

Christine E. Heitsch

Contact Information

2120 Genetics / Biotechnology Center
University of Wisconsin – Madison
425 Henry Mall
Madison, WI 53706-1580

Fax: 608.262.6748
Office phone: 608.890.0373
Email: heitsch@math.wisc.edu
Web: www.math.wisc.edu/~heitsch

Research Interests

Discrete mathematical biology — combinatorics motivated by and with applications to molecular biology, and also string algorithms (MSC 05 and 92 as well as 68). Specifically: combinatorics of plane trees and de Bruijn sequences; design, analysis, and prediction of RNA secondary structures and DNA code words; computational complexity of generalized pattern matching; algorithms for unavoidability testing.

Education

- University of California at Berkeley, Ph.D. in Mathematics, December 2000. Advisor: John Rhodes. Thesis: *Computational Complexity of Generalized Pattern Matching*.
- University of Illinois at Urbana-Champaign, B.S. with Highest Distinction in Mathematics, Magna Cum Laude, May 1994.

Professional Experience

- Burroughs Wellcome Fund (BWF) Career Award at the Scientific Interface (CASI) Postdoctoral Fellow, Genome Center of Wisconsin / Biotechnology Center, University of Wisconsin – Madison, January 2005 – present.
- Visiting Assistant Professor, Department of Mathematics, Duke University, August 23 – September 24, 2004.
 - One month series of invited talks in Math 389.01: Current Research in Applied Mathematics.
 - Title: *Mathematical and Computational Biology: A Combinatorial Approach to Single-Stranded Nucleotide Sequences*.
- Associate Director, Bringing Advanced Computational Techniques to Environmental Research (BACTER), DOE Institute for the Advancement of Computational Biology Research and Education, Mathematics Department and Department of Biochemistry, University of Wisconsin – Madison, August 2004 – December 2004.
- Postdoctoral Fellow, Computation and Informatics in Biology and Medicine (CIBM) Training Program, National Library of Medicine NIH Training Grant, University of Wisconsin – Madison, 2002 – 2004.
 - Research proposal: *The Design and Analysis of Short Oligonucleotides, with Applications to DNA-Based Computation and RNA Secondary Structure Algorithms*.
 - In collaboration with: Rob Corn and the Corn Research Group in the Department of Chemistry.
- Honorary Fellow, Mathematics Department, University of Wisconsin – Madison, 2002 – 2004, January 2005 – present.

- Postdoctoral Fellow, Department of Computer Science, University of British Columbia, 2000 – 2002.
 - Member, Bioinformatics and Empirical & Theoretical Algorithms Laboratory (β -Lab).
 - Taught Alternate Routes to Computing (ARC) version of department's discrete mathematics course, Spring 2001.
 - Taught department's discrete mathematics course, Fall 2001, Fall 2000.
- Graduate Student Instructor (GSI), Department of Mathematics, University of California at Berkeley, 1994 – 2000.
 - Taught department's teaching pedagogy and practice course, Fall 1998, Fall 1999. Planned and developed the revised curriculum and course materials.
 - Assistant for department's teaching pedagogy and practice course, 1997 – 1998. Responsible for the individual videotaping and consultation program.
 - Head Graduate Student Instructor, 1996 – 1997. Provided training and support for initial offering of workshop-based calculus sequence.
 - Section leader, 1994 – 1996. Taught two calculus sections a semester for large lecture course.
- Course Assistant, Mentoring Program for Women in Mathematics, Park City Mathematics Institute / Institute for Advanced Study, May 1999. Supervised problem sessions for the undergraduate "Codes and Curves" course.
- Calculus Development Team, Department of Mathematics, University of California at Berkeley, Summer 1996, Summer 1997. Independently created a complete set of supplemental course materials for the two semester introductory calculus sequence.
- Summer Institute Participant, The Geometry Center, University of Minnesota, Summer 1993.
- Laboratory Assistant, Biology Honors Program, University of Illinois at Urbana-Champaign, 1991 - 1992.
- Research Assistant, Department of Chemistry, University of Illinois at Urbana-Champaign, Summer 1991. Internship in the nuclear magnetic resonance (NMR) laboratory of Paul C. Lauterbur.

