Matthew Leighton

Mossman Postdoctoral Fellow, Yale University

Education

2020–2024 **Ph.D. in Physics**, *Simon Fraser University*, Burnaby, Canada
- **Thesis:** *Stochastic Thermodynamics of Multi-Component Molecular Machines*, supervised by Prof. David Sivak.

2016–2020 **B.Sc. Honours in Physics and Mathematics**, *Dalhousie University*, Halifax, Canada
- **Honours Thesis:** *Modelling the Formation of Cross-Linked Collagen Fibrils*, supervised by Prof. Andrew Rutenberg.
- Middle-Distance Runner with the Varsity Track & Field Team (2016-2018)
- Choral Scholar with the University of King's College Chapel Choir (2016-2020)

2023 **Beg Rohu Summer School on Statistical Physics of Complex Systems**, Saint-Pierre-Quiberon, France

2019 **Exchange Term studying Mathematics, Statistics, and Finance**, *Chalmers University of Technology*, Göteborg, Sweden

Experience

Research

Nov 2024 – **Mossman Postdoctoral Fellow**, *Department of Physics and QBIO Institute*, Yale University
Independent researcher studying the physics of biological systems across scales through the lens of nonequilibrium thermodynamics and information theory. Areas of interest include molecular machines, mitochondrial geometry, bacterial chemotaxis, hierarchical protein fibers, neuronal systems, and animal behavior. Working with Professors Lynn, Machta, Clark, and Emonet.

Jan 2025 – **Guest Researcher**, *Center for Computational Biology*, Flatiron Institute
Collaborating with experts on molecular dynamics and Cryo-EM to study free energy transduction in the bacterial flagellar motor and the nonequilbrium thermodynamics of rapid cooling processes used in Cryo-EM.

2020–2024 **Graduate Researcher**, *Sivak Group*, Simon Fraser University
Worked under the supervision of professor David Sivak, analyzing biological molecular machines using the theory of nonequilibrium statistical mechanics. Research included deriving fundamental physical limits on molecular machine performance, inferring hidden thermodynamic quantities in biological molecular machines, and uncovering design principles for nanoscale machinery.

2018–2020 **Undergraduate Researcher**, *Rutenberg Group*, Dalhousie University
Worked with professor Andrew Rutenberg on various research projects in theoretical biophysics using computational and mathematical methods. Research included modelling stochastic effects in the process of host cell invation by *S. Typhimurium* bacteria, developing models for *in vivo* collagen fibril growth, structure, and mechanics.

Teaching and Mentoring

2022-2025 **Research Supervisor**, *Undergraduate Researchers in the Sivak Group*, Simon Fraser University
- Formulated and supervised three research projects involving modelling and simulation of molecular machines (3x Summer Internships, 1x Honours Thesis).

2021-2022 **Teaching Assistant**, *Department of Physics*, Simon Fraser University

- Teaching assistant for undergraduate (PHYS 132 and PHYS 344) and graduate (PHYS 801) courses.
- Responsibilities included helping to run lab sessions and grading lab reports (PHYS 132), leading tutorials and grading assignments (PHYS 344), and running peer review sessions and providing feedback on graduate student research presentations (PHYS 801).
- Received the Fall 2021 Physics TA Teaching Award for outstanding teaching efforts.

Industry

2021-2022 **Co-Founder**, OnDeck Fisheries AI Inc.

- Co-founded a tech startup with the mission of bringing modern computer vision technology to bear on longstanding problems in the fisheries monitoring industry.
- Led efforts to raise more than $200,000 in non-dilutive funding in the company's first year of incorporation.

2017–2018 **Business Analyst**, *Inetco Systems LTD*, Vancouver, Canada

- Led the planning process for the release of a major new cloud SaaS product; wrote and presented the business plan at a quarterly board meeting for board approval.
- Performed financial modelling and analysis, managed marketing campaigns, and communicated requirements to the software team.
- Started as summer co-op student, hired on as part-time consultant over the next year.

