

Education

- 2020/22 **M.A.Sc., Mechanical Engineering**
University of Toronto
4.00/4.00, Canada Graduate Scholarship Recipient
Fellow, John A. Paulson School of Engineering and Applied Sciences, Harvard University
Advisor: Prof. Benjamin Hatton (Materials Science and Engineering)
- 2016/20 **B.A., Architecture, Technology**
University of Toronto
3.95/4.00, High Distinction, Dean's List Scholar, University of Toronto Scholar
Governor General's Silver Medal Nominee
Top Graduate, Faculty of Architecture (Graduating rank: 1 of 250)

Special Circumstance

- 2020 **M.Des., Technology**
Harvard University
Offer accepted, enrolled, did not attend due to circumstances related to COVID-19

Awards, Scholarships, Fellowships, and Distinctions

- 2022 **Thomas H. Hogg Overseas Fellowship** (\$10 000/year, renewable)
Awarded by the University of Toronto to support ambitious international research on topics pertaining to fluid mechanics, heat transfer, thermodynamics, or energy.
- 2021 **International Experience Award** (\$8 000)
Awarded by the Centre for International Experience at the University of Toronto to support an international research collaboration as a Harvard Fellow within the John A. Paulson School of Engineering and Applied Sciences at Harvard University.
- 2021 **Michael Smith Foreign Study Scholarship** (\$6 000)
Awarded by the National Sciences and Engineering Research Council of Canada to support an international research collaboration as a Harvard Fellow within the John A. Paulson School of Engineering and Applied Sciences at Harvard University.
- 2021 **Canada Graduate Scholarship** (\$17 500)
Awarded by the National Sciences and Engineering Research Council of Canada to support research efforts of the top graduate students in all disciplines of academic study within the country.
- 2021 **Ontario Graduate Scholarship** (\$15 000, declined)
Awarded by the Government of Ontario to the top graduate students in all disciplines of academic study within the province.
- 2021 **C.W. Bowman Graduate Scholarship in Energy Research** (\$5 000)
Awarded by the Centre for Global Engineering for innovative research on global energy systems relating to the environment and sustainability.
- 2021 **Bert Wasmund Graduate Fellowship in Sustainable Energy Research** (\$1 150)
Awarded by the Department of Mechanical Engineering for innovative research on the recovery and utilization of energy derived sustainably from the sun.
- 2020 **Governor General's Silver Medal Nominee**
Recognized by the University of Toronto as a top graduate in the undergraduate student body.

- 2020 **Top Graduating Student, Faculty of Architecture**
Recognized by the Daniels Faculty of Architecture as the top graduate of the Honours Bachelor of Arts program in 2020. Graduating rank: 1/250.
- 2020 **University of Toronto Academic Merit Award (\$500)**
Awarded by the Daniels Faculty of Architecture to graduating undergraduate students with a cumulative grade point average of 3.8 or higher (3.95).
- 2020 **NSERC Undergraduate Student Research Award (\$6 500)**
Awarded one of the few departmental placements by the Department of Materials Science and Engineering to carry out a proposed research study under the supervision of a faculty member.
- 2020 **University of Toronto Dean's List Scholar**
Recognized by the University of Toronto for achieving a cumulative grade point average of 3.5 or higher (Final CGPA: 3.95).
- 2019 **Oxford Rhodes Scholarship Finalist**
Selected by the Ontario Rhodes Scholarship Selection Committee, chaired by the Honourable Dennis O'Connor, as one of 13 provincial finalists for the scholarship from a pool of over 100 000 students.
- 2019 **Oxford Rhodes Scholarship Nominee**
Selected by the University of Toronto as one of six graduating students, from a pool of over 15 000, to be presidentially endorsed for the Oxford Rhodes Scholarship.
- 2019 **Leaders of Tomorrow Award (\$2 500)**
Awarded by the French engineering company, SOPREMA, to the professionals of tomorrow, researching new methods and ideas that will shape the buildings of the future.
- 2019 **University of Toronto Scholar (\$1 500)**
Awarded by the Daniels Faculty of Architecture to the most outstanding students who have completed the third year of an undergraduate program.
- 2019 **University of Toronto Dean's List Scholar**
Recognized by the University of Toronto for achieving a cumulative grade point average of 3.5 or higher (Final CGPA: 3.95).
- 2019 **NSERC Undergraduate Student Research Award (\$6 500)**
Awarded one of the few departmental placements by the Department of Materials Science and Engineering to carry out a proposed research study under the supervision of a faculty member.
- 2018 **University of Toronto Dean's List Scholar**
Recognized by the University of Toronto for achieving a cumulative grade point average of 3.5 or higher (Final CGPA: 3.95).
- 2018 **NSERC Undergraduate Student Research Award (\$6 500)**
Awarded one of the few departmental placements by the Department of Civil and Mineral Engineering to carry out a proposed research study under the supervision of a faculty member.
- 2017 **University of Toronto Dean's List Scholar**
Recognized by the University of Toronto for achieving a cumulative grade point average of 3.5 or higher (Final CGPA: 3.95).
- 2017 **Cansbridge Fellowship Finalist**
Selected as one of 30 finalists, from a pool of 360 applicants, for the National Cansbridge Fellowship to travel and work abroad.
- 2016 **DECA Provincial Finalist**
Recognized by the Distributive Education Clubs of America as a top-ten finalist in the annual regional case competition.

