ACT2019 School Application Statement

David L. Meretzky

January 14, 2019

An explanation of any relevant background you have in category theory or any of the specific projects areas

I have a basic understanding of Topos Theory and a firm grasp of basic Category Theory at the level of Riehl's text, *Category Theory in Context*. I understand the basics of logic, syntax, and semantics, from both a universal algebraic and model theoreric perspective and from the direction of Topos Theory. I have written extensive notes on Locally Cartesian Closed Categories and Logic which can be found on my GitHub page https://github.com/DavidMeretzky.

I attended the 2018 Category Theory Oktoberfest and saw David Spivak and Brendan Fong Speak on the graphical language for regular categories that will be used in their project. I also saw presentations on categorical models of linguistics and I am interested Mehrnoosh Sadrzadeh's project.

The date you completed or expect to complete your Ph.D and a one-sentence summary of its subject matter.

I expect to complete my Ph.D in Spring 2023. I will be investigating Categorical Logic and Applied Category Theory. For reference, I graduated with a masters degree from Hunter College in Math in Spring 2018. I have just applied to doctoral programs in these areas and expect to hear back from programs begining in February 2019. I have applied to MIT to work with David Spivak and to Johns Hopkins to work with Emily Reihl to list a couple of places.

Order of project preference

1. Toward a mathematical foundation for autopoiesis.

2. Formal and experimental methods to reason about dialogue and discourse using categorical models of vector spaces.

3. Complexity classes, computation, and Turing categories.

4. Traversal optics and profunctors.

5. Simplifying quantum circuits using the ZX-calculus.

6. Partial evaluations, the bar construction, and second-order stochastic dominance.

To what extent can you commit to coming to Oxford (availability of funding is uncertain at this time)

I can commit fully.

A brief statement (~ 300 words) on why you are interested in the ACT2019 School. Some prompts: how can this school contribute to your research goals? how can this school help in your career?

ACT2019 would be an exceptional opportunity as I prepare to begin a doctoral program in Applied Category Theory and Categorical Logic. A specific research goal that I have is to apply David Spivak and Brendan Fong's Behavioral Mereology to Systems Biology. I have worked in a Systems Biology Lab at the Mount Sinai School of Medicine for three years as a computational research assistant. Systems Biology studies how subcellular processes compose to perform the higher level functions of the cell. The guiding philosophy of this field is inherrently compositional. To quote the conference organizer, Jules Hedges, "Scalability is the end, compositionality is the means, and Category Theory is the means to the means." In the next few years, problems in fields such as health care, climate change, and economics will demand scalable solutions which may come from Applied Category Theory.

It is often remarked that when large groups of people write software together, the structure of the code ends up reflecting the structure of the group of programmers. The logic outlined in Spivak and Fong's recent paper "Behavioral Mereology" is trying to tackle the particularly interesting topic of self organization. Some questions and ideas I have been toying with in relation to Behavioral Mereology are:

Would it be useful to seperate the spacial and temporal indexing of the parts of the system?

Would it be useful to define a notion of independence within a system S? For example, disjoint subcollections of parts are called independent when their constraints are compatible with all behaviors of the other subcollection of parts but do not determine any of their behaviors. Furthermore, does this define a pregeometry or a matroid?

Finally, the logic captures one very important notion of how organizations understand their own internal structure which is by viewing how each part constrains the whole. One aspect not touched on is the need to restructure. Since we are interested in self organization it must be a behavior which encodes some type of change in the logic.

I am eager for the opportunity work with leaders in the field of Applied Category Theory at the ACT2019 School as I prepare to begin my Ph.D.

