

Lenwood Scott Heath

Curriculum Vitae

January 2, 2024

CONTACT INFORMATION

Mailing Address:

Virginia Tech
Department of Computer Science
1160 Torgersen Hall
620 Drillfield Drive
Blacksburg, VA 24061

Physical Office:

2160J Torgersen Hall

Web: <http://people.cs.vt.edu/~heath/>

Google Scholar: <http://scholar.google.com/citations?user=9VDFIQoAAAAJ>

ORCID: <https://orcid.org/0000-0003-1608-431X>

Email: heath@vt.edu

Office Phone: (540) 231-4352

FAX: (540) 231-6075

EDUCATION

Ph.D., Computer Science, University of North Carolina, Chapel Hill, 1985

Dissertation: **Algorithms for Embedding Graphs in Books**

M.S., Mathematics, University of Chicago, 1976

B.S., Mathematics, University of North Carolina, Chapel Hill, 1975

RESEARCH INTERESTS

Algorithms, theoretical computer science, graph theory, bioinformatics, computational biology, computational epidemiology, genomics, probability, symbolic computation, computational algebra, parallel architectures, graph embeddings, topology, computational geometry

PROFESSIONAL EXPERIENCE

- 2021– Affiliated Faculty of the Center for Advanced Innovation in Agriculture (CAIA), Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2020– Affiliated Faculty of the Center for Emerging, Zoonotic, and Arthropod-borne Pathogens (CeZAP), Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2019–2021 Member of the Quantum Information Science and Engineering (QISE) Working Group, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2018– Member of Microbial Systems, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2014– Faculty of Health Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2011– Sanghani Center for Artificial Intelligence and Data Analytics (Formerly, the Discovery Analytics Center (DAC)), Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2003– Faculty of the Genomics, Bioinformatics, and Computational Biology PhD program, Founding Faculty Member, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 2003– Professor of Computer Science, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 1993–2003 Associate Professor of Computer Science, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 1987–1993 Assistant Professor of Computer Science, Virginia Polytechnic Institute and State University, Blacksburg, VA
- 1985–1987 Instructor of Applied Mathematics, Theoretical Computer Science Group, Department of Mathematics, Massachusetts Institute of Technology, Cambridge, MA

JOURNAL PAPERS

Published

- [1] “A Deep-Learning Approach for Identifying Prospective Chemical Hazards,” Sohaib Habiballah, Lenwood S. Heath, and Brad Reisfeld. **Toxicology** **501**, 2023, 9 pages.
- [2] “ARGem: A New Metagenomics Pipeline for Antibiotic Resistance Genes: Metadata, Analysis, and Visualization,” Xiao Liang, Jingyi Zhang, Yoonjin Kim, Josh Ho, Kevin Liu, Ishi Keenum, Suraj Gupta, Benjamin Davis, Shannon L. Hepp, Liqing Zhang, Kang Xia, Katharine F. Knowlton, Jingqiu Liao, Peter J. Vikesland, Amy Pruden, and Lenwood S. Heath. Accepted to **Frontiers in Genetics**, 2023.

-
- [3] “Towards Understanding Paleoclimate Impacts on Primate De Novo Genes,” Xiao Liang and Lenwood S. Heath. **G3: Genes—Genomes—Genetics**, 2023, 14 pages.
- [4] “Adaptive Group Testing Strategy for Infectious Diseases using Social Contact Graph Partitions,” Jingyi Zhang and Lenwood S. Heath. **Scientific Reports**, 2023, 16 pages.
- [5] “A Complete Theoretical Framework for Inferring Horizontal Gene Transfers using Partial Order Sets,” Nahla A. Belal and Lenwood S. Heath. **PLOS ONE**, 2023, 39 pages.
- [6] “EpiCNet: Epidemiology Inspired Community Based Time Evolving Online Social Network Generation,” Pouyan Shirzadian, Blessy Antony, Akshaykumar Gattani, Nure Tasnina, and Lenwood S. Heath. **Scientific Reports** **13**, 2023, 14 pages.
- [7] “Connecting Genomic Islands across Prokaryotic and Phage Genomes via Protein Families,” Reem Aldaihani and Lenwood S. Heath. **Scientific Reports** **13**, 2023, 9 pages.
- [8] “HT-ARGfinder: A Comprehensive Pipeline for Identifying Horizontally Transferred Antibiotic Resistance Genes and Directionality in Metagenomic Sequencing Data,” Badhan Das, Muhit Islam Emon, Nazifa Ahmed Mouni, Justin Sein, Amy Pruden, Lenwood S. Heath, and Liqing Zhang. **Frontiers in Environmental Science** **10**, 2022, 9 pages.
- [9] “Investigating Plant Disease Outbreaks with Long-read Metagenomics: Sensitive Detection and Strain-level Identification of *Xylella fastidiosa*,” Marcela A. Johnson, Haijie Liu, Elizabeth Bush, Parul Sharma, Shu Yang, Reza Mazloom, Lenwood S. Heath, Mizuho Nita, Song Li, and Boris A. Vinatzer. **Microbial Genomics** **8**, 2022, 14 pages.
- [10] “Could a Focus on the “Why” of Taxonomy Help Taxonomy Better Respond to the Needs of Science and Society?” Leighton Pritchard, C. Titus Brown, Bailey Harrington, Lenwood S. Heath, N. Tessa Pierce-Ward, and Boris Vinatzer. **Frontiers in Microbiology** **13**, Evolutionary and Genomic Microbiology, 2022, 4 pages.
- [11] “Meta Analysis of the *Ralstonia solanacearum* Species Complex (RSSC) Based on Comparative Evolutionary Genomics and Reverse Ecology,” Parul Sharma, Marcela A. Johnson, Reza Mazloom, Caitilyn Allen, Lenwood S. Heath, Tiffany M. Lowe-Power, and Boris A. Vinatzer. **Microbial Genomics** **8**, 2022, 14 pages.
- [12] “Developmental gene regulatory network connections predicted by machine learning from gene expression data alone,” Jingyi Zhang, Farhan Ibrahim, Emily Najmulski, George Katholos, Doaa Altarawy, Lenwood S. Heath, and Sarah L. Tulin. **PLOS ONE** **16**, 2021, 17 pages.
- [13] “MetaMLP: A Fast Word Embedding Based Classifier to Profile Target Gene Databases in Metagenomic Samples,” Gustavo Arango-Argoty, Lenwood S. Heath, Amy Pruden, Peter Vikesland, and Liqing Zhang. **Journal of Computational Biology** **28**, 2021, 12 pages.
- [14] “Next Generation Sequencing Approaches to Evaluate Water and Wastewater Quality,” Emily Garner Benjamin C. Davis, Erin Milligan, Matthew F. Blair, Ishi Keenum, Ayella Maile-Moskowitz, Jin Pan, Mariah Gnegy, Krista Liguori, Suraj Gupta, Aaron J. Prussin, Linsey C. Marr, Lenwood S. Heath, Peter J. Vikesland, Liqing Zhang, and Amy Pruden. **Water Research** **194**, 2021, 24 pages.

-
- [15] “LINflow: A Computational Pipeline that Combines an Alignment-free with an Alignment-based Method to Accelerate Generation of Accurate Similarity Matrices for Prokaryotic Genomes,” Long Tian, Reza Mazloom, Lenwood S. Heath, and Boris A. Vinatzer. **PeerJ**, 2021, 17 pages.
- [16] “AgroSeek: A System for Computational Analysis of Environmental Metagenomic Data and Associated Metadata,” Xiao Liang, Kyle Akers, Ishi Keenum, Lauren Wind, Suraj Gupta, Chaoqi Chen, Reem Aldaihani, Amy Pruden, Liqing Zhang, Katharine F. Knowlton, Kang Xia, and Lenwood S. Heath. **BMC Bioinformatics** **22**, 2021, 14 pages.
- [17] “Systematic Auditing is Essential to Debiasing Machine Learning in Biology,” Fatma-Elzahraa Eid, Haitham Elmarakeby, Yujia Alina Chan, Nadine Fornelos, Mahmoud ElHefnawi, Eli Van Allen, Lenwood S. Heath, and Kasper Lage. **Communications Biology** **4**, 2021, 9 pages.
- [18] “Computing Genomic Signatures Using de Bruijn Chains,” Lenwood S. Heath and Amrita Pati. **Advances in Computing and Engineering** **1**, 2021, 26 pages.
- [19] “Characterization of Protein-protein Interactions Between Rice Viruses and Vector Insects,” Junjie Zhu, Fatma Elzahraa Eid, Lu Tong, Wan Zhao, Wei Wang, Lenwood S. Heath, Le Kang, and Feng Cui. **Insect Science** **28**, 2021, 976–986.
- [20] “Strain-level Identification of Bacterial Tomato Pathogens Directly from Metagenomic Sequences,” Marco E. Mechan Llontop, Parul Sharma, Marcela Aguilera Flores, Shu Yang, Jill Pollock, Long Tian, Chenjie Huang, Lenwood S. Heath, Steve Rideout, Song Li, and Boris A. Vinatzer. **Phytopathology** **110**, 2020, 12 pages.
- [21] “LINbase: A Web Server for Genome-based Identification of Prokaryotes as Members of Crowdsourced Taxa,” Long Tian, Chengjie Huang, Reza Mazloom, Lenwood S. Heath, and Boris A. Vinatzer. **Nucleic Acids Research**, 2020, 9 pages.
- [22] “ARGminer: A Web Platform for Crowdsourcing-based Curation of Antibiotic Resistance Genes,” Gustavo Alonso Arango-Argoty, Giselle K. P.Guron, Emily Garner, Virginia Riquelme, Peter J. Vikesland, and Liqing Zhang. **Bioinformatics**, 2020, 8 pages.
- [23] “Comparing Time Series Transcriptome Data Between Plants Using a Network Module Finding Algorithm,” Jiyoung Lee, Lenwood S. Heath, Ruth Grene, and Song Li. **Plant Methods** **15**, 2019, 16 pages.
- [24] “NanoARG: A Web Service for Contextualizing Antimicrobial Resistance Genes Identified from Nanopore-Derived Metagenomes,” Gustavo Arango, Dongjuan Dai, Amy Pruden, Peter Vikesland, Lenwood S Heath, and Liqing Zhang. **Microbiome** **7**, 2019, 18 pages.
- [25] “Cyberbiosecurity Challenges of Pathogen Genome Databases,” Boris A. Vinatzer, Lenwood S. Heath, Hussain Almohri, Micheal J. Stuhlberg, Christopher Lowe, and Song Li. **Frontiers in Bioengineering and Biotechnology**, 2019, 11 pages.
- [26] “Effect of Antibiotic Use and Composting on Antibiotic Resistance Gene Abundance and Resistome Risks of Soils Receiving Manure-derived Amendments,” Chaoqi Chen, Christine A. Pankow, Min Oh, Lenwood S. Heath, Liqing Zhang, Pang Du, Kang Xia, and Amy Pruden. **Environment International** **128**, 2019, 233–243.