- 2016 **Lynn MacGillivray Memorial Scholarship** (\$300)
Awarded on the basis of scholarly achievement in Secondary School.
- 2016 **Rob Crombie Memorial Scholarship** (\$2 000)
Awarded on the basis of scholarly achievement in Secondary School.

Formal Research Activities

- 2022/22 **Visiting Researcher, Hub for Biotechnology in the Built Environment** (*upcoming*)
School of Architecture, Newcastle University, Dr. Marin Sawa
Conceived project that utilizes local photosynthetic electricity generation to develop an autonomous, optically-responsive, biomaterial for achieving dynamic solar shading in buildings.
- 2022/22 **Harvard Fellow, John A. Paulson School of Engineering and Applied Sciences** (*upcoming*)
Biomaterialization and Biomimetics Lab, International Experience Award, Michael Smith Foreign Study Scholarship, Harvard University, Prof. Joanna Aizenberg
Conceived project in collaboration with the Harvard Graduate School of Design to develop a thermoresponsive dynamic building facade, leveraging temperature-sensitive fluid injections to improve building operational performance and energy efficiency.
- 2020/22 **Functional and Adaptive Surfaces Group, Materials Science and Engineering**
Graduate Student, Canada Graduate Scholarship, C.W. Bowman Graduate Scholarship in Energy Research, Bert Wasmund Graduate Fellowship in Sustainable Energy Research, University of Toronto, Prof. Benjamin Hatton.
Leading multiple projects at the intersection of microfluidics, nonlinear pattern dynamics, and self-assembly, towards developing novel materials for zero-energy buildings.
- 2020/20 **Functional and Adaptive Surfaces Group, Materials Science and Engineering**
NSERC Undergraduate Student Research Award, University of Toronto, Prof. Benjamin Hatton
Conceived and led project using instabilities between fluids to create conditions for reversible fluid pocket growth within building skins to regulate heat and light transmission.
- 2019/20 **Sustainable Built Environment Performance Assessment Group, School of the Environment**
Undergraduate Researcher, University of Toronto, Prof. John Robinson
Led project addressing the discrepancy between perceived indoor air quality and measured indoor air quality, and set best practices for alleviating this discrepancy.
- 2019/20 **Functional and Adaptive Surfaces Group, Materials Science and Engineering**
NSERC Undergraduate Student Research Award, University of Toronto, Prof. Benjamin Hatton
Led project designing, prototyping, and testing micro-fluidic window system, based on biological capillary temperature regulation.
- 2018/19 **Siegel Group, Indoor Air Quality, Civil and Mineral Engineering**
NSERC Undergraduate Student Research Award, University of Toronto, Prof. Jeffery Siegel
Led project comparing microbial research within lab setting to microbial growth in field setting. Conducted experiments investigating particulate matter emissions from indoor sources, and filter forensics experiments studying new means of collecting indoor air quality data.

Informal Research Activities

- 2019/20 **Self-Propelling Autonomous Robotic Locomotion**
University of Waterloo, University of Toronto, Prof. David Correa
Co-designed and fabricated (w/ Kevin Nitiema) self-propelling hygroscopic robot with capability to crawl without active energy.
- 2019/19 **Sustainable Design Team, Net Positive Data Centre**
Living Lab of Sustainability, University of Toronto, Prof. John Robinson
Provided design suggestions to the Managing Director of University of Toronto Planning for one of the first net-energy positive buildings in Toronto (course code: ENV461).

Employment

- 2019/19 **School of the Environment, University of Toronto**, Toronto, Ontario
Studied and quantified effect of psychosocial influences on indoor air quality measurement.
- 2017/18 **Founder, TAP Parking**, Toronto, Ontario
Co-founded a startup concept that connects drivers with empty driveways in areas where parking opportunities are scarce and expensive. Eventually met with leading competitor, Rover, to discuss ways to work together to solve ultimate goal of alleviating parking stress.