Publications and Manuscripts

Peer-Reviewed Publications

first author: 10, h-index: 8, total citations: 110 **[Google Scholar]**

*: These authors contributed equally

10. **M.P. Leighton,** D.A. Sivak, "Flow of Energy and Information in Molecular Machines", *Annual Reviews of Physical Chemistry*, **76**:16.1-16.25, 2025.
9. **M.P. Leighton***, J. Ehrich*, and D.A. Sivak, "Information Arbitrage in Bipartite Heat Engines", *Physical Review X*, **14**:041038, 2024.
   ★ Featured in **Physics Magazine**.
8. **M.P. Leighton,** D.A. Sivak, "Jensen Bound for the Entropy Production Rate in Stochastic Thermodynamics", *Physical Review E (Letter)*, **109**:L012101, 2024.
7. **M.P. Leighton,** L. Kreplak, and A.D. Rutenberg, "Torsion and Bistability of Double-Twist Elastomers", *Soft Matter*, **19**:6376, 2023.
6. **M.P. Leighton,** D.A. Sivak, "Inferring Subsystem Efficiencies in Bipartite Molecular Machines", *Physical Review Letters*, **130**:178401, 2023.
   ★ Featured in **Physics Magazine**.
5. **M.P. Leighton,** D.A. Sivak, "Dynamic and Thermodynamic Bounds for Collective Motor-Driven Transport", *Physical Review Letters,* **129**:118102, 2022.
   ★ Selected for award: top student paper of 2022, Biophysical Society of Canada.
4. **M.P. Leighton,** D.A. Sivak, "Performance Scaling and Trade-offs in Collective Motor-Driven Transport", *New Journal of Physics*, **24**:013009, 2022.
3. **M.P. Leighton,** A.D. Rutenberg, and L. Kreplak, "D-Band Strain Underestimates Fibril Strain for Twisted Collagen Fibrils at Low Strains", *Journal of the Mechanical Behavior of Biomedical Materials*, **124**:104854, 2021.
2. **M.P. Leighton,** L. Kreplak, and A.D. Rutenberg, "Chiral Phase-Coexistence in Compressed Double-Twist Elastomers", *Soft Matter*, **17**:5018, 2021.
1. **M.P. Leighton,** L. Kreplak, and A.D. Rutenberg, "Nonequilibrium Growth and Twist of Cross-Linked Collagen Fibrils", *Soft Matter*, **17**:1415, 2021.

Preprints

1. J. du Buisson*, J. Ehrich*, **M.P. Leighton*,** A. Kundu, T.K. Saha, J. Bechhoefer, and D.A. Sivak, "Hunting for Maxwell's Demon in the Wild", *arXiv:2504.11329.*
2. Q. Yu, **M.P. Leighton,** and C.W. Lynn, "Coarse-Graining Dynamics to Maximize Irreversibility", *arXiv:2506.01909.*
3. J.D. Jiménez-Paz, **M.P. Leighton*,** and D.A. Sivak*, "Information Thermodynamics of Cellular Ion Pumps", *arXiv:2506.11248.*

Presentations

Invited Talks (10)

May 2025 **How Molecular Machines Work to keep our Cells Alive**, Department of Physics, Dalhousie University

October 2024 **Flow of Energy and Information in Molecular Machines**, *Biophysics Seminar*, Simon Fraser University

January 2024 **Stochastic Thermodynamics of Free Energy Transduction by Molecular Machines**, *Center for Computational Biology*, Flatiron Institute

January 2024 **Stochastic Thermodynamics of Free Energy Transduction by Molecular Machines**, National Institute for Theory and Mathematics in Biology

January 2024 **Stochastic Thermodynamics of Free Energy Transduction by Molecular Machines**, Santa Fe Institute

December 2023 **Stochastic Thermodynamics of Free Energy Transduction by Molecular Machines**, *Center for the Physics of Biological Function*, Princeton University

May 2023 **Free Energy Transduction within Molecular Machines**, Biophysical Society of Canada Annual Meeting

May 2023 **Stochastic Thermodynamics of Multi-Component Molecular Machines**, Aidan Brown Group Meeting, Toronto Metropolitan University

November 2022 **A Guided Tour of the Nanoscale Machines that keep Us Alive**, Guest Lecture for SFU PHYS344 (Thermal Physics)

July 2022 **Inferring Subsystem Efficiencies in Bipartite Molecular Machines**, Shoichi Toyabe Group Meeting, Tohoku University (virtual)

Contributed Talks (18)

March 2025 **Hunting for Maxwell's Demon in the Wild**, American Physical Society March Meeting

December 2024 **Hunting for Maxwell's Demon in the Wild**, *Quantitative Biology Institute* Community Retreat, Yale University

March 2024 **Information Arbitrage in Bipartite Heat Engines**, *GSNP Student Speaker Award Session* at the American Physical Society March Meeting
★ Selected for talk award.

October 2023 **Inferring Free Energy Transduction within Molecular Machines**, Junior Scientist Workshop on Theoretical Biophysics at *Janelia Research Campus*

October 2023 **Stochastic Thermodynamics of Energy and Information Conversion at the Nanoscale**, Junior Scientist Workshop on Theoretical Biophysics at *Janelia Research Campus*

July 2023 **Inferring Free Energy Transduction within Molecular Machines**, Frontiers in Biophysics
★ Selected for talk award.