- [27] “MCAT: Motif Combining and Association Tool,” Yanshen Yang, Jeffrey A. Robertson, Zhen Guo, Jake Martinez, Christy Coghlan, and Lenwood S. Heath. **Journal of Computational Biology** **26**, 2018, 15 pages.
- [28] “MetaCompare: A Computational Pipeline for Prioritizing Environmental Resistome Risk,” Min Oh, Amy Pruden, Lenwood S. Heath, Kang Xia, and Liqing Zhang. **FEMS Microbiology Ecology** **94**, 2018, 9 pages.
- [29] “DeepARG: A Deep Learning Approach for Predicting Antibiotic Resistance Genes from Metagenomic Data,” Gustavo Arango-Argoty, Emily Garner, Amy Pruden, Lenwood S. Heath, Peter Vikesland, and Liqing Zhang. **Microbiome** **6**, 2018, 15 pages.
- [30] “Identification of Regulatory Modules in Genome Scale Transcription Regulatory Networks,” Qi A. Song, Ruth Grene, Lenwood S. Heath, and Song Li. **BMC Systems Biology** **18**, 2017, 18 pages.
- [31] “PEAK: Integrating Curated and Noisy Prior Knowledge in Gene Regulatory Network Inference,” Doaa Altarawy, Fatma-Elzahraa Eid, and Lenwood S. Heath. **Journal of Computational Biology** **24**, 2017, 863–873.
- [32] “MicroTarget: MicroRNA Target Gene Prediction Approach with Application to Breast Cancer,” Hanaa Torkey, Lenwood S. Heath, and Mahmoud Elhefnawi. **Journal of Bioinformatics and Computational Biology** **15**, 2017, 17 pages.
- [33] “Beacon Editor: Capturing Signal Transduction Pathways Using the SBGN Activity Flow Language,” Haitham Elmarakeby, Mostafa Arefiyan, Elijah Myers, Song Li, Ruth Grene, and Lenwood S. Heath. **Journal of Computational Biology** **24**, 2017, 4 pages.
- [34] “Expresso: A Database and Web Server for Exploring the Interaction of Transcription Factors and Their Target Genes in *Arabidopsis thaliana* Using ChIP-Seq Data,” Delasa Aghamirzaie, Karthik Raja Velmurugan, Shuchi Wu, Doaa Altarawy, Lenwood S. Heath, and Ruth Grene. **F1000Research** **6**, 2017, 5 pages.
- [35] “A Proposal for a Portal to Make Earth’s Microbial Diversity Easily Accessible and Searchable,” Boris A. Vinatzer, Long Tian, and Lenwood S. Heath. **Antonie van Leeuwenhoek** **110**, 2017, 1271–1279.
- [36] “A Proposal for a Precise Genome Similarity-based Taxonomy for Plant Pathogenic Bacteria that is Sufficiently Precise to Reflect Phylogeny, Host Range, and Outbreak Affiliation Applied to *Pseudomonas syringae sensu lato* as a Proof of Concept,” Boris A. Vinatzer, Alexandra J. Weisberg, Caroline L. Monteil, Haitham A. Elmarakeby, Samuel K. Sheppard, and Lenwood S. Heath. **Phytopathology** **107**, 2017, pp. 18–28.
- [37] “Labeled Cuts in Graphs,” Tridib Dutta, Lenwood S. Heath, V. S. Anil Kumar, and Madhav V. Marathe. **Theoretical Computer Science** **648**, 2016, pp. 34–39.
- [38] “Computational Identification of Tissue-Specific Splicing Regulatory Elements in Human Genes from RNA-Seq Data,” Eman Badr and Lenwood S. Heath. **PLOS ONE** **11**, 2016, 18 pages.

- [39] “A Machine Learning Approach to Predict Gene Regulatory Networks in Seed Development in Arabidopsis,” Ying Ni, Delasa Aghamirzaie, Haitham Elmarakeby, Eva Collakova, Song Li, Ruth Grene, and Lenwood S. Heath. **Frontiers in Plant Science** **7**, 2016, 13 pages.
- [40] “Metagenomic Profiling of Historic Colorado Front Range Flood Impact on Distribution of Riverine Antibiotic Resistance Genes,” Emily Garner, Joshua Wallace, Gustavo Argoty, Caitlin Wilkinson, Nicole Fahrenfeld, Lenwood S. Heath, Liqing Zhang, Mazdak Arabi, Diana Aga, and Amy Pruden. **Scientific Reports** **6**, 2016, 10 pages.
- [41] “MetaStorm: A Public Resource for Customizable Metagenomics Annotation,” Gustavo Arango-Argoty, Gargi Singh, Lenwood S. Heath, Amy Pruden, Weidong Xiao, and Liqing Zhang. **PLOS ONE** **11**, 2016, 13 pages.
- [42] “DeNovo: Virus-Host Sequence-Based Protein-Protein Interaction Prediction,” Fatma-Elzahraa Eid, Mahmoud ElHefnawi, and Lenwood S. Heath. **Bioinformatics** **32**, 2016, pp. 1144-1150.
- [43] “Potential Targets of VIVIPAROUS1/ABI3-LIKE1 (VAL1) Repression in Developing *Arabidopsis thaliana* Embryos,” Andrew Schneider, Delasa Aghamirzaie, Haitham Elmarakeby, Arati N. Poudel, Abraham J. Koo, Lenwood S. Heath, Ruth Grene, and Eva Collakova. **The Plant Journal** **85**, 2016, pp. 305–319.
- [44] “Transcriptome-wide Functional Characterization Reveals Novel Relationships Among Differentially Expressed Transcripts in Developing Soybean Embryos,” Delasa Aghamirzaie, Dhruv Batra, Lenwood S. Heath, Andrew Schneider, Ruth Grene, and Eva Collakova. **BMC Genomics** **16**, 2015, 23 pages.
- [45] “CoSREM: A Graph Mining Algorithm for the Discovery of Combinatorial Splicing Regulatory Elements,” Eman Badr and Lenwood S. Heath. **BMC Bioinformatics** **16**, 2015, 15 pages.
- [46] “Similarity-Based Codes Sequentially Assigned to Ebolavirus Genomes are Informative of Species Membership, Associated Outbreaks, and Transmission Chains,” Alexandra J. Weisberg, Haitham A. Elmarakeby, Lenwood S. Heath, and Boris A. Vinatzer. **Open Forum Infectious Diseases** **2**, 2015, 11 pages.
- [47] “Identifying Splicing Regulatory Elements with de Bruijn Graphs,” Eman Badr and Lenwood S. Heath, **Journal of Computational Biology** **21**, 2014, pp. 880-897.
- [48] “A System to Automatically Classify and Name Any Individual Genome-Sequenced Organism Independently of Current Biological Classification and Nomenclature,” Haitham Marakeby, Eman Badr, Hanaa Torkey, Yuhyun Song, Scotland Leman, Caroline L. Monteil, Lenwood S. Heath, and Boris A. Vinatzer. **PLOS ONE** **9**, 2014, 12 pages.
- [49] “Mining Posets from Linear Orders,” Proceso L. Fernandez, Lenwood S. Heath, Naren Ramakrishnan, Michael Tan, and John Paul C. Vergara. **Discrete Mathematics, Algorithms and Applications** **5**, 2013, 15 pages.
- [50] “Changes in RNA Splicing in Developing Soybean (*Glycine max*) Embryos,” Delasa Aghamirzaie, Mahdi Nabiyouni, Yihui Fang, Curtis Klumas, Lenwood S. Heath, Ruth Grene, and Eva Collakova. **Biology** **2**, Special issue on Insights from Plant Genomes, 2013, 1311–1337.

-
- [51] “The Poset Cover Problem,” Lenwood S. Heath and Ajit K. Nema. **Open Journal of Discrete Mathematics** **3**, 2013, 101–111.
- [52] “Metabolic and Transcriptional Reprogramming in Developing Soybean (*Glycine max*) Embryos,” Eva Collakova, Delasa Aghamirzaie, Yihui Fang, Curtis Klumas, Farzaneh Tabataba, Akshay Kakumanu, Elijah Myers, Lenwood S. Heath, and Ruth Grene. **Metabolites** **3**, 2013, 26 pages.
- [53] “Evidence for Extensive Heterotrophic Metabolism, Antioxidant Action, and Associated Regulatory Events during Winter Hardening in Sitka Spruce,” Eva Collakova, Curtis Klumas, Haktan Suren, Elijah Myers, Lenwood S. Heath, Jason A. Holliday, and Ruth Grene. **BMC Plant Biology** **13**, 2013, 16 pages.
- [54] “Mining and Visualization of Microarray and Metabolomic Data Reveal Extensive Cell Wall Remodeling During Winter Hardening in Sitka Spruce (*Picea sitchensis*),” Ruth Grene, Curtis Klumas, Haktan Suren, Kuan Yang, Eva Collakova, Elijah Samuel Myers, Lenwood S. Heath, and Jason A. Holliday. **Frontiers in Plant Systems Biology** **3**, 2012, 14 pages.
- [55] “REGEN: Ancestral Genome Reconstruction for Bacteria,” Kuan Yang, Lenwood S. Heath, and João C. Setubal. **Genes** **3**, 2012, pp. 423–443.
- [56] “Mining for Meaning: Visualization Approaches to Deciphering Arabidopsis Stress Responses in Roots and Shoots,” Lecong Zhou, Christopher Franck, Kuan Yang, Guillaume Pilot, Lenwood S. Heath, and Ruth Grene. **OMICS: A Journal of Integrative Biology** **16**, 2012, pp. 208–228.
- [57] “ClaMS: A Classifier for Metagenomic Sequences,” Amrita Pati, Lenwood S. Heath, Nikos C. Kyrpides, and Natalia Ivanova. **Standards in Genomic Sciences** **5**, 2011, pp. 248–253.
- [58] “Generating Random Graphs with Tunable Clustering Coefficient,” Lenwood S. Heath and Nidhi Parikh. **Physica A** **390**, 2011, pp. 4577–4587.
- [59] “A Network of SCOP Hidden Markov Models and Its Analysis,” Liqing Zhang, Layne T. Watson, and Lenwood S. Heath. **BMC Bioinformatics** **12**, 2011, 11 pages.
- [60] “A Theoretical Model for Whole Genome Alignment,” Nahla A. Belal and Lenwood S. Heath. **Journal of Computational Biology** **18**, 2011, pp. 705–728.
- [61] “Differential Expression of Heat Shock Protein Genes in Preconditioning for Photosynthetic Acclimation in Water-Stressed Loblolly Pine,” Cecilia Vasquez-Robinet, Jonathan I. Watkinson, Allan A. Sioson, Naren Ramakrishnan, Lenwood S. Heath, and Ruth Grene. **Plant Biochemistry and Physiology** **48**, 2010, pp. 256–264.
- [62] “Multimodal Networks: Structure and Operations,” Lenwood S. Heath and Allan A. Sioson, **IEEE/ACM Transactions on Computational Biology and Bioinformatics** **6**, 2009, pp. 321–332.
- [63] “Semantics of Multimodal Network Models,” Lenwood S. Heath and Allan A. Sioson, **IEEE/ACM Transactions on Computational Biology and Bioinformatics** **6**, 2009, pp. 271–280.