Volunteer Work

- 2017/17 **Volunteer, Public Architecture**, San Francisco, California (remote work)
Worked with leader in social-impact environmental design, specifically facilitating the connection between non-profit organizations and pro bono design work.

International Collaboration

- 2019 **Delft University of Technology**, Certificate, Planning and Design with Water for Sustainability
Chosen as one of three students to represent Canada in multinational water management program. Collaborated with students from 52 countries to engineer flood-protection solutions along coastlines.

Refereed Research Contributions

- Preprints of all accepted, post-revision, under-review, submitted, and in-progress manuscripts can be found [here](#) (or <https://www.rafaelkay.com/preprints>).*
- 2022 First author. Kay, R., Nitièma, K., Katrycz, C., Jakubiec, J. A., Hoban, N., & B. D. Hatton (2022). **Shape-programmable fluid bubbles for responsive building skins**. *Journal of Building Engineering*, 48: 103942. doi:<https://doi.org/10.1016/j.jobbe.2021.103942>.
- 2022 First author. Kay, R., Mattacchione, A., Katrycz, C., & B. D. Hatton (2022). **Stepwise slime mould growth as a template for urban design**, accepted, *Scientific Reports*.
- 2020 First author. Kay, R., K. Nitièma, & D. Correa. **The bio-inspired design of a self-propelling robot driven by changes in humidity**, in *Proceedings of the 38th eCAADe Conference*, L. Werner and D. Koering, Editors. 2020: Berlin, Germany. p. 233-242. http://papers.cumincad.org/cgi-bin/works/Show?ecaade2020_195.

Under Review Refereed Research Contributions

- 2022 First author. Kay, R., Katrycz, C., Nitièma, K., & B. D. Hatton. **Self-organizing fluids for active building facades**, completed revisions for *Nature Communications*.
- 2022 First author. Kay, R., Katrycz, C., Heimlich, E., & B. D. Hatton. **Programmable Droplets: Leveraging digitally-responsive flow fields to tune liquid morphology**, completed revisions for *PLOS One*.
- 2022 First author. Kay, R., Katrycz, C., & B. D. Hatton. **The potential for thermoresponsive fluid self-organization within dynamic building facades**, under review for *Journal of Building Physics*.

Working Refereed Research Contributions

- 2022 First author. Kay, R., Jakubiec, J.A., Katrycz, C., & B. D. Hatton. **Active multilayered liquid chemistries for buildings**, for submission to *Nature Materials*.
- 2022 First author. Kay, R., Katrycz, C., & B. D. Hatton. **Self-assembling optically-programmable apertures**, for submission to *Advanced Materials*.
- 2022 First author. Kay, R., & B. D. Hatton. **Active bio-inspired skins for dynamic functionality in architecture**, for submission to *Advanced Materials (Review)*.
- 2022 First author. Kay, R., & B. D. Hatton. **Fluid flow as a switchable thermal bridge**, undetermined destination.

2022 Second author. Katrycz, C., Kay, R., & B. D. Hatton. **Functional nonlinear pattern dynamics**, undetermined destination.

Non-refereed Research Contributions

2020 Co-author. Kay, R., and K. Nitièma. **Bio-inspired fluid cell growth for adaptive optical transmission in buildings**. Undergraduate Thesis. Faculty of Architecture, University of Toronto.

2019 Co-author. Kay, R., Chakwera, A., Patrick, B., Vashisth, S., Trewern, N., and Y. Husodo. **Vision for a net-positive data sciences centre**: Report to the Department of Campus and Facilities Planning. University of Toronto.

Provisional Patent Applications

2021 Co-inventor. Kay, R., Hatton, B.D., Katrycz, C., Jakubiec, J.A., and K. Nitièma. **Layered device with pigment fluid injection into a confined fluid layer for active shading of building facades**.

Scholarly Conference Presentations

2021 **Slime mould networks as a template for the design of cities**, in *Sustainability and Water*, 2nd University of Toronto Engineering Research Conference 2021, University of Toronto (virtual). July 8, 2021.

2021 **Biological microfluidics for smart optical control in buildings**, in *Functional and Emerging Materials*, 32nd Canadian Materials Science Conference 2021, Queen's University (virtual). June 4, 2021.

2020 **From pinecones to robots**, in *Cognizant Architecture - What if Buildings Could Think?*, 38th eCAADe Conference, TU Berlin (virtual). September 14, 2020. <https://vimeo.com/452713318>.

Selected Academic Presentations

2020 **Hypothesized design of a contactless delivery robot for SARS-CoV-2 testing and administration**. Final presentation: Physical Computing course, University of Toronto. <https://vimeo.com/403169347>.