March 2023 **Inferring Subsystem Efficiencies in Bipartite Molecular Machines**, American Physical Society March Meeting

November 2022 **Dynamic and Thermodynamic Bounds on the Performance of Multi-Component Molecular Machines**, Physics of Life: Students and Postdocs Edition Symposium at the *Center for the Physics of Biological Function*

June 2022 **Dynamic and Thermodynamic Bounds for Collective Motor-Driven Transport**, Frontiers in Biophysics

May 2022 **Dynamic and Thermodynamic Bounds for Collective Motor-Driven Transport**, Workshop on Stochastic Thermodynamics III, *hosted by the University of Tokyo (virtual)*

June 2021 **Scaling Laws and Performance Trade-offs for Collective Transport**, Frontiers in Biophysics

November 2020 **Structural Phase Transitions in Double-Twist Elastomers**, Collagen Cafe II

July 2020 **Nonequilibrium Growth of Cross-Linked Collagen Fibrils**, Collagen Cafe I

June 2020 **Elastomeric Properties of Double-Twist Collagen Fibrils**, Soft Matter Canada Symposium

March 2020 **Modelling Cross-Linking in Collagen Fibrils**, APS March Meeting (via DSOFT Virtual Meeting)

January 2020 **Coarse-Grained Structure of Double-Twist Liquid Crystals**, Atlantic Undergraduate Physics Conference
★ Selected for talk award.

November 2019 **Modelling Cross-Linking in Collagen Fibrils**, Canadian Undergraduate Physics Conference

August 2018 **Stochastic Modelling of Cellular *Salmonella* Infection**, Dalhousie Bioblast Symposium

Posters (8)

January 2025 **Hunting for Maxwell's Demon in the Wild**, Gordon Research Conference on Stochastic Physics in Biology
★ Selected for poster award.

January 2025 **Hunting for Maxwell's Demon in the Wild**, Berkeley Stat Mech Meeting
★ Selected for poster award.

October 2023 **Inferring Free Energy Transduction in Molecular Machines**, Junior Scientist Workshop on Theoretical Biophysics at *Janelia Research Campus*

June 2023 **Dynamic and Thermodynamic Performance Bounds for Multi-Component Molecular Machines**, Beg Rohu Summer School

May 2023 **Thermodynamic Performance Bounds for Multi-Component Molecular Machines**, Biophysical Society of Canada Annual Meeting

January 2023 **Dynamic and Thermodynamic Performance Bounds for Multi-Component Molecular Machines**, Gordon Research Conference on Stochastic Physics in Biology

January 2023 **Dynamic and Thermodynamic Performance Bounds for Multi-Component Molecular Machines**, Berkeley Stat Mech Meeting

May 2021 **Scaling Laws and Performance Trade-offs for Collective Transport**, Biophysical Society of Canada Annual Meeting
★ Selected for poster award.

Grants, Fellowships, Awards, and Scholarships

Research Support

2024-2025 **DARPA HR0011-25-3-0046 "Modeling Hierarchical Fiber Formation"**
- $100,000 USD over 6 months.
- Co-investigator with Tim McGee (Speculative Technologies), Ashwin Samudre (Allen Institute), and John Frampton (Dalhousie University and 3DBioFibR).

Research Fellowships and Awards

2024-2027 **Mossman Postdoctoral Fellowship**, *Yale University*

2025-2027 **NSERC Postdoctoral Fellowship**, *Natural Sciences and Engineering Research Council of Canada*

2024-2027 **Complexity Postdoctoral Fellowship *(declined)***, *Santa Fe Institute*

2024-2027 **NITMB Postdoctoral Fellowship *(declined)***, *National Institute for Theory and Mathematics in Biology*

2022-2024 **NSERC CGS-Doctoral Fellowship**, *Simon Fraser University*

2020–2021 **NSERC CGS-Masters Fellowship**, *Simon Fraser University*

2018,2020 **NSERC USRA (x2)**, *Dalhousie University*

Service, Presentation, and Paper Awards

2025 **Springer Thesis Prize**, *Springer Nature*

2025 **Poster Award**, *Gordon Research Conference on Stochastic Physics in Biology*

2025 **Poster Award**, *Berkeley Stat Mech Meeting*

2024 **1st Place Student Speaker Talk Award** , *American Physical Society Group on Statistical & Nonlinear Physics*