David L. Meretzky

334 East 5th Street #9
New York, NY 10003

Cell: (917) 406-2918
davmicmar@gmail.com

EDUCATION

Macaulay Honors College at Hunter College, NYC   Graduate GPA 4.0   Undergraduate GPA 3.8
Bachelor and Master of Arts, May 2018
Discipline: Pure Mathematics
High School of American Studies at Lehman College, Class of 2013, Bronx, NY

RELEVANT COURSEWORK

Calculus with Analytic Geometry I, II, and III	General and Algebraic Topology
Advanced Statistics and Probability Theory	Differential Geometry
Ordinary Differential Equations	Real and Analytic Function Theory
Organic Chemistry with Lab, I and II	Stochastic Optimization
Advanced Linear Algebra,	Physical Chemistry
Numerical Analysis I, II, and III	Modern Algebra, Galois Theory

EXPERIENCE

Independent Study, **Hunter College Mathematics Dept.** NYC, August 2018 – Present
- Meet weekly to give lectures on Equivariant Stable Homotopy Theory to Professor Martin Bendersky
- Solve exercises, prepare, and type up lecture notes during the week
- Notes are kept at Github: https://github.com/DavidMeretzky/Topology_Independent_Study

Independent Study, **Hunter College Mathematics Dept.** NYC, September 2017 – Present
- Meet weekly to discuss Algebraic Logic and Model Theory with Professor Richard Churchill
- Notes are kept at Github: https://github.com/DavidMeretzky/ModelTheory

Assistant Researcher, **Hunter College Mathematics Dept.** NYC, January 2016 – May 2018
- Analyze microscopy frames using Mathematica's machine vision functionality
- Utilize numerical methods to obtain accurate physical data about the mechanics of cell motility
- Coordinate meetings, briefings, and presentations among the biology and math teams on the project

Computational Assistant Researcher, **Mount Sinai, Systems Biology Center** NYC, August 2015 – Present
- Analyze mRNA microarray data to create gene ontologies using graph theory techniques
- Clean and fix data sets using Perl, R, and Python when they are incomplete or erroneous
- Write and optimize Perl scripts to extract records from large gene expression databases
- Find differentially expressed genes using Google Chrome extensions and R packages
- Build and validate Cellular Potts Models, comb literature for parameters and write scripts
- Apply Topological Data Analysis Methods and Machine Learning Techniques to clinical data

Assistant Researcher, **Hunter College Chemistry Dept.** NYC, November 2013 – December 2014
- Worked in nano-scale self-assembly of peptide chains with a variety of applications, transforming E-coli DNA to increase flexibility in the B877 protein, and sought to assemble a new collagen trimer
- Completed delicate multi-day procedures, learning and implementing a variety of biochemical protocols, including DNA and Protein Mutagenesis and Purification
- Worked closely, four days a week, in a team of researchers of differing skill levels, back-grounds, and ages, while supervised by Principal Investigator Dr. Hiroshi Matsui

Adjunct Lecturer, **Hunter College Mathematics Dept.** NYC, August 2017 – present
- Taught Numerical Analysis at the Graduate Level, prepared and gave all lectures, created, administered and graded all exams and programming assignments
- Taught Calculus II, created lectures, assignments, homework, exams, organized guest lecture series on programming in Mathematica
- Teaching Undergraduate Linear Algebra, designing a theory focused course which is manageable for undergraduates

SKILLS: R, Python, Mathematica, Unix, Cellular Potts Modeling, Finite Element Method, Computer Vision, Topological Data Analysis

HONORS AND AWARDS
Overall Finalist in the 2016 and 2017 CUNY Math Challenge
Pi Mu Epsilon Mathematics Honors Society Member
Four-Year Full Merit Scholarship to the William E. Macaulay Honors College
2017 Society Of Applied and Industrial Mathematics (SIAM) Student of the Year Award
2018 Landers/Hughes Prize (Mathematics Departmental Award $1000)

LECTURES
Topological Data Analysis and Persistent Homology *Mount Sinai School of Medicine* (2018)
The Development of Microrheological Methods for Biopolymers Over Two Decades *Hunter College Math Department* (2016)
Weak Convergence for Robot Bees to Optimal Hive Trajectory *Hunter College Math Department* (2016)

PUBLICATIONS
A Flexible Ontology for Inference of Emergent Whole Cell Function from Relationships Between Subcellular Processes Nature Scientific Reports **7** (2017), no. 1

Novel Microscopy and Geometric Techniques for Visualizing Blebbing in Chemotacting Dictyostelium Cells PLOS One (forthcoming)

CONFERENCES
Category Theory Oktoberfest New York (2018)
Young Topologists Meeting Copenhagen (2018)
SIAM International Conference Boston (2016)

WEBSITE: GitHub https://github.com/DavidMeretzky

REFERENCES: Available Upon Request