- [64] “Molecular and Physiological Adaptation to Prolonged Drought Stress in the Leaves of two Andean Potato Genotypes,” Srinivasrao P. Mane, Cecilia Vasquez Robinet, Alexander Ulanov, Roland Schafleitner, Luz Tincopa, Amelie Gaudin, Giannina Nomberto, Carlos Alvarado, Christian Solis, Luis Avila Bolivar, Raul Blas, Oscar Ortega, Julio Solis, Ana Panta, Cristina Rivera, Ilanit Samolski, Doris H. Carbajulca, Meredith Bonierbale, Amrita Pati, Lenwood S. Heath, Hans J. Bohnert and Ruth Grene, **Functional Plant Biology** **35**, 2008, pp. 669–688.
- [65] “Tuber Development Phenotypes in Adapted and Acclimated, Drought-stressed *Solanum tuberosum* ssp. *andigena* Have Distinct Expression Profiles of Genes Associated with Carbon Metabolism,” Jonathan I. Watkinson, Lori Hendricks, Allan A. Sioson, Lenwood S. Heath, Hans J. Bohnert, and Ruth Grene, **Plant Physiology and Biochemistry** **46**, 2008, pp. 34–45.
- [66] “CMGSDB: Integrating Heterogeneous *Caenorhabditis elegans* Data Sources Using Compositional Data Mining,” Amrita Pati, Ying Jin, Karsten Klage, Rich Helm, Lenwood S. Heath, and Naren Ramakrishnan, **Nucleic Acids Research** **36 (Database Issue)**, 2008, pp. D69–76.
- [67] “Early PLD α -Mediated Events in Response to Progressive Drought Stress in Arabidopsis: A Transcriptome Analysis,” Srinivasrao P. Mane, Cecilia Vasquez-Robinet, Allan A. Sioson, Lenwood S. Heath, and Ruth Grene, **Journal of Experimental Botany** **58**, 2007, pp. 241–252.
- [68] “Accessions of *Solanum tuberosum* ssp. *andigena* Show Differences in Photosynthetic Recovery After Drought Stress as Reflected in Gene Expression Profiles,” Jonathan I. Watkinson, Lori Hendricks, Allan A. Sioson, Cecilia Vasquez-Robinet, Lenwood S. Heath, Mary Schuler, Hans J. Bohnert, Merideth Bonierable, and Ruth Grene. **Plant Science** **171**, 2006, pp. 745–758.
- [69] “Effects of Chronic Ozone Exposure on Gene Expression in *Arabidopsis thaliana* Ecotypes and in *Thellungiella halophila*,” P. H. Li, S. P. Mane, A. A. Sioson, C. V. Robinet, L. S. Heath, H. J. Bohnert, and R. Grene, **Plant Cell and Environment** **29**, 2006, pp. 854–868.
- [70] “Response Diversity of *Arabidopsis thaliana* Ecotypes in Elevated [Co₂] in the Field,” P. H. Li, A. Sioson, S. P. Mane, A. Ulanov, G. Grothaus, L. S. Heath, T. M. Murali, H. J. Bohnert, and R. Grene, **Plant Molecular Biology** **62**, 2006, pp. 593–609.
- [71] “Some Fundamental Operations on Multimodal Networks in Biology,” Allan A. Sioson and Lenwood S. Heath. **Philippine Computing Journal** **1** 2006, pp. 13–22.
- [72] “The Statistics of Identifying Differentially Expressed Genes in Espresso and TM4: A Comparison,” Allan A. Sioson, Srinivasrao P. Mane, Pinghua Li, Wei Sha, Lenwood S. Heath, Hans J. Bohnert, and Ruth Grene. **BMC Bioinformatics** **7**, 2006, 15 pages in main article; plus 5 pages in 2 additional files.
- [73] “XcisClique: Analysis of Regulatory Bicliques,” Amrita Pati, Cecilia Vasquez-Robinet, Lenwood S. Heath, Ruth Grene, and T. M. Murali. **BMC Bioinformatics** **7**, 2006, 14 pages in main article; plus 16 pages in 7 additional files.

-
- [74] “The PMU Placement Problem,” Dennis J. Brueni and Lenwood S. Heath, **SIAM Journal on Discrete Mathematics** **19**, 2005, pp. 744–761.
- [75] “H++: A Server for Estimating pK(a)s and Adding Missing Hydrogens to Macromolecules,” John C. Gordon, Jonathan B. Myers, Timothy Folta, Valia Shoja, Lenwood S. Heath, Alexey Onufriev, **Nucleic Acids Research** **33**, 2005, pp. W368-W371, Supplement 2.
- [76] “Processor-Efficient Sparse Matrix-Vector Multiplication,” Lenwood S. Heath, Calvin J. Ribbens, and Sriram V. Pemmaraju, **Computers and Mathematics with Applications** **48**, 2004, pp. 589–608.
- [77] “Efficient Algorithms for Finding Conway Polynomials,” Lenwood S. Heath and Nicholas A. Loehr, **Journal of Symbolic Computation** **38**, 2004, pp. 1003-1024.
- [78] “Photosynthetic Acclimation is Reflected in Specific Patterns of Gene Expression in Drought-Stressed Loblolly Pine,” Jonathan I. Watkinson, Allan A. Sioson, Cecilia Vasquez-Robinet, Maulik Shukla, Deept Kumar, Margaret Ellis, Lenwood S. Heath, Naren Ramakrishnan, Boris I. Chevone, Layne T. Watson, Leonel Merwe van Zyl, Ulrika Egertsdotter, Ronald R. Sederoff, and Ruth Grene, **Plant Physiology** **133(4)**, 2003, pp. 1702–1716.
- [79] “Sorting by Short Swaps,” Lenwood S. Heath and John Paul C. Vergara, **Journal of Computational Biology** **10(5)**, 2003, pp. 775–789.
- [80] “Clustering Mass Spectrometry Data using Order Statistics,” Douglas J. Slotta, Lenwood S. Heath, Naren Ramakrishnan, Rich Helm, and Malcolm Potts, **Proteomics** **3 (9)**, 2003, pp. 1687–1691.
- [81] “Studying the Functional Genomics of Stress Responses in Loblolly Pine using the Espresso Microarray Management System,” Lenwood S. Heath, Naren Ramakrishnan, Ronald R. Sederoff, Ross W. Whetten, Boris I. Chevone, Craig A. Struble, Vincent Y. Jouenne, Dawei Chen, Leonel Merwe van Zyl, and Ruth Grene, **Comparative and Functional Genomics** **3**, 2002, pp. 226–243.
- [82] “Role of Superoxide Dismutase (SODs) in Controlling Oxidative Stress in Plants,” Ruth Alscher, Neval Erturk, and Lenwood S. Heath, **Journal of Experimental Botany** **53**, 2002, pp. 1331-1341.
- [83] “Constructing Homomorphism Spaces and Endomorphism Rings,” Edward L. Green, Lenwood S. Heath, and Craig A. Struble, **Journal of Symbolic Computation** **32**, 2001, pp. 101-117.
- [84] “The Pagenumber of k -Trees is $O(k)$,” Joseph L. Ganley and Lenwood S. Heath, **Discrete Applied Mathematics** **109**, 2001, pp. 215–221.
- [85] “Sorting by Short Block-Moves,” Lenwood S. Heath and John Paul C. Vergara, **Algorithmica** **28**, 2000, pp. 323–352.
- [86] “Stack and Queue Layouts of Directed Acyclic Graphs: Part I,” Lenwood S. Heath, Sriram V. Pemmaraju, and Ann Trenk, **SIAM Journal on Computing** **28**, 1999, pp. 1510–1539.