Refereed Publications

- C. E. Heitsch, *Insufficiency of Four Known Necessary Conditions on String Unavoidability*, Journal of Algorithms, 56(2):96-123, 2005.
- C. E. Heitsch, A. E. Condon, and H. H. Hoos, *From RNA Secondary Structure to Coding Theory: A Combinatorial Approach*, in Proceedings of the Eighth International Meeting on DNA Based Computers (DNA8), Lecture Notes in Computer Science, Springer-Verlag, Sapporo, Japan, June 2002.
- C. E. Heitsch, *Exact Distribution of Deletion Sizes for Unavoidable Strings*, in Proceedings of the 8th International Symposium on String Processing and Information Retrieval (SPIRE'01), IEEE Computer Society Press, Laguna de San Rafael, Chile, November 2001.
- C. E. Heitsch, *Generalized Pattern Matching and the Computational Complexity of Unavoidability Testing*, in Proceedings of the 12th Annual Symposium on Combinatorial Pattern Matching (CPM 2001), Lecture Notes in Computer Science, Springer-Verlag, Jerusalem, Israel, July 2001.

- C. E. Heitsch, *Computational Complexity of Generalized Pattern Matching*, Ph.D. Thesis, Department of Mathematics, University of California at Berkeley, August 2000.
- C. E. Heitsch, *Slicing the Cubic Connectedness Locus*, Research Report GCG59, The Geometry Center, University of Minnesota, September 1993.
- C. E. Heitsch, *Intractability of the Reductive Decision Procedure for Unavoidability Testing, a Special Case of Generalized Pattern Matching*, submitted to Theoretical Computer Science.
- C. E. Heitsch, *Combinatorics on Plane Trees Motivated by RNA Secondary Structure Reconfigurations*, to be submitted to the SIAM Journal on Discrete Mathematics.
- C. E. Heitsch, *Combinatorial Insights Into RNA Secondary Structure*, in preparation for the Journal of Computational Biology.
- C. E. Heitsch, A. E. Condon, H. H. Hoos, *The Limits of Simplicity: a Combinatorial Solution to RNA Secondary Structure Design*, in preparation.
- C. E. Heitsch, *Random De Bruijn Sequences and the Design of DNA Codewords*, in preparation.
- C. E. Heitsch, *Enumerating Pseudoknotted RNA Secondary Structures and Dual Graphs*, in preparation.

Fellowships & Grants

- Principal Investigator, Burroughs Wellcome Fund (BWF) Career Award at the Scientific Interface (CASI).
 - Research proposal: *A Combinatorial and Computational Approach to Deciphering the Biological Information Encoded by Single-Stranded Nucleotide Sequences*.
 - Award of \$500,000 for the period January 1, 2005 – December 31, 2009.
- Principal Investigator, NIH Early Career Award for Informatics (K22), National Library of Medicine, submitted September 30, 2003.
 - Research proposal: *Biochemical Information Theory for DNA/RNA Sequences*.
 - Original proposed budget of \$543,800 for the period September 1, 2004 – August 31, 2007.
 - In revision for resubmission.
- Graduate Fellowship, Department of Mathematics, University of California at Berkeley, Fall 1999.
- Julia Robinson Fellowship, Department of Mathematics, University of California at Berkeley, Spring 1999.
- Departmental Grant, GSI Teaching and Resource Center, University of California at Berkeley, Fall 1998. Funded improvements to departmental teaching resources including equipment for the videotaping program.
- Departmental Grant, GSI Teaching and Resource Center, University of California at Berkeley, Fall 1996. Funded the “GSI Preparation and Support Program for Math 1AW.”
- Graduate Student Research Grant, Department of Mathematics, University of California at Berkeley, Summer 1995, Summer 1996.

Honors & Awards

- Incredible Instructor Honorable Mention, Department of Computer Science, University of British Columbia, February 2002.
- Certificate, Faculty Instructional Skill Workshop, The Center for Teaching and Academic Growth, University of British Columbia, December 2001.
- Nikki Kose Memorial Teaching Prize, University of California at Berkeley, May 2000.
Departmental graduation award for “exceptional teaching as a graduate student instructor.”
- Promoted to Step IV Graduate Student Instructor, University of California at Berkeley, August 1998.
Exception appointment subject to approval by the Associate Dean of the Graduate Division.
- Outstanding Graduate Student Instructor, University of California at Berkeley, May 1996.
- H. R. Brahana Prize in Mathematics, University of Illinois at Urbana-Champaign, May 1994.
Departmental award for “exceptional performance by the most outstanding graduating senior.”
- Bronze Tablet, University of Illinois at Urbana-Champaign, May 1994.
University honors; top three percent of graduating class.
- Phi Beta Kappa Award, University of Illinois at Urbana-Champaign, May 1994.
One of four chapter awards recognizing the achievements of graduating seniors.
- Phi Beta Kappa, May 1994.
- Chancellor’s Scholar, Campus Honors Program, University of Illinois at Urbana-Champaign, 1990 - 1994.
- Edmund J. James Scholar, College of Liberal Arts and Sciences, University of Illinois at Urbana-Champaign, 1990 - 1994.
- Deans’ List, College of Liberal Arts and Sciences, University of Illinois at Urbana-Champaign, 1990 - 1994.
- Biology Honors Program, University of Illinois at Urbana-Champaign, 1991 - 1992.
Provides “a rigorous introduction to biology for a limited number of highly motivated students.”
- Robert W. Rogers Merit Scholar, College of Liberal Arts and Sciences, University of Illinois at Urbana-Champaign, 1990 - 1992.
Financial support offered “to a maximum of 12 entering freshmen who have distinguished themselves through outstanding academic achievement during their high school years.”