Awarded Features, Public Exhibitions, and Interviews

2020 **Molten Snowflakes**. Selected as opening Research Revealed feature. <https://researchrevealed.utoronto.ca/shape-changing-apertures-that-control-how-much-light-or-heat-enters-a-building/>.

2020 **Check out the work of the Daniels Faculty's first-ever undergraduate thesis students**. One of three graduating theses publicly highlighted, with accompanying interview. <https://www.daniels.utoronto.ca/news/2020/05/11/check-out-work-daniels-facultys-first-ever-undergraduate-thesis-students/>.

2019 **A Graduate of the University of Toronto Faculty of Architecture Receives Soprema's Leaders of Tomorrow Award**. Interviewed in recognition of the Leaders of Tomorrow Award. <https://www.soprema.ca/graduate-university-toronto-faculty-architecture-receives-sopremas-leaders-tomorrow-award/>.

Software and Fabrication Proficiency

Graphic Design, Video, and Communication: Adobe Creative Cloud (Photoshop, Illustrator, InDesign, Premier Pro, Acrobat Pro), Microsoft Office Suite (Excel, Word, PowerPoint)

3D Modeling: Rhinoceros, SketchUp, Autodesk Fusion 360 (beginner)

Computational Design and Electronics: Processing, Grasshopper (GH), GHPython (GH), Kangaroo (GH), Arduino

Programming, Statistical Analysis, and Geographical Analysis: R Studio, MATLAB, ArcGIS/ArcMap, Python (beginner)

Computational Fluid Dynamics: ANSYS Fluent, RhinoCFD (GH)

Computational Thermodynamics: ANSYS Steady/Transient State Thermal FEA, THERM

Computational Energy Analysis: Climate Studio (GH), Ladybug (GH), HoneyBee/Energy+ (GH), DesignBuilder, Climate Consultant

Computational Structural Analysis: Karamba3D (GH)

Digital Fabrication: CNC Milling (RhinoCAM), Laser Cutting, 3D Printing

Relevant Engineering Coursework

- 2016/21 **Computational Modeling:** Physical Computing (Arduino hardware/software), Computation & Design (Processing), Computational Thinking, Modeling & Fabrication in Design (GH Python), Simulation & Data Visualization (Grasshopper, Python), Geographical Information Systems I (GIS), Design Technology (Grasshopper, Python)
- 2016/20 **Mathematics:** Calculus I, Calculus II, Linear Algebra I
- 2016/21 **Structural/Mechanical/Materials Engineering:** Structures & Building Systems & Environments I, Structures & Building Systems & Environments II
- 2016/21 **Materials Science:** Smart Materials and Structures, Advanced Topics in Technology of Architecture (Building Science), Selected Topics in Advanced Computer Applications: Architectural Thermal and Fluid Dynamics (Ansys Fluent)
- 2016/20 **Energy:** Science of Energy, Efficient Energy, Environmental Design, Carbon-Free Energy
- 2016/20 **Natural Sciences:** Physics I, Chemistry: Physical Principles, Bioenergy & Refinery Technology

Audited/Online Coursework (not on transcript)

- 2021 **Surface Engineering** (audited, University of Toronto)
- 2021 **Biochemistry I: Proteins, Lipids and Metabolism** (audited, University of Toronto)
- 2021 **Organic Chemistry, selected lectures** (Khan Academy)
- 2021 **Engineering Chemistry and Materials Science** (audited, University of Toronto)
- 2021 **Multivariable Calculus, selected lectures** (Khan Academy)
- 2021 **Learn to Program**, python language (Coursera, University of Toronto)
- 2020 **Introduction to Materials Science** (audited, University of Toronto)
- 2020 **Fluid Mechanics I** (audited, University of Toronto)
- 2020 **Introductory Physics II** (audited, University of Toronto)
- 2019 **Physical Chemistry** (audited, University of Toronto)

Non-academic Leadership Activities and Achievements

- 2018/20 **Intramural Basketball, Dodgeball Captain**, University of Toronto
- 2019/19 **Orientation Leader**, University of Toronto Faculty of Architecture
- 2017/18 **Head of Recruitment**, Alpha Epsilon Pi, Tau Omega Chapter
- 2015/17 **Senior Basketball Camp Coach and Counsellor**, Upper Canada College Summer Camps
- 2008/16 **Provincial Club Basketball Player**, Ontario Basketball Association
- 2016/16 **Culture Club President**, North Toronto Collegiate Institute
- 2016/16 **Volunteer House League Basketball Head Coach**, North Toronto Basketball Association
- 2015/16 **Co-captain**, North Toronto Collegiate Institute senior basketball team
- 2013/14 **Captain**, North Toronto Collegiate Institute junior basketball team
- 2013/14 **Most Valuable Player**, North Toronto Collegiate Institute junior basketball team

January 2022