-
- [87] “Stack and Queue Layouts of Directed Acyclic Graphs: Part II,” Lenwood S. Heath and Sriram V. Pemmaraju, **SIAM Journal on Computing** **28**, 1999, pp. 1588–1626.
- [88] “Sorting by Bounded Block-Moves,” Lenwood S. Heath and John Paul C. Vergara, **Discrete Applied Mathematics** **88**, Second special issue on computational biology, 1998, pp. 181–206.
- [89] “Edge-Packing in Planar Graphs,” Lenwood S. Heath and John Paul C. Vergara, **Theory of Computing Systems** **31**, 1998, pp. 629–662.
- [90] “An Experimental Evaluation of Local Search Heuristics for Graph Partitioning,” Joseph L. Ganley and Lenwood S. Heath, **Computing** **60**, 1998, pp. 121–132.
- [91] “Edge-Packing Planar Graphs by Cyclic Graphs,” Lenwood S. Heath and John Paul C. Vergara, **Discrete Applied Mathematics** **81**, 1998, pp. 169–180.
- [92] “Stack and Queue Layouts of Posets,” Lenwood S. Heath and Sriram V. Pemmaraju, **SIAM Journal on Discrete Mathematics** **10**, 1997, pp. 599–625.
- [93] “Graph Embeddings and Simplicial Maps,” Lenwood S. Heath, **Theory of Computing Systems** **30**, 1997, pp. 51–65. Invited submission for the special issue on SPAA '93.
- [94] “Envision: A User-Centered Database of Computer Science Literature,” Lenwood S. Heath, Deborah Hix, Lucy T. Nowell, William C. Wake, Guillermo A. Averbach, Eric Labow, Scott A. Guyer, Dennis J. Brueni, Robert K. France, Kaushal Dalal, and Edward A. Fox, **Communications of the ACM** **38**, 1995, pp. 52–53.
- [95] “Optimal and Random Partitions of Random Graphs,” Joseph L. Ganley and Lenwood S. Heath, **The Computer Journal** **37**, 1994, pp. 641–643.
- [96] “New Results for the Minimum Weight Triangulation Problem,” Lenwood S. Heath and Sriram V. Pemmaraju, **Algorithmica** **12**, 1994, pp. 533–552.
- [97] “Heuristics for Laying Out Information Graphs,” Joseph L. Ganley and Lenwood S. Heath, **Computing** **52**, 1994, pp. 389–405.
- [98] “Representing Polyhedra: Faces are Better than Vertices,” Lenwood S. Heath, Praveen K. Paripati, and John W. Roach, **Computational Geometry: Theory and Applications** **3**, 1993, pp. 327–351.
- [99] “Users, User Interfaces, and Objects: Envision, a Digital Library,” Edward A. Fox, Deborah Hix, Lucy T. Nowell, Dennis J. Brueni, William C. Wake, Lenwood S. Heath, and Durgesh Rao, **Journal of the American Society for Information Science** **44**, 1993, pp. 480–491.
- [100] “A Generalized Comparison of Quadtree and Bintree Storage Requirements,” Clifford A. Shaffer, Ramana R. Juvvadi, and Lenwood S. Heath, **Image and Vision Computing** **11**, 1993, pp. 402–412.
- [101] “Laying Out Graphs Using Queues,” Lenwood S. Heath and Arnold L. Rosenberg, **SIAM Journal on Computing** **21**, 1992, pp. 927–958.

- [102] “The Pagenumber of Genus g Graphs is $O(g)$,” Lenwood S. Heath and Sorin Istrail, **Journal of the Association for Computing Machinery** **39**, 1992, pp. 479–501.
- [103] “Comparing Queues and Stacks as Mechanisms for Laying Out Graphs,” Lenwood S. Heath, Frank Thomson Leighton, and Arnold L. Rosenberg, **SIAM Journal on Discrete Mathematics** **5**, 1992, pp. 398–412.
- [104] “Practical Minimal Perfect Hash Functions for Large Databases,” Edward A. Fox, Lenwood S. Heath, Qi Fan Chen, and Amjad M. Daoud, **Communications of the ACM** **35**, 1992, pp. 105–121.
- [105] “Order-Preserving Minimal Perfect Hash Functions and Information Retrieval,” Edward A. Fox, Qi Fan Chen, Amjad M. Daoud, and Lenwood S. Heath, invited paper, **ACM Transactions on Information Systems** **9**, 1991, pp. 281–308.
- [106] “Optimal Embeddings of Butterfly-Like Graphs in the Hypercube,” David S. Greenberg, Lenwood S. Heath, and Arnold L. Rosenberg, **Mathematical Systems Theory** **23**, 1990, pp. 61–77.
- [107] “Covering a Set with Arithmetic Progressions is NP-Complete,” Lenwood S. Heath, **Information Processing Letters** **34**, 1990, 293–298.
- [108] “The Physical Mapping Problem for Parallel Architectures,” Lenwood S. Heath, Arnold L. Rosenberg, and Bruce T. Smith, **Journal of the Association for Computing Machinery** **35**, 1988, pp. 603–634.
- [109] “Embedding Outerplanar Graphs in Small Books,” Lenwood S. Heath, **SIAM Journal on Algebraic and Discrete Methods** **8**, 1987, pp. 198–218.

CONFERENCE PAPERS

Published

- [1] “LINGroups as a Principled Approach to Compare and Integrate Multiple Bacterial Taxonomies,” Reza Mazloom, Leighton Pritchard, C. Titus Brown, Boris A. Vinatzer, and Lenwood S. Heath. **The 13th ACM Conference on Bioinformatics, Computational Biology, and Health Informatics (ACM-BCB 2022)**, 2022, 7 pages.
- [2] “SNPwise: A SNP Aware Short Read Aligner,” Saima Sultana Tithi, Lenwood S. Heath and Liqing Zhang, **7th International Conference on Bioinformatics and Computational Biology (BICoB-2015)**, 2015, 6 pages.
- [3] “Human MicroRNAs Targeting Hepatitis C Virus,” Fatma Elzahraa Eid, Haitham Elmarakeby, Lenwood S. Heath, and Mahmoud Elhefnawi, **Proceedings of the Middle East Conference on Biomedical Engineering (MECBME)**, 2014, pp. 184–187.
- [4] “Blended HMMs: Reducing Redundancy in the SCOP HMM Database,” Mingming Liu, Lenwood S. Heath, Layne T. Watson, and Liqing Zhang. **The 13th International Conference on Bioinformatics and Computational Biology (BIOCOMP’12)**, 2012, 6 pages.

-
- [5] “Sorting Genomes Using Almost-Symmetric Inversions,” Zanoni Dias, Ulisses Dias, Lenwood S. Heath, and João C. Setubal. **Proceedings of the 27th ACM Symposium on Applied Computing (SAC 2012)**, 2012, pp. 47–53.
- [6] “Optimizing a Cost Matrix to Solve Rare-Class Biological Problems,” Mark J. Lawson, Lenwood S. Heath, Hai Zhao, and Liqing Zhang. **The 2011 International Conference on Bioinformatics and Computational Biology (BIOCOMP’11)**, 2011, pp. 544–550.
- [7] “A Network of Hidden Markov Models and Its Analysis,” Liqing Zhang, Layne T. Watson, and Lenwood S. Heath. **Proceedings of the 2011 International Conference on Bioinformatics and Computational Biology (BIOCOMP’11)**, Las Vegas, Nevada, 2011, pp. 337–342.
- [8] “Extracting Temporal Signatures for Comprehending Systems Biology Models,” Naren Sundaravaradan, K. S. M. Tozammel Hossain, Vandana Sreedharan, Douglas J. Slotta, John Paul C. Vergara, Lenwood S. Heath, Naren Ramakrishnan, **16th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD-2010)**, Washington, DC, 2010, pp. 453–462.
- [9] “A Genome Compression Algorithm Supporting Manipulation,” Lenwood S. Heath, Aoping Hou, Huadong Xia, and Liqing Zhang, **9th Annual International Conference on Computational Systems Bioinformatics (CSB 2010)**, Stanford, California, 2010, pp. 38–49.
- [10] “Correlation Between Computed Equilibrium Secondary Structure Free Energy and siRNA Efficiency,” Puranjay Bhattacharjee, Naren Ramakrishnan, Lenwood S. Heath, and Alexey V. Onufriev, **IEEE International Conference on Bioinformatics and Biomedicine Workshop (BIBMW 2009)**, Washington, DC, 2009, pp. 351–351.
- [11] “Using Relative Importance Methods to Model High-throughput Gene Perturbation Screens,” Ying Jin, Naren Ramakrishnan, Lenwood S. Heath, and Richard F. Helm, **Computational Systems Bioinformatics: Proceedings of the CSB 2008 Conference**, Stanford, California, 2008, pp. 225–236.
- [12] “Using Cost-Sensitive Learning to Determine Gene Conversions,” Mark J. Lawson, Lenwood S. Heath, Naren Ramakrishnan, and Liqing Zhang, **Proceedings of Advanced Intelligent Computing Theories and Applications, With Aspects of Artificial Intelligence**, Lecture Notes in Computer Science 5227, Springer, 2008, pp. 1030–1038.
- [13] “Predicting Markov Chain Order in Genomic Sequences,” Lenwood S. Heath and Amrita Pati, **Proceedings of the IEEE International Conference on Bioinformatics and Biomedicine (BIBM)**, IEEE Computer Society Press, 2007, pp. 159–164.
- [14] “Genomic Signatures in de Bruijn Chains,” Lenwood S. Heath and Amrita Pati, **Proceedings of the Workshop on Algorithms in Bioinformatics (WABI)**, Springer Lecture Notes in Computer Science, volume 4645, 2007, pp. 216–227.
- [15] “Genomic Signatures from DNA Word Graphs,” Lenwood S. Heath and Amrita Pati. **Proceedings of the Third International Symposium on Bioinformatics Research and Applications, ISBRA 2007**, Springer Lecture Notes in Computer Science, volume 4463, 2007, pp. 317–328.