Invited Programs

- BWF-HHMI Course in Scientific Management, Howard Hughes Medical Institute (HHMI) Headquarters, Chevy Chase, MD, June 6 – 10, 2005.
- Regulatory and Functional RNAs: Computational, Genomic, and Structural Approaches, Benasque Center for Science, Benasque, Spain, July 27 – August 8, 2003. (Unable to attend.)
- Program for Women in Mathematics, Institute for Advanced Study and Princeton University, Princeton, NJ, May 12 – 22, 2003.

- Graduate Summer School in Computational Complexity Theory, Park City Mathematics Institute / Institute for Advanced Study, Princeton, NJ, July 16 – August 5, 2000.
- Summer Graduate Program in Mathematical and Computational Challenges in Molecular and Cell Biology, Florida State University Program in Mathematics and Molecular Biology / Mathematical Sciences Research Institute, Berkeley, CA, June 12 – June 23, 2000.
- Mentoring Program for Women in Mathematics, Park City Mathematics Institute / Institute for Advanced Study, Princeton, NJ, May 30 – June 9, 2000.

Invited Talks

- *Random De Bruijn Sequences and the Design of DNA Codewords.*
 - Special Session on Discrete Models in Biology, Fall Southeastern Section Meeting, American Mathematical Society, East Tennessee State University, October 15, 2005.
 - Franco-Canadian Workshop on Combinatorial Algorithms, McMaster University, August 19, 2005.
 - Combinatorics Seminar, Mathematics Department, University of Wisconsin – Madison, March 7, 2005.
- *Deciphering the Information Encoded in RNA Viral Genomes.*
 - Workshop on Algebraic Statistics and Computational Biology, Clay Mathematics Institute, November 14, 2005.
 - Department of Biomedical Informatics Seminar, Ohio State University, Columbus, November 2, 2005.
 - Workshop on Detecting and Processing Regularities in High Throughput Biological Data, DIMACS Center, Rutgers University, June 21, 2005.
- *Encoding Branched Structures in Sequences: the Combinatorics of Plane Trees and RNA Secondary Structures.*
 - Applied/Interdisciplinary Mathematics Seminar, University of Illinois at Urbana-Champaign, November 17, 2004.
 - Pritchard Lab Seminar, Department of Mathematics, Penn State University, University Park, October 26, 2004.
 - Mathematical Biology Seminar, Department of Mathematics, University of Michigan, Ann Arbor, October 11, 2004.
- *A New DNA Word Design Strategy Using Random de Bruijn Sequences.*
 - The Bioinformatics / Algorithmics Reading Group, Department of Computer Science, University of British Columbia, June 15, 2004.
 - NYU Bioinformatics Group Seminar, New York University, May 13, 2004.
 - Computation and Informatics in Biology and Medicine Seminar, University of Wisconsin – Madison, January 20, 2004.

