2016 University of Washington Presidential Distinguished Teaching Award, and the 2015 Jaconette L. Tietze Young Scientist Award. More recently, Cole was also recognized as one of AIChE's inaugural "35 Under 35", awarded to acknowledge the successes of some of AIChE's youngest members, all under the age of 35, who exemplify the best our profession has to offer in bioengineering, chemicals, education, energy, innovation, leadership and safety.

What inspired you to pursue chemical engineering?
Three main factors contributed to my decision to pursue chemical engineering: 1) Having demonstrated success in high school chemistry, physics, and biology courses, I was always encouraged by my mentors to pursue a challenging major that combined fundamental aspects from all three sciences; 2) Following in the footsteps of my father who is also a card-carrying engineer, I wanted to work on and solve problems with real-world applications; and 3) I wanted a career that was guaranteed to be intellectually stimulating for the entirety of my working life.

What professional achievement are you most proud of?
I received the 2016 Presidential Distinguished Teaching Award, the highest recognition for teaching excellence at the University of Washington (awarded to one assistant professor university wide each year).

What personal achievement are you most proud of?
One of my biggest priorities is to maintain a healthy work-life balance. Despite all of the hecticness that comes with being on the tenure track, I continue to find time to live life to the fullest with my family and friends.

What is the most challenging part of your job?
Saying goodbye to students as they graduate continues to be challenging for me, even when I know that they are headed off to bigger and better things.

ENABLING CHEMICAL ENGINEERING WITH DATA SCIENCE (CONTINUED FROM COVER)

Finally, statistics and visualization play important roles in Data Science.

A rigorous knowledge of statistics, including probability distributions and hypothesis testing, are important to high quality experimental design that will yield valid and reproducible results. Statistics also plays a vital role in mean-time-between-failure analysis and other production floor associated concepts. In the case of visualization, when data contain thousands of variables across millions of observations, we have go beyond scatterplots to convey the stories in our data to stakeholders and peers.

Building on our leadership position in graduate Data Science training (see accompanying articles), we are developing curricula and enhanced experimental facilities at the undergraduate level. Students will continue to learn how to design statistically rigorous experiments, but will do so in a high-throughput setting. The large datasets they will generate will then be used for Data Science coursework, such as process modeling and control with Machine Learning techniques.

These future chemical engineers will be poised to dive into a data-rich future to generate new knowledge and solutions for our changing world.

Image: Detail of De Bruijn graph of genome assembly for an antibiotic resistant Klebsiella pneumoniae Courtesy of Dr. Mitchel Pesesky, (Lidstrom Laboratory).

FACULTY HONORS & ACHIEVEMENTS

UW Chemical Engineering Faculty are passsionate about the creation of knowledge and solutions for a changing world. Here are some of their select acomplishments from the past year.

DAVID BECK'S lab (with Murray Hackett) published a paper in *Nature Microbiology.* Prof. Beck also presented an NYU podcast entitled "Data Science Demystified."

DAVID CASTNER won the 2017 ECASIA Award.

COLE DEFOREST won the 2017 NSF CAREER award, the 2017 ACS Young Investigator Award, was recognized as one of AIChE's 2017 35 under 35; and published the Cover Story in the October 2017 issue of *Advanced Materials.*

SHAOYI JIANG won the 2017 AIChE Braskem Award for Excellence in Materials Engineering and Science, and edited a special issue of *Langmuir* (with Carol Hall) in honor of Keith Gubbins.

ELIZABETH NANCE was awarded a $2M MIRA R35 Grant from NIH, and was elected by young EU researchers as the European Union's Nanomedicine Young Nobel Prize Winner

JIM PFAENDTNER'S Data Science graduate training program - DIRECT- was highlighted by KNKX

JONATHAN POSNER'S work on phoretic self-propulsion was featured in an article in *Knowable Magazine.*

JONATHAN POSNER, with **FRANÇOIS BANEYX**, Barry Lutz, and Ashleigh Theberge, wrote a winning proposal to the Murdoch Charitable Trust to establish a Biochemical Foundry for Translational Research.

LILO POZZO received a UW College of Engineering Strategic Instructional Initiative grant for a new freshman course entitled *Kitchen Engineering*, and was honored at the 2017 UW Latinx Faculty Recognition Event.

BUDDY RATNER received a $15M gift from the Northwest Kidney Center to establish the Center for Dialysis Innovation. Buddy was also recognized by his peers in a special issue of *Biointerphases* in honor of his 70th birthday.

DAN SCHWARTZ accepted the CleanTech Alliance 2017 CleanTech Achievement Award on behalf of UW and CEI.

DAN SCHWARTZ and **DAVID BECK** (with Matt Murbach) ran Data Science Hack Day at ECS, where the UW Chapter won the 2017 "Chapter of Exellence" Award.