

# Matthew Leighton

## Curriculum Vitae

### Education

- 2020–2024 **Ph.D. in Theoretical Biophysics**, *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 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

- 2020–Present **Graduate Researcher**, *Sivak Group*, Simon Fraser University
- Working under the supervision of professor David Sivak, analyzing biological molecular machines using the theory of nonequilibrium statistical mechanics. Research includes 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. Projects included modelling stochastic effects in the process of host cell invasion by *S. Typhimurium* bacteria, developing a theoretical model for the thermodynamics of *in vivo* Collagen fibril growth, and studying the mechanics of double-twist liquid crystal elastomer systems under applied strain.

#### Teaching and Mentoring

- 2022–Present **Research Supervisor**, *Undergraduate Researchers in the Sivak Group*, Simon Fraser University
- Formulated and supervised three research projects involving modelling and simulation of molecular machines (2x Summer Internships, 1x Honours Thesis).
- Fall 2022 **Teaching Assistant**, *PHYS 801: Grad Student Seminar*, Simon Fraser University
- Responsibilities included running peer review sessions and providing feedback on graduate student research presentations.

- Fall 2021 **Teaching Assistant, PHYS 132: Physics Laboratory I**, Simon Fraser University
- Responsibilities included helping to run the lab sessions and grading lab reports.
  - Received the Fall 2021 Physics TA Teaching Award for outstanding teaching efforts.
  - *"Matt is a great physics TA. Although most of physics TAs are generally pretty boring, he is full of personality and was great to have in lab. No matter how silly the question, or how many times I asked, he always helped me and made sure I understood what I was doing in lab. Although I probably will not take another physics class in my undergraduate studies here at SFU, Matt has definitely set the bar high when it comes to my expectations of TAs in a lab class."*—Anonymous Student Evaluation
- Fall 2021 **Teaching Assistant, PHYS 344: Thermal Physics**, Simon Fraser University
- Responsibilities included leading tutorials and grading assignments.
  - *"The TA shows great interest in this subject. His knowledge and teaching style is excellent. I like that he waits for his students to think of an answer first. Usually profs just give you the answer. There is no weakness in my opinion. Matt is a great person and is very approachable."*—Anonymous Student Evaluation

## 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: 8, first author: 8, h-index: 5, total citations: 50 [Google Scholar]

\*: These authors contributed equally, ‡: Corresponding author(s)

8. **M.P. Leighton<sup>‡</sup>**, D.A. Sivak<sup>‡</sup>, "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<sup>‡</sup>, "Torsion and Bistability of Double-Twist Elastomers", *Soft Matter*, **19**:6376, 2023.
6. **M.P. Leighton<sup>‡</sup>**, D.A. Sivak<sup>‡</sup>, "Inferring Subsystem Efficiencies in Bipartite Molecular Machines", *Physical Review Letters*, **130**:178401, 2023.  
★ Featured in **Physics Magazine**.
5. **M.P. Leighton<sup>‡</sup>**, D.A. Sivak<sup>‡</sup>, "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<sup>‡</sup>, "Performance Scaling and Trade-offs in Collective Motor-Driven Transport", *New Journal of Physics*, **24**:013009, 2022.
3. **M.P. Leighton**, A.D. Rutenberg<sup>‡</sup>, 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<sup>‡</sup>, "Chiral Phase-Coexistence in Compressed Double-Twist Elastomers", *Soft Matter*, **17**:5018, 2021.

1. **M.P. Leighton**, L. Kreplak, and A.D. Rutenberg<sup>‡</sup>, "Nonequilibrium Growth and Twist of Cross-Linked Collagen Fibrils", *Soft Matter*, **17**:1415, 2021.

### Manuscripts Under Review and In Revision

**M.P. Leighton**<sup>\*‡</sup>, J. Ehrich<sup>\*‡</sup>, and D.A. Sivak<sup>‡</sup>, "Information Arbitrage in Bipartite Heat Engines", *arXiv:2308.06325*, in revision for *Physical Review X*.

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## Presentations

### Invited Talks (8)

- 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)

### Selected Talks (Competitive) (5)

- March 2024 **Information Arbitrage in Bipartite Heat Engines**, *GSNP Student Speaker Award Session* at the American Physical Society March Meeting
- 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*
- 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*
- May 2022 **Dynamic and Thermodynamic Bounds for Collective Motor-Driven Transport**, Workshop on Stochastic Thermodynamics III, *hosted by the University of Tokyo (virtual)*

### Contributed Talks (11)

- 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

- June 2022 **Dynamic and Thermodynamic Bounds for Collective Motor-Driven Transport**, Frontiers in Biophysics
- 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 DSOF Virtual Meeting)
- January 2020 **Coarse-Grained Structure of Double-Twist Liquid Crystals**, Atlantic Undergraduate Physics Conference  
★ Selected for award – top theory talk.
- November 2019 **Modelling Cross-Linking in Collagen Fibrils**, Canadian Undergraduate Physics Conference
- August 2018 **Stochastic Modelling of Cellular *Salmonella* Infection**, Dalhousie Bioblast Symposium
- [Posters \(9\)](#)
- 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
- March 2023 **Inferring Subsystem Efficiencies in Bipartite Molecular Machines**, SFU Physics Department Poster Session
- 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
- April 2022 **Dynamic and Thermodynamic Bounds for Collective Motor-Driven Transport**, SFU Physics Department Poster Session
- May 2021 **Scaling Laws and Performance Trade-offs for Collective Transport**, Biophysical Society of Canada Annual Meeting  
★ Selected for poster award.
- February 2021 **Performance Trade-offs in Cooperative Intracellular Transport**, SFU Physics Department Poster Session

## Fellowships, Awards, and Scholarships

### Research Fellowships and Awards

- 2024-2026 **Mossman Fellowship**, Yale University
- 2024 **Complexity Postdoctoral Fellowship (*declined*)**, Santa Fe Institute

- 2024 **NITMB Postdoctoral Fellowship (*declined*)**, *National Institute for Theory and Mathematics in Biology*
- 2022–2024 **NSERC CGS-D**, *Simon Fraser University*
- 2024 **Graduate Travel and Research Award**, *Simon Fraser University*
- 2023 **Graduate Travel and Research Award**, *Simon Fraser University*
- 2020–2021 **NSERC CGS-M**, *Simon Fraser University*
- 2020 **NSERC USRA**, *Dalhousie University*
- 2018 **NSERC USRA**, *Dalhousie University*
- [Service, Presentation, and Paper Awards](#)
- 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](#)
- 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*
- 2017–2018 **USports Academic All-Canadian**, *Dalhousie University*
- 2016–2017 **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

### Mentoring

- Summer 2023 **Graham Rich**, Undergraduate Honours Thesis in the Sivak Group
- Spring 2024
- Formulated and supervised a project investigating free energy transduction between chemical and mechanical degrees of freedom in flashing ratchet models for molecular motors.
- 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. A manuscript based on this project is currently in preparation.
  - Now: MSc student, ESPCI Paris.

### Conference Roles

- Spring 2022 **Organizer**, *Frontiers in Biophysics 2022*, 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.

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### Media Coverage

- October 2023 **"When living cells malfunction, can science help?"**, *SFU Scholarly Impact of the Week*, ([link](#))
- April 2023 **"The Efficiency of Tandem Molecular Machines"**, *APS Physics Magazine*, ([link](#))
- January 2022 **"New research sheds light on how molecular "machines" work together to speed up transport"**, *EurekAlert!*, ([link](#))

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### 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

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### Miscellaneous Qualifications

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

**DEL F 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*