- *A Combinatorial Approach to Designing RNA Secondary Structures and DNA Code Words*, Theoretical Computer Science Seminar, Departments of Mathematics and of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, October 13, 2004.
- *Combinatorial Results Motivated by Computational Biology*.
 - Combinatorics Seminar, Mathematics Department, University of California at Berkeley, October 24, 2005.
 - Geometry/Topology Seminar, Mathematics Department, Duke University, September 22, 2004.
 - Problems in Discrete Maths Seminar, Mathematics Department, University of British Columbia, June 14, 2004.
 - Combinatorics Seminar, Mathematics Department, University of Wisconsin – Madison, April 26, 2004.
 - Mathematics Department Colloquium, University of Rhode Island, Kingston, March 24, 2004.
 - Association for Women in Mathematics Workshop, Joint Mathematics Meetings, Phoenix, AZ, January 10, 2004.
 - Combinatorics Seminar, Mathematics Department, University of Wisconsin – Madison, January 27, 2003.
- *From Nucleotide Sequences to Secondary Structures, and Back Again*.
 - Computational Biology Seminar, Mathematics Department, University of California at Berkeley, October 24, 2005.
 - Computational Biosciences Group Seminar, Pacific Northwest National Laboratory, June 29, 2004.
 - Center for Bioinformatics & Computational Biology Seminar, Duke University, September 8, 2004.
 - Computer Science Department Seminar, City College, City University of New York, May 19, 2004.
 - Bioinformatics COALESCE Seminar, Purdue University, West Lafayette, April 20, 2004.
 - Computer Science Seminar, University of Western Ontario, London, ON, April 15, 2004.
 - School of Informatics Colloquium, Indiana University, Bloomington, April 9, 2004.
 - Department of Computer Science Colloquium, University of Chicago, April 7, 2004.
 - Department of Biomedical Informatics Seminar, Ohio State University, Columbus, April 5, 2004.
 - Computer Science and Engineering Department Colloquium, Penn State University, University Park, April 1, 2004.
- *Computational and Combinatorial Aspects of RNA Secondary Structures*.
 - Department of Computer Science Colloquium, University of Iowa, December 10, 2003.
 - Computer Science Department Colloquium, Duke University, April 22, 2003.
 - Program for Women in Mathematics Seminar, Institute for Advanced Study, May 13, 2003.
- *Combinatorial Insights in RNA Secondary Structures*, Special Session on Mathematical Molecular Biology, Fall Southeastern Section Meeting, American Mathematical Society, Chapel Hill, NC, October 25, 2003.
- *Biochemical Properties of Random de Bruijn Sequences*, Selected Speaker, National Library of Medicine Annual Training Meeting, Bethesda, MD, July 9, 2003.

- *Creating a Lexicon of Nucleotide Code Words*, Computation and Informatics in Biology and Medicine Seminar, University of Wisconsin – Madison, April 15, 2003.
- *A Road Less Traveled? – Following an Interdisciplinary Mathematical Career Path*, Vigre Seminar, Department of Mathematics, University of Wisconsin – Madison, November 6, 2002.
- *From RNA Secondary Structure to Coding Theory: A Combinatorial Approach*, Computation and Informatics in Biology and Medicine Seminar, University of Wisconsin – Madison, October 8, 2002.
- *The Unavoidability of Generalized Zimin Word Constructions*.
 - Laboratoire d’informatique Seminar, Institut d’électronique et d’informatique Gaspard-Monge, Marne-la-Vallée, France, June 25, 2002.
 - International Workshop on Semigroups, Automata, and Formal Languages, Crema, Italy, June 18, 2002.
- *An Application of Combinatorics on Words to RNA Secondary Structure Design*, Semigroups, Automata, and Formal Languages Special Session, American Mathematical Society and Unione Matematica Italiana First Joint International Meeting, Pisa, Italy, June 13, 2002.
- *Generalized Pattern Matching and the Computational Complexity of Unavoidability Testing*.
 - Logic and Category Theory Seminar, Philosophy, Mathematics and Computer Science Departments, University of Calgary, March 4, 2002.
 - Computer Science Theory Seminar, University of Wisconsin – Madison, February 20, 2001.
- *Catalan Numbers and the Tree of Life*, Computer Science Theory Seminar, University of British Columbia, October 16, 2001.
- *Computational Complexity of Generalized Pattern Matching*.
 - Association for Women in Mathematics Workshop, Joint Mathematics Meetings, New Orleans, LA, January 13, 2001.
 - Mentoring Program for Women in Mathematics Seminar, Institute for Advanced Study, June 5, 2000.
- *On Generalized Pattern Matching*, Computer Science Theory Seminar, University of British Columbia, October 11, 2000.
- *Computational Complexity of Generalized Pattern Matching, and an Exponential Lower Bound on One Algorithmic Approach*, International Conference on Geometric and Combinatorial Methods in Group Theory and Semigroup Theory, Lincoln, NE, May 15, 2000.
- *The Difficulty of Pattern Classification*, Mentoring Program for Women in Mathematics, Institute for Advanced Study, May 20, 1999.
- *Infinite Sequences Without Patterns*, Series of three talks for the Semigroup and Automata Theory Seminar, Department of Mathematics, University of California at Berkeley, April 1998.
- *The Undecidability of the Word Problem for Finite Semigroups*, Series of three talks for the Semigroup and Automata Theory Seminar, Department of Mathematics, University of California at Berkeley, March 1997.