-
- [16] “Espresso and Chips: Creating a Next Generation Microarray Experiment Management Systems,” Allan A. Sioson, Jonathan I. Watkinson, Cecilia Vasquez-Robinet, Margaret Ellis, Maulik Shukla, Deept Kumar, Naren Ramakrishnan, Lenwood S. Heath, Ruth Grene, Boris I. Chevone, K. Kafadar, and Layne T. Watson, **Proceedings of the Next Generation Software Workshop, 17th International Parallel and Distributed Processing Symposium (IPDPS’03)**, Nice, France, IEEE Computer Society, ISBN 0769519261 (CDROM), 2003, 8 pages.
- [17] “Networks in Bioinformatics,” Lenwood S. Heath, **Proceedings of the 2002 International Symposium on Parallel Architectures, Algorithms, and Networks (ISPAN 2002)**, 2002, pp. 141–150.
- [18] “Computational Approaches to Combining Predictive Biological Models,” Douglas J. Slotta, Lenwood S. Heath, Naren Ramakrishnan, Rich Helm, and Malcolm Potts, **Proceedings of the High Performance Computing Symposium, Advanced Simulation Technologies Conference (HPC 2002)**, 2002, pp. 75–80.
- [19] “Espresso — A Problem Solving Environment for Bioinformatics: Finding Answers With Microarray Technology,” Ruth G. Alscher, Boris I. Chevone, Lenwood S. Heath, and Naren Ramakrishnan, **Proceedings of the High Performance Computing Symposium, Advanced Simulation Technologies Conference (HPC 2001)**, 2001, pp. 64–69.
- [20] “Constructing Endomorphism Rings Via Duals,” Edward L. Green, Lenwood S. Heath, and Craig A. Struble, **International Symposium on Symbolic and Algebraic Computation (ISSAC 2000)**, 2000, pp. 129–136.
- [21] “Efficient Construction of Drinfel’d Doubles,” Gerard P. Brunick, Edward L. Green, Lenwood S. Heath, and Craig A. Struble, **International Symposium on Symbolic and Algebraic Computation (ISSAC’99)**, 1999, pp. 45–52.
- [22] “New Algorithms for Generating Conway Polynomials over Finite Fields,” Lenwood S. Heath and Nicholas A. Loehr, **Tenth Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)**, 1999, pp. 429–437.
- [23] “Opal: A System for Computing Noncommutative Gröbner Bases (System Description),” Edward A. Green, Lenwood S. Heath, and Benjamin J. Keller, **Eighth International Conference on Rewriting Techniques and Applications (RTA-97)**, 1997, pp. 331–334.
- [24] “Visualizing Search Results: Some Alternatives to Query-Document Similarity,” Lucy T. Nowell, Robert K. France, Deborah Hix, Lenwood S. Heath, and Edward A. Fox, **Proceedings of the 19th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval**, 1996, pp. 67–75.
- [25] “SWAN: A Student-Controllable Data Structure Visualization System,” Clifford A. Shaffer, Lenwood S. Heath, Jeffrey M. Nielsen, and Jun Yang, **Proceedings of ED-MEDIA 96**, 1996, pp. 632–637.
- [26] “Using the SWAN Data Structure Visualization System for Computer Science Education,” Clifford A. Shaffer, Lenwood S. Heath, and Jun Yang, **Proceedings of the Twenty-Seventh SIGCSE Technical Symposium on Computer Science Education**, 1996, pp. 140–144.

-
- [27] “Recognizing Leveled-Planar Dags in Linear Time,” Lenwood S. Heath and Sriram V. Pemmaraju, **Proceedings of Graph Drawing ’95**, Springer, Lecture Notes in Computer Science 1027, 1996, pp. 300–311.
- [28] “SWAN: A Data Structure Visualization System,” Jun Yang, Clifford A. Shaffer, and Lenwood S. Heath, **Proceedings of Graph Drawing ’95**, Lecture Notes in Computer Science 1027, 1996, pp. 520–523.
- [29] “Progress in Interactive Learning with a Digital Library in Computer Science,” Edward A. Fox, N. Dwight DAGS, Clifford A. Shaffer, Lenwood Heath, William C. Wake, Lucy T. Nowell, JAN Lee, Deborah Hix, and H. Rex Hartson, **Proceedings ED-MEDIA 95, World Conference on Educational Multimedia and Hypermedia**, 1995, Graz, Austria, pp. 7–12.
- [30] “Lower Bounds for Graph Embeddings Via Algebraic Topology (Extended Abstract),” Lenwood S. Heath, **Proceedings of the Fifth Annual ACM Symposium on Parallel Algorithms and Architectures**, 1993, pp. 311–317.
- [31] “A User-Centered Database from the Computer Science Literature,” Edward A. Fox, Lenwood S. Heath, and Deborah Hix, **Proceedings of the NSF Scientific Database Projects 1991–1993**, AAAS Workshop on Advances in Data Management for the Scientist and Engineer, Boston, Massachusetts, February 14–16, 1993, Wesley W. Chu, A. F. Cardena, and Ricky K. Taira (Editors), pp. 70–75.
- [32] “What If There Were Desktop Access to the Computer Science Literature?” Dennis J. Brueni, Bailey Cross, Edward A. Fox, Lenwood S. Heath, Deborah Hix, Lucy T. Nowell, and William C. Wake, **Proceedings of the 21st Annual ACM Computer Science Conference**, 1993, pp. 15–22.
- [33] “A Faster Algorithm for Constructing Minimal Perfect Hash Functions,” Edward A. Fox, Qi Fan Chen, and Lenwood S. Heath, **Proceedings of the 15th Annual International Conference on Research and Development in Information Retrieval**, 1992, pp. 266–273.
- [34] “Edge Coloring Planar Graphs with Two Outerplanar Subgraphs,” Lenwood S. Heath, **Proceedings of the Second ACM-SIAM Symposium on Discrete Algorithms**, 1991, pp. 195–202.
- [35] “Graph Layout Using Queues (Extended Abstract),” Lenwood S. Heath, Frank Thomson Leighton, and Arnold L. Rosenberg, **Proceedings of the 28th Annual Allerton Conference on Communication, Control, and Computing**, 1990, pp. 305–314.
- [36] “Order Preserving Minimal Perfect Hash Functions and Information Retrieval,” Edward A. Fox, Qi Fan Chen, Amjad M. Daoud, and Lenwood S. Heath, **Proceedings of the 13th Annual International Conference on Research and Development in Information Retrieval**, 1990, pp. 279–311.
- [37] “Polyhedra: Faces are Better than Vertices (Extended Abstract),” Lenwood S. Heath, P. K. Paripati, and J. W. Roach, **Proceedings of the Second Canadian Conference in Computational Geometry**, 1990, pp. 191–199.

- [38] “A More Cost Effective Algorithm for Finding Minimal Perfect Hash Functions,” Edward A. Fox, Qi Fan Chen, Lenwood S. Heath, and Sanjeev Datta, **Seventeenth Annual ACM Computer Science Conference**, 1989, pp. 114–122.
- [39] “The Pagenumber of Genus g Graphs is $O(g)$,” Lenwood S. Heath and Sorin Istrail, **Proceedings of the 19th Annual ACM Symposium on Theory of Computing**, 1987, pp. 388–397.
- [40] “Embedding Planar Graphs in Seven Pages,” Lenwood S. Heath, **Proceedings of the 25th Annual IEEE Symposium on Foundations of Computer Science**, 1984, pp. 74–83.

ABSTRACTS AND POSTERS

- [1] “Constrained Mining of Minimal Separators with Applications to Gene Perturbation Studies (Poster),” Ying Jin, Naren Ramakrishnan, Lenwood S. Heath, and Richard Helm, **Seventh Asia Pacific Bioinformatics Conference (APBC 2009)**, Beijing, China, January, 2009.
- [2] “Genomic signatures from DNA word graphs (poster),” Amrita Pati and Lenwood S. Heath, Grace Hopper Celebration of Women in Computing, October 17-20, 2007.
- [3] “Effects of Drought Stress on Phospholipid Signaling in Arabidopsis (Poster),” Srinivasrao Mane, Cecilia Vasquez-Robinet, Allan A. Sioson, Lenwood S. Heath, and Ruth Grene. InterDrought-II, The Second International Conference on Integrated Approaches to Sustain and Improve Plant Production Under Drought Stress, Rome, Italy, September, 2005. Also presented at the International Conference on Plant Lipid Mediated Signaling: Building Connections, Raleigh, NC, October, 2005.
- [4] “XcisClique: Analyzing Regulatory Bicliques in *Arabidopsis thaliana* (Poster),” Amrita Pati, Cecilia Vasquez-Robinet, Lenwood S. Heath, Ruth Grene, and T. M. Murali. 8th Annual Conference on Computational Genomics, Cambridge, MA, November, 2005.
- [5] “Clustering Mass Spectrometry Data using Order Statistics (Abstract),” Douglas J. Slotta, Lenwood S. Heath, and Naren Ramakrishnan. First Annual Proteomics Data Mining Conference, Duke University, Durham, NC, September, 2002.
- [6] “Identifying Changes in Gene Expression During Drought Stress Using Expresso (Poster),” Jonathan I. Watkinson, Allan A. Sioson, Maulik Shukla, Lenwood S. Heath, Naren Ramakrishnan, Boris I. Chevone, Layne T. Watson, Jennifer W. Weller, Ronald R. Sederoff, Leonel Merwe van Zyl, and Ruth G. Alscher. Presented at ASPB (American Society of Plant Biologists) Plant Biology 2002, Denver, CO, August, 2002.
- [7] “Effects of Drought Stress on Gene Expression Patterns in the Needles of Loblolly Pine Trees: Towards a PSE for the Analysis of Microarray Data (Poster),” Lenwood S. Heath, Naren Ramakrishnan, Ronald R. Sederoff, Leonel Merwe van Zyl, Dawei Chen, Y.-H. Sun, Boris I. Chevone, S.-H. Li, Keying Ye, Ross Whetten, and Ruth G. Alscher. Presented at the Gordon Conference on Biological Regulatory Mechanisms, Holderness, NH, July 2000.

BOOKS

- [1] **Understanding Computation: Pillars, Paradigms, Principles**, Arnold L. Rosenberg and Lenwood S. Heath, Springer, ISBN-13: 978-3-031-10054-3, 2022, 570 pp.
- [2] **The Problem Solving Handbook for Computational Biology and Bioinformatics**, Lenwood S. Heath and Naren Ramakrishnan, editors, Springer, ISBN-13: 978-0387097596, 2011, 347 pp.
- [3] **Graph Separators, with Applications**, Arnold L. Rosenberg and Lenwood S. Heath, Kluwer Academic Publishers, Norwell, Massachusetts, ISBN 0-306-46464-0, June, 2001, 264 pp.

BOOK CHAPTERS

- [1] “Stack and Queue Layouts of Directed Acyclic Graphs,” Lenwood S. Heath, Sriram V. Pemmaraju, and Ann Trenk, an extended abstract in **Planar Graphs**, William T. Trotter, editor, American Mathematical Society, Providence, Rhode Island, 1993, pp. 5–11.
- [2] “Hashing,” Steve Wartik, Edward A. Fox, Lenwood S. Heath, and Qi Fan Chen, chapter in **Information Retrieval: Data Structures and Algorithms**, William B. Frakes and Ricardo Baeza-Yates, editors, Prentice-Hall, Engelwood Cliffs, NJ, 1992, pp. 293–362.

PREFACE

- [1] “The Emerging Landscape of Bioinformatics Software Systems,” Lenwood S. Heath and Naren Ramakrishnan, Guest editors’ introduction to the Special Issue on Bioinformatics Software, **IEEE Computer** **35**, July, 2002, pp. 41–45.