2023 **2nd Place Talk Award**, *Frontiers in Biophysics*

2023 **Trainee Paper Award**, *Biophysical Society of Canada*

2021 **TA Teaching Award (PHYS 132)**, *SFU Physics*

2021 **Poster Award**, *Canadian Biophysical Society*

2020 **Theory Talk Award**, *Atlantic Undergraduate Physics Conference*

Academic Scholarships and Awards

2025 **Dean's Convocation Medal**, *Simon Fraser University*

2024 **Michael and Jenifer Thewalt Graduate Award**, *Simon Fraser University*

2022 **Hargreaves Scholarship**, *Simon Fraser University*

2022 **Howard Malm Graduate Scholarship**, *Simon Fraser University*

2021 **Kirk H. Michaelian Graduate Scholarship**, *Simon Fraser University*

2020–2021 **BC Graduate Scholarship**, *Simon Fraser University*

2016–2020 **Chancellor's Scholarship**, *Dalhousie University*

2016–2018 **USports Academic All-Canadian**, *Dalhousie University*

2017 **Archibald Physics Prize**, *Dalhousie University*

2016–2020 **Dean's List**, *Dalhousie University*

Other (non-academic)

2022 **1st place**, *University of Washington Dempsey Startup Competition*
with OnDeck Fisheries AI Inc.

2022 **2nd place**, *WashU Olin's Big IdeaBounce Startup Competition*
with OnDeck Fisheries AI Inc.

2016–2020 **Helen Roby Choral Scholarship**, *University of King's College*

Service

Peer Review

Reviewer for Physical Review Letters, Physical Review X, Physical Review Research, Nature Nanotechnology, Nature Communications, Symmetry, Biomimetics, & Minerals (1x each).

Mentoring

Spring 2025 - Present — **Yuchang Tian**, M.Sc. student in the Lynn Group
- Supervising a research project involving numerical simulation and optimization of models for positional information encoding by place cells in the hippocampus.

Summer 2024 - Fall 2025 — **Julián Jiménez-Paz**, Summer Research Intern in the Sivak Group
- Formulated and supervised a project analyzing the thermodynamics of sodium-potassium Pumps. A manuscript based on Julián's work is currently in revision at Physical Review Research.
- Next: PhD student, Physics, Cornell University.

Summer 2023 - Spring 2024 — **Graham Rich**, Undergraduate Honours Thesis in the Sivak Group
- Formulated and supervised a project investigating free energy flows between chemical and mechanical degrees of freedom in flashing ratchet models for molecular motors.
- Next: BSc student, Physics and Mathematics, Simon Fraser University.

Summer 2023 — **Juan Carlos Pérez Ramírez**, Summer Research Intern in the Sivak Group
- Formulated and supervised a project investigating the effect of the gearing ratio between coupled rotary motors on output power and efficiency.
- Now: BSc student, Physics, Universidad de Guanajuato.

Summer 2022 — **Lilian Paty**, Summer Research Intern in the Sivak Group
- Formulated and supervised a project investigating comparisons between discrete and continuous models for molecular motors.
- Next: MSc student, ESPCI Paris.

Conference Roles

Summer 2024 — **Panelist**, *APS DBIO Webinar*, "Transition from Graduate School to Postdoc"

Summer 2024 — **Poster Judge**, *Frontiers in Biophysics*, Vancouver, Canada

Spring 2022 — **Organizer**, *Frontiers in Biophysics*, Vancouver, Canada
- Member of the organizing committee for Frontiers in Biophysics 2022, a conference run by and for graduate students in biophysics and related areas in the Pacific Northwest.
- Conference was held in person in downtown Vancouver, with 85 attendees.

Spring 2022 — **Talk Judge**, *SFU Postdoc Research Symposium*, Burnaby, Canada

Fall 2021 — **Talk Judge**, *Canadian Undergraduate Physics Conference*, Toronto, Canada (Virtual)

Outreach

Summer 2018,2019 — **Science Outreach**, *Dalhousie University*, Halifax, Canada
- Led interactive physics experiment demonstrations as part of the Discovery Days outreach program for elementary and high school students.

Media Coverage

2024 — **"Information Flow in Molecular Machines"**, *APS Physics Magazine*, (link)

2023 — **"When living cells malfunction, can science help?"**, *SFU Scholarly Impact of the Week*, (link)

2023 — **"The Efficiency of Tandem Molecular Machines"**, *APS Physics Magazine*, (link)

2022 — **"New research sheds light on how molecular "machines" work together to speed up transport"**, *EurekAlert!*, (link)

Languages and Technical Skills

- **Languages:** English (Native), French (Fluent)
- Extensive experience with scientific programming and numerical optimization in Python
- Experienced in the use of Digital Research Alliance of Canada computing clusters
- Experienced in the use of computer algebra software including MATLAB, Mathematica, and Maple

Miscellaneous Qualifications

Grade 8 Piano and Advanced Music Theory, *Royal Conservatory of Music*

DELF B2, *French language Certification*

CSIA Level 1 Ski Instructor, *Canadian Ski Instructors Alliance*

AST 1 Avalanche Skills, *Avalanche Canada*

Emergency First Aid, CPR-C, and Bronze Cross, *Canadian Lifesaving Society*

Cansail 4, *Sail Canada*