Poster Presentations

- *Analyzing the Branching Degree of RNA Viral Genomes: A Hepatitis C Case Study*. Abstract and Poster. The Ninth Annual International Conference on Research in Computational Molecular Biology (RECOMB 2005), Cambridge, MA, May 17 - 18, 2005.
- *Encoding Biological Information in Nucleotide Sequences: the Combinatorics of RNA Secondary Structures and DNA Code Words*, First Young Researchers Workshop in Mathematical Biology, Mathematical Biosciences Institute, the Ohio State University, March 30, 2005.
- *Biochemical Properties of Random de Bruijn Sequences*, with M. Li and R. Corn. Abstract and Poster. Digital Biology: The Emerging Paradigm, Biomedical Information Science and Technology Initiative (BISTI) Symposium, National Institutes of Health, Bethesda, MD, November 6-7, 2003.
- *Towards the Design of RNA Molecules*, with A. E. Condon and H. H. Hoos. Abstract and Poster. Mathematics and Molecular Biology VII: Modeling Across the Scales – Atoms to Organisms, Santa Fe, NM, January 9, 2002.

Professional Service & Committee Appointments

- Selection Committee, AWM Workshop for Women Graduate Students and Recent PhDs at the Joint Mathematics Meetings in San Antonio, September 2005.
- Organizer, Combinatorial Biology Minisymposium, International Conference for Mathematics in Biology and Medicine, Annual Meeting for the Society for Mathematical Biology, Ann Arbor, MI, July 25 - 28, 2004.
- Review panel, Department of Energy, May 2004.
- Seminar organizer, Mathematical & Computational Biology Research Group, University of Wisconsin – Madison, 2003 – 2004.
- Reviewer, Journal of Algorithms.
- Organizing Committee, Ninth International Meeting on DNA Based Computers (DNA9), Madison, WI, June 1-4, 2003.
- Reviewer, the 11th International Conference on Intelligent Systems for Molecular Biology (ISMB 2003).
- Review Panel, Genomes to Life Program, Department of Energy, May 29 – 31, 2002.
- Supporting Women in InFormation Technology (SWIFT), Department of Computer Science, University of British Columbia, 2000 – 2002.
- Graduate Assembly, University of California at Berkeley, 1995 – 1997.
Served as departmental delegate and elected graduate representative on the Graduate Council, Executive Committee, Academic Planning Board, and the Committee on Educational Policy.
- Officer, Noetherian Ring, Department of Mathematics, University of California at Berkeley, Spring 1999, 1995 – 1997.
As president and vice-president, invited and hosted eight female colloquium speakers, wrote articles for publication, organized outreach efforts and mentoring opportunities.

Professional Societies

- American Mathematical Society (AMS)
- Association for Computing Machinery Special Interest Group on Algorithms and Computational Theory (ACM SIGACT)
- Association for Women in Mathematics (AWM)
- International Society for Computational Biology (ISCB)
- RNA Society
- Society for Mathematical Biology (SMB)

References

Bernd Sturmfels
Professor
Department of Mathematics
970 Evans Hall
University of California at Berkeley
Berkeley, CA 94720
(510) 642-4687
bernd@math.berkeley.edu

Michael C. Reed
Bishop-MacDermott Family Professor
Mathematics Department
Duke University, Box 90320
Durham, NC 27708-0320
(919) 660-2808
reed@math.duke.edu

Amir Assadi
Professor
Mathematics Department
University of Wisconsin – Madison
480 Lincoln Drive
Madison, Wisconsin 53706-1388
(608) 262-3219
ahassadi@facstaff.wisc.edu

John Rhodes, advisor
Professor Emeritus
Department of Mathematics
970 Evans Hall
University of California at Berkeley
Berkeley, CA, 94720
(510) 642-6550
BlvdBastille@aol.com
rhodes@math.berkeley.edu

Maria Klawe
Dean of Engineering and Applied Science
Princeton University
Room C-230 E-Quad
Princeton, NJ 08544
(609) 258-2260
devuono@princeton.edu
klawe@princeton.edu

Anne Condon
Professor
Department of Computer Science
201-2366 Main Mall
University of British Columbia
Vancouver, BC, V6T 1Z4, Canada
(604) 822-8175
condon@cs.ubc.ca