REPORTS

- [1] “Standardizing Methods with QA/QC Standards for Investigating the Occurrence and Removal of Antibiotic Resistant Bacteria/Antibiotic Resistance Genes (ARB/ARGs) in Surface Water, Wastewater, and Recycled Water,” Liguori, K., I. Keenum, B. Davis, E. Milligan, L. S. Heath, A. Pruden, J. Calarco, and V. J. Harwood. Project 5052. Denver, CO: The Water Research Foundation. 2023, 239 pages.
- [2] “Could a Focus on the “Why” of Taxonomy Help Taxonomy Better Respond to the Needs of Science and Society?” Leighton Pritchard, C. Titus Brown, Bailey Harrington, Lenwood S. Heath, N. Tessa Pierce-Ward, and Boris Vinatzer. preprints.org, 2022, 6 pages. <https://www.preprints.org/manuscript/202203.0069/v1>.
- [3] “EnTrance: Exploration of Entropy Scaling Ball Cover Search in Protein Sequences,” Yoonjin Kim, Zhen Guo, Jeffrey A. Robertson, Benjamin Reidys, Ziyang Zhang, and Lenwood S. Heath. bioRxiv, 2021. DOI: <https://doi.org/10.1101/2021.05.31.446458>.

-
- [4] “Systematic Auditing is Essential to Debiasing Machine Learning in Biology,” Fatma-Elzahraa Eid, Haitham Elmarakeby, Yujia Alina Chan, Nadine Fornelos Martins, Mahmoud Elhefnawi, Eliezer Van Allen, Lenwood S. Heath, and Kasper Lage. *bioRxiv*, 2020. DOI: <https://doi.org/10.1101/2020.05.08.085183>.
 - [5] “MetaMLP: A Fast Word Embedding Based Classifier to Profile Target Gene Databases in Metagenomic Samples,” Gustavo Arango-Argoty, Lenwood S. Heath, Amy Pruden, Peter Vikesland, and Liqing Zhang. *bioRxiv*, 2019. DOI: <https://doi.org/10.1101/569970>.
 - [6] “LINbase: A Web Service for Genome-based Identification of Microbes as Members of Crowdsourced Taxa,” Long Tian, Chengjie Huang, Lenwood S. Heath, and Boris A. Vinatzer. *bioRxiv*, 2019. DOI: <https://doi.org/10.1101/752212>.
 - [7] “Comparing Time Series Transcriptome Data Between Plants Using A Network Module Finding Algorithm,” Jiyoung Lee, Lenwood S. Heath, Ruth Grene, Song Li. *bioRxiv*, 2019. DOI: <https://doi.org/10.1101/564286>.
 - [8] “Strain-level Identification of Bacterial Tomato Pathogens Directly from Metagenomic Sequences,” Marco E. Mehan Llontop, Parul Sharma, Marcela Aguilera Flores, Shu Yang, Jill Pollock, Long Tian, Chenjie Huang, Steve Rideout, Lenwood S. Heath, Song Li, and Boris A. Vinatzer. *bioRxiv*, 2019. DOI: <https://doi.org/10.1101/777706>.
 - [9] “New Methods to Generate Massive Synthetic Networks,” Malay Chakrabarti, Lenwood S. Heath, and Naren Ramakrishnan. *arXiv*, 2017. <https://arxiv.org/abs/1705.08473>.
 - [10] “The Poset Cover Problem,” Lenwood S. Heath and Ajit Kumar Nema, Technical Report TR-12-17, Department of Computer Science, Virginia Polytechnic Institute and State University, 2012.
 - [11] “The Espresso Microarray Experiment Management System: The Functional Genomics of Stress Responses in Loblolly Pine,” Lenwood S. Heath, Naren Ramakrishnan, Ronald R. Sederoff, Ross W. Whetten, Boris I. Chevone, Craig A. Struble, Vincent Y. Jouenne, Dawei Chen, Leonel van Zyl, and Ruth G. Alscher. *arXiv*, 2001. [arXiv:cs/0110047](https://arxiv.org/abs/cs/0110047).
 - [12] “Sorting by Short Swaps,” Lenwood S. Heath and John Paul C. Vergara, Technical Report TR 99-07 (originally, TR 99-2), Department of Computer Science, Virginia Polytechnic Institute and State University, 1999.
 - [13] “Derandomized Vector Sorting,” Lenwood S. Heath and Gabriel Mateescu, Technical Report TR 98-19, Department of Computer Science, Virginia Polytechnic Institute and State University, 1998.
 - [14] “New Algorithms for Generating Conway Polynomials over Finite Fields,” Lenwood S. Heath and Nicholas A. Loehr, Technical Report TR 98-14, Department of Computer Science, Virginia Polytechnic Institute and State University, 1998.
 - [15] “Sorting by Short Block-Moves,” Lenwood S. Heath and John Paul C. Vergara, Technical Report TR 98-03, Department of Computer Science, Virginia Polytechnic Institute and State University, 1998.

-
- [16] “Subsequence and Run Heuristics for Sorting by Transpositions,” Scott A. Guyer, Lenwood S. Heath, and John Paul C. Vergara, Technical Report TR 97-20, Department of Computer Science, Virginia Polytechnic Institute and State University, 1997.
 - [17] “Sorting by Bounded Block-Moves,” Lenwood S. Heath and John Paul C. Vergara, Technical Report TR 97-09, Department of Computer Science, Virginia Polytechnic Institute and State University, 1997.
 - [18] “Edge-Packing Planar Graphs by Cyclic Graphs,” Lenwood S. Heath and John Paul C. Vergara, Technical Report TR 96-15, Department of Computer Science, Virginia Polytechnic Institute and State University, 1996.
 - [19] “Stack and Queue Layouts of Directed Acyclic Graphs: Part I,” Lenwood S. Heath, Sriram V. Pemmaraju, and Ann Trenk, Technical Report TR-95-03, Department of Computer Science, University of Iowa, 1995.
 - [20] “Stack and Queue Layouts of Directed Acyclic Graphs: Part II,” Lenwood S. Heath and Sriram V. Pemmaraju, Technical Report TR-95-06, Department of Computer Science, University of Iowa, 1995.
 - [21] “Edge-Packing in Planar Graphs,” Lenwood S. Heath and John Paul C. Vergara, Technical Report TR 95-18, Department of Computer Science, Virginia Polytechnic Institute and State University, 1995.
 - [22] “The Pagenumber of k -Trees is $O(k)$,” Joseph L. Ganley and Lenwood S. Heath, Technical Report TR 95-17, Department of Computer Science, Virginia Polytechnic Institute and State University, 1995.
 - [23] “Some Experiments on the Sorting by Reversals Problem,” Lenwood S. Heath and John Paul C. Vergara, Technical Report TR 95-16, Department of Computer Science, Virginia Polytechnic Institute and State University, 1995.
 - [24] “Queue Layouts and Staircase Covers of Matrices,” Lenwood S. Heath and Sriram V. Pemmaraju, Technical Report TR 94-22, Department of Computer Science, Virginia Polytechnic Institute and State University, 1994.
 - [25] “Seeing Things Your Way: Information Visualization for a User-Centered Database of Computer Science Literature,” Lucy T. Nowell, Edward A. Fox, Lenwood S. Heath, Deborah Hix, William C. Wake, and Eric A. Labow, Technical Report TR 94-06, Department of Computer Science, Virginia Polytechnic Institute and State University, 1994.
 - [26] “Sparse Matrix-Vector Multiplication on a Small Linear Array,” Lenwood S. Heath, Sriram V. Pemmaraju, and Calvin J. Ribbens, Technical Report 93-11, Department of Computer Science, University of Iowa, 1993.
 - [27] “Graph Embeddings and Simplicial Maps,” Lenwood S. Heath, Technical Report TR 93-40, Department of Computer Science, Virginia Polytechnic Institute and State University, 1993.
 - [28] “Local Search for the Retrieval Layout Problem,” Lenwood S. Heath and Joseph W. Lavinus, Technical Report TR 93-28, Department of Computer Science, Virginia Polytechnic Institute and State University, 1993.

-
- [29] “Heuristics for Laying Out Information Graphs,” Lenwood S. Heath and Joseph W. Lavinus, Technical Report TR 93-27, Department of Computer Science, Virginia Polytechnic Institute and State University, 1993.
 - [30] “Optimal and Random Partitions of Random Graphs,” Lenwood S. Heath and Joseph W. Lavinus, Technical Report TR 93-24, Department of Computer Science, Virginia Polytechnic Institute and State University, 1993.
 - [31] “Stack and Queue Layouts of Posets,” Lenwood S. Heath and Sriram V. Pemmaraju, Technical Report 93-06, Department of Computer Science, University of Iowa, 1993.
 - [32] “What If There Was Desktop Access to the Computer Science Literature,” Dennis J. Brueni, Edward A. Fox, Lenwood S. Heath, Deborah Hix, Lucy T. Nowell, and William C. Wake, Technical Report TR 92-42, Department of Computer Science, Virginia Polytechnic Institute and State University, 1992.
 - [33] “Stack and Queue Layouts of Posets,” Lenwood S. Heath and Sriram V. Pemmaraju, Technical Report TR 92-31, Department of Computer Science, Virginia Polytechnic Institute and State University, 1992.
 - [34] “New Results for the Minimum Weight Triangulation Problem,” Lenwood S. Heath and Sriram V. Pemmaraju, Technical Report TR 92-30, Department of Computer Science, Virginia Polytechnic Institute and State University, 1992.
 - [35] “Representing Polyhedra: Faces are Better than Vertices,” Lenwood S. Heath, Praveen K. Paripati, and John W. Roach, Technical Report TR 92-20, Department of Computer Science, Virginia Polytechnic Institute and State University, 1992.
 - [36] “LEND and Faster Algorithms for Constructing Minimal Perfect Hash Functions,” Edward A. Fox, Qi Fan Chen, and Lenwood S. Heath, Technical Report TR 92-02, Department of Computer Science, Virginia Polytechnic Institute and State University, 1992.
 - [37] “Edge Coloring Planar Graphs with Two Outerplanar Subgraphs,” Lenwood S. Heath, Technical Report TR 91-34, Department of Computer Science, Virginia Polytechnic Institute and State University, 1991.
 - [38] “Edge-Packing by Isomorphic Subgraphs,” John Paul C. Vergara and Lenwood S. Heath, Technical Report TR 91-3, Department of Computer Science, Virginia Polytechnic Institute and State University, 1991.
 - [39] “Order Preserving Minimal Perfect Hash Functions and Information Retrieval,” Edward A. Fox, Qi Fan Chen, Amjad M. Daoud, and Lenwood S. Heath, Technical Report TR 91-1, Department of Computer Science Virginia Polytechnic Institute and State University, 1991.
 - [40] “Improved Algorithms for the Minimum Weight Triangulation Problem,” Lenwood S. Heath and Sriram Pemmaraju, Technical Report TR 90-65, Department of Computer Science, Virginia Polytechnic Institute and State University, 1990.
 - [41] “Polyhedra: Faces are Better than Vertices,” Lenwood S. Heath, Praveen K. Paripati, and John W. Roach, Technical Report TR 90-64, Department of Computer Science, Virginia Polytechnic Institute and State University, 1990.

-
- [42] “Comparing Queues and Stacks as Mechanisms for Laying Out Graphs,” Lenwood S. Heath, Frank Thomson Leighton, and Arnold L. Rosenberg, COINS Technical Report 90-105, Computer and Information Science, University of Massachusetts at Amherst, 1990.
 - [43] “Laying Out Graphs Using Queues,” Lenwood S. Heath and Arnold L. Rosenberg, COINS Technical Report 90-75, Computer and Information Science, University of Massachusetts at Amherst, 1990.
 - [44] “Practical Minimal Perfect Hash Functions for Large Databases,” Edward A. Fox, Lenwood S. Heath, Qi Fan Chen, and Amjad M. Daoud, Technical Report TR 90-41, Department of Computer Science, Virginia Polytechnic Institute and State University, 1990.
 - [45] “The Pagenumber of Genus g Graphs is $O(g)$,” Lenwood S. Heath and Sorin Istrail, Technical Report TR 90-21, Department of Computer Science, Virginia Polytechnic Institute and State University, 1990.
 - [46] “Graph Layout Using Queues,” Lenwood S. Heath and Arnold L. Rosenberg, Technical Report TR 89-45, Department of Computer Science, Virginia Polytechnic Institute and State University, 1989.
 - [47] “Development of New Heuristics for the Euclidean Traveling Salesman Problem,” Lenwood S. Heath and T. W. Tunnell, Technical Report TR 89-30, Department of Computer Science, Virginia Polytechnic Institute and State University, 1989.
 - [48] “Covering a Set with Arithmetic Progressions is NP-Complete,” Lenwood S. Heath, Technical Report TR 89-25, Department of Computer Science, Virginia Polytechnic Institute and State University, 1989.
 - [49] “A Generalized Comparison of Quadtree and Bintree Storage Requirements,” Clifford A. Shaffer, Ramana Juvvadi, and Lenwood S. Heath, Technical Report TR 89-23, Department of Computer Science, Virginia Polytechnic Institute and State University, 1989.
 - [50] “An $O(n \log n)$ Algorithm for Finding Minimal Perfect Hash Functions,” Edward A. Fox, Lenwood S. Heath, and Qi Fan Chen, Technical Report TR 89-10, Department of Computer Science, Virginia Polytechnic Institute and State University, 1989.
 - [51] “Optimal Embeddings of Butterfly-Like Graphs in the Hypercube,” David S. Greenberg, Lenwood S. Heath, and Arnold L. Rosenberg, COINS Technical Report 88-103, Computer and Information Science, University of Massachusetts at Amherst, 1988.
 - [52] “Optimal Embeddings of the FFT Graph in the Hypercube,” David S. Greenberg, Lenwood S. Heath, and Arnold L. Rosenberg, COINS Technical Report 88-23, Computer and Information Science, University of Massachusetts at Amherst, 1988.
 - [53] “A More Cost Effective Algorithm for Finding Perfect Hash Functions,” Edward A. Fox, Qi Fan Chen, Lenwood S. Heath, and Sanjeev Datta, Technical Report TR 88-30, Department of Computer Science, Virginia Polytechnic Institute and State University, 1988.
 - [54] “An Optimal Mapping of the FFT Algorithm onto the Hypercube Architecture,” Lenwood S. Heath and Arnold L. Rosenberg, COINS Technical Report 87-19, Computer and Information Science, University of Massachusetts at Amherst, 1987.

- [55] “Algorithms for Embedding Graphs in Books,” Lenwood S. Heath, Doctoral Dissertation, Technical Report 85-028, University of North Carolina, Chapel Hill, 1985.
- [56] “Multi-layer Circuit Layouts,” Lenwood S. Heath, abstract in Proceedings of the First Microelectronics Center of North Carolina Semi-Annual Research Review, 1984.
- [57] “Final Technical Report, SRC Contract 82-11-003, Transfer of Software Methodology to VLSI Design,” Frederick P. Brooks, Jr., with Richard R. Gross and Lenwood S. Heath, University of North Carolina, Chapel Hill, 1984.
- [58] “Multi-Layer Channel Routing,” Lenwood S. Heath, in Course Projects on VLSI Algorithms: 1983, Microelectronics Center of North Carolina Technical Report 83-06, 1983.

FUNDING

Current

- [1] USDA NIFA: *Expanding an Established Genome-based Identification Resource to Surveillance of Fungal Pathogens*, \$650,000. 07-01-2023 - 06-30-2026. PI: Boris A. Vinatzer. Co-PIs: Lenwood S. Heath, David C. Haak. Personal share: 25%.
- [2] Virginia Tech ICTAS EFO Seed Grant Award: *A Unified, Natural, and Computationally Efficient Genome-Based Classification System for All Microbes*, \$10,000. 10/17/2022 - 06/30/2023. PI: Lenwood S. Heath. Co-PI: Boris A. Vinatzer. Personal share: 50%.
- [3] National Science Foundation 2125798: *NRT-HDR: Convergence at the Interfaces of Policy, Data Science, Environmental Science and Engineering to Combat the Spread of Antibiotic Resistance*, \$3,000,000. 09/01/2021 - 08/31/2026. PI: Amy Pruden. Co-PIs: Liqing Zhang, Leigh Anne Krometis, Todd Schenk, Tiffany Drape. Senior Personnel: Lenwood S. Heath et al. Personal share: 8%.
- [4] National Science Foundation 1918656: *Collaborative Research: Expeditions: Global Pervasive Computational Epidemiology*, \$10,000,000. 04/01/2020 - 03/31/2025. PI: Madhav V. Marathe. VT share: \$1,587,064. VT PI: Naren Ramakrishnan. VT co-PIs: Lenwood S. Heath et al. Personal share of VT share: 14%.
- [5] National Science Foundation DBI-2018522: *BBSRC-NSF/BIO:Collaborative Research: CIBR: genomeRxiv: A Microbial Whole-genome Database and Diagnostic Marker Design Resource for Classification, Identification, and Data Sharing*, \$653,114. 08/01/20 - 07/31/24. PI: Boris A. Vinatzer. Co-PI: Lenwood S. Heath. Personal share: 50%.
- [6] Water Research Foundation: *Standardizing Methods with QA/QC Standards for Investigating the Occurrence and Removal of Antibiotic Resistant Bacteria/Antibiotic Resistance Genes (ARB/ARGs) in Surface Water, Wastewater, and Recycled Water*, \$200,000. 09/01/2020 - 12/01/2022. PI: Amy Pruden. Co-PIs: Valerie J. Harwood, Lenwood S. Heath. Personal share: 20%.
- [7] USDA 2017-68003-26498: *Developing Computational Tools to Identify Critical Control Points for Mitigating the Spread of Antibiotic Resistance in Agro-ecosystem*, \$1,200,000. 05/16/17 - 05/15/23. PI: Amy J. Pruden-Bagchi. Co-PIs: Lenwood S. Heath, Katharine F. Knowlton, Kang Xia, Liqing Zhang. Personal share: 25%.

- [8] NSF 2243691: *Collaborative Research: RESEARCH-PGR: Unraveling the Origin of Vegetative Desiccation Tolerance in Vascular Plants*, \$2,000,000. 02/02/2023 – 01/31/2026. PI: Luis R Herrera-Estrella (Texas Tech University). Co-PI: John C Cushman (University of Nevada, Reno). Virginia Tech PI: Lenwood S. Heath. Virginia Tech funding share: \$370,704. Personal share: 100% of VT share.

Completed

- [9] Water Research Foundation: *The Use of Next Generation Sequencing (NGS) Technologies and Metagenomics Approaches to Evaluate Water and Wastewater Quality Monitoring and Treatment Technologies*, \$300,000. 10/01/2019 - 09/30/2021. PI: Amy Pruden. Co-PIs: Emily Garner, Peter Vikesland, Linsey Marr, Liqing Zhang. Senior personnel: Lenwood S. Heath, et al. Personal share: 10%.
- [10] USDA Animal and Plant Health Inspection Service (APHIS): *Genome-based Circumscription and Phenotyping of Regulated Microbes, Especially the Select Agent Ralstonia solanacearum*, \$261,207. 08/01/19 - 08/01/21. PI: Kellye Eversole. Co-PIs: Caitilyn Allen, Mohammad Arif, Gwyn Beattie, Lenwood S. Heath, Michael Stulberg (USDA-APHIS), Boris A. Vinatzer (VT-SPES). VT share: \$129,210. Personal share: 50% of VT share.
- [11] IARPA: *Integrative Genomics Approach to Computational Assessment of Threats (IGACAT)*, \$12,622,546. 03/01/17 - 05/31/20. PI: Stephen Eubank. Research Scientist: Lenwood S. Heath. Personal share: 4%.
- [12] National Science Foundation 1545756: *PIRE: Halting Environmental Antimicrobial Resistance Dissemination (HEARD)*, \$3,333,000. 10/01/15 - 09/30/20. PI: Peter Vikesland. Co-PIs: Pedro Alvarez, Diana Aga, Amy Pruden, Krista Wigginton. Senior Personnel: Lenwood S. Heath, Liqing Zhang, et al. Personal share: 0%.
- [13] Virginia Tech Microbiology at the Nexus of Food, Energy, Water, and Health Systems (MicroFEWHS) concept area: *Continued Development and Enhancement of DeepARG, a Web Service for Accurate Annotation of Antibiotic Resistance Genes*, \$3,725. 12/01/2019 - 05/15/2020. PI: Liqing Zhang. Co-PIs: Lenwood S. Heath. Personal share: 50%.
- [14] Virginia Tech Microbiology at the Nexus of Food, Energy, Water, and Health Systems (MicroFEWHS) concept area: *Developing ARGminer, a Powerful Web Platform for Crowdsourcing-based Curation of Antibiotic Resistance Genes*, \$3,000. 12/01/2018 - 05/15/2019. PI: Liqing Zhang. Co-PIs: Lenwood S. Heath. Personal share: 50%.
- [15] Virginia Tech College of Agriculture and Life Sciences (CALS): *Identifying Select Agents Using a Nanopore Sequencing and Secure Cyberphysical System*, \$20,000. 05/15/2018 - 12/31/2018. PI: Song Li. Co-PIs: Lenwood S. Heath, Boris Vinatzer. Personal share: 25%.
- [16] National Science Foundation 1238057: *GEPR-Evolutionary Gain and Loss of Function in Parasitic Plant Genomes*, \$3,406,833. 08/01/13 - 07/31/18. PI: James H. Westwood. Co-PIs: Eva Collakova, Claude W. dePamphilis, Lenwood S. Heath, Aaron Mackey, Michael P. Timko, John I. Yoder. Personal share: 10%. VT share: \$934,389.

- [17] National Science Foundation DBI-1062472: *ABI Development: Representation, Visualization, and Modeling of Signaling Pathways in Higher Plants*, Advances in Biological Informatics (ABI), \$1,057,337. 04/15/11 - 03/31/17. PI: Lenwood S. Heath. Co-PIs: Ruth Grene, Andy Pereira. Personal share: 37%.
- [18] National Institutes of Health Grant 1 R25 GM066354-06: *VT Post Baccalaureate Research and Education*, National Institute of General Medical Sciences. First year: \$275,603; second year: \$276,635; third year: \$277,689; fourth year: \$278,793. 03/01/2009 - 01/31/2013. PI: Edward J. Smith; Research Mentor: Lenwood S. Heath, *et al.*
- [19] National Science Foundation ITR-0428344: *ITR-(NHS)-(sim): Computational Models for Gene Silencing: Elucidating a Pervasive Biological Defensive Response*, Information Technology Research (ITR), \$1,500,000. 09/01/04 - 8/31/10. PI: Lenwood S. Heath. Co-PIs: Richard F. Helm, Alexey Onufriev, Malcolm Potts, Naren Ramakrishnan.
- [20] National Institutes of Health Grant 1 R25 GM066354-01A1: *VT Post Baccalaureate Research and Education*, National Institute of General Medical Sciences. First year: \$254,871; second year: \$411,184; third year: \$413,757; fourth year: \$416,407; fifth year: \$419,135. 08/04/2003 - 07/31/2008. PI: Edward J. Smith; Research Mentor: Lenwood S. Heath, *et al.*
- [21] Department of Defense Multidisciplinary University Research Initiative (MURI), Defense Advanced Research Projects Agency Grant N00014-01-1-0852: *Dryophile Genes to Engineer Stasis-Recovery of Human Cells*, \$4,532,622: \$2,602,790 (basic 3-year) plus \$1,929,832 (2-year option), 05/01/2001 - 05/31/2007. Principal investigator: Malcolm Potts. Senior Personnel: Lenwood S. Heath, Richard F. Helm, Naren Ramakrishnan, Thomas O. Sitz (Virginia Tech), Frederic Bloom, Paul Price (Life Technologies), and John Battista (Louisiana State University).
- [22] National Science Foundation Grant ITR-0219322: *ITR: Understanding Stress Resistance Mechanisms in Plants: Multimodal Models Integrating Experimental Data, Databases, and the Literature*, Division of Integrative Biology and Neuroscience (BIO/IBN) — ITR Small grants, \$499,973. 09/15/2002 - 08/31/2005. PI: Lenwood S. Heath; Co-PIs: Ruth G. Alscher, Boris I. Chevone, Naren Ramakrishnan, and Layne T. Watson. Supplemental funding of \$70,705 received February, 2005; expiration extended until 12/31/2006.
- [23] National Science Foundation Grant EIA-01903660: *A Microarray Experiment Management System*, \$600,000. 8/01/2001 - 8/31/2004. Principal investigators: Naren Ramakrishnan, Lenwood S. Heath, Layne T. Watson, Ruth G. Alscher, and Jennifer W. Weller (VBI).
- [24] Virginia Tobacco Settlement Foundation (VTSF): *Using Molecular Genetics to Target "High Risk" Youth Smokers*. Initial participation with the Virginia Tobacco Prevention Research Consortium, in particular, research in furthering the Espresso project and applying it to the needs of the consortium. \$96,000. 3/16/2002 - 3/15/2002. Principal investigators: Naren Ramakrishnan, Lenwood S. Heath.
- [25] National Science Foundation Grant INT-0000424: *U.S.-Brazil Cooperative Research: The Fine Algebraic Structure of Derivations and Hochschild Cohomology*. \$24,900, 9/1/00-8/31/03. Principal investigators: Daniel R. Farkas, Edward L. Green, and Lenwood S. Heath.

- [26] National Science Foundation Grant CCR-9732068: *A System for Symbolic Computation in Hopf Algebras*. \$180,000, 8/16/98–8/31/01. Principal investigators: Edward L. Green and Lenwood S. Heath.
- [27] Arts and Sciences Pilot Research Project Grant: *Experimenting With Algorithms for Difficult, Non-numeric Problems*. \$3,000, 12/96–12/98.
- [28] National Science Foundation Grant IRI-9116991: *A User-Centered Database from the Computer Science Literature (REU Supplement)*. \$8,000, 5/15/92–5/15/93. Principal investigator. Funding to pay two undergraduates to participate in research.
- [29] National Science Foundation Grant IRI-9116991: *A User-Centered Database from the Computer Science Literature*. \$443,391, 9/15/91–2/28/95. Equipment supplement \$29,941, 1992. Principal investigators: Edward A. Fox, Lenwood S. Heath, and Deborah Hix.
- [30] National Science Foundation Grant CCR-9009953: *Analyzing Parallel Architectures With Algebraic Topology*. \$40,000, 7/15/90–12/31/92. Principal investigator.

DOCTORAL STUDENTS SUPERVISED

- [1] Reem Aldaihani, “Identifying The Structure Of Genomic Islands In Prokaryotes,” 2022.
- [2] Siddharth Krishnan, “Seeing the Forest for the Trees: New Approaches to Characterizing and Forecasting Cascades,” 2018.
- [3] Hanaa A. Torkey, “Machine Learning Approaches for Identifying microRNA Targets and Conserved Protein Complexes,” 2017.
- [4] Fatma Elzahraa Sobhy Eid, “Predicting the Interactions of Viral and Human Proteins,” 2017.
- [5] Doaa Abdelsalam Ahmed Mohamed Altarawy, “DeTangle: A Framework for Interactive Prediction and Visualization of Gene Regulatory Networks,” 2017.
- [6] Haitham Abdulrahman Elmarakeby, “Deep Learning for Biological Problems,” 2017.
- [7] Andrew Scott Warren, “Methods for Analysis of Prokaryotic Genome Architecture,” 2017.
- [8] Eman Badr, “Identifying Splicing Regulatory Elements with de Bruijn Graphs,” 2015.
- [9] Kuan Yang, “Ancestral Genome Reconstruction in Bacteria,” 2012. Ph.D. in Genetics, Bioinformatics, and Computational Biology. Co-advisor with João C. Setubal of the Virginia Bioinformatics Institute.
- [10] Nahla A. Belal, “Two Problems in Computational Genomics,” 2011.
- [11] Amrita Pati, “Graph-Based Genomic Signatures,” 2008.
- [12] Allan A. Sioson, “Multimodal Networks in Biology,” 2005.
- [13] Douglas J. Slotta, “Evaluating Biological Data Using Rank Correlation Methods,” 2005.

- [14] Craig A. Struble, “Analysis and Implementation of Algorithms for Noncommutative Algebra,” 2000. Co-advisor with Edward L. Green of the Department of Mathematics.
- [15] John Paul A. Vergara, “Sorting by Bounded Rearrangements,” 1997.
- [16] Benjamin J. Keller, “Algorithms and Orders for Finding Noncommutative Gröbner Bases,” 1997. Co-advisor with Edward L. Green of the Department of Mathematics.
- [17] Ramana R. Juvvadi, “Perfect Hashing and Some Related Problems,” 1993.
- [18] Sriram V. Pemmaraju, “Exploring the Powers of Stacks and Queues via Graph Layouts,” 1992.

MASTERS THESIS STUDENTS SUPERVISED

- [1] Aarathi Raghuraman, “Predicting Mutational Pathways of Influenza A H1N1 Virus using Q-learning,” 2021.
- [2] Ashkan Nazari, “Machine Learning Application in Energy Storage System’s State Estimation: State of Health (SOH),” 2021.
- [3] Jeffrey A. Robertson, “Entropy Measurements and Ball Cover Construction for Biological Sequences,” 2018.
- [4] Yanshen Yang, “MCAT: Motif Combining and Association Tool,” 2018.
- [5] Rathna Senthil, “IDLE: A Novel Approach to Improving Overlapping Community Detection in Complex Networks,” 2016.
- [6] Ying Ni, “A Machine Learning Approach to Predict Gene Regulatory Networks in Seed Development in Arabidopsis Using Time Series Gene Expression Data,” 2016.
- [7] Deepti Aggarwal, “Inferring Signal Transduction Pathways from Gene Expression Data using Prior Knowledge,” 2015.
- [8] Nidhi Kiranbhai Parikh, “Generating Random Graphs with Tunable Clustering Coefficient,” 2011.
- [9] Amrita Pati, “Modeling and Analysis of Regulatory Elements in *Arabidopsis thaliana* from Annotated Genomes and Gene Expression Data,” 2005.
- [10] Maulik Shukla, “GeneSieve: A Probe Selection Strategy for cDNA Microarrays,” 2004.
- [11] Harsha K. Rajasimha, “PathMeld: A Methodology for The Unification of Metabolic Pathway Databases,” 2004.
- [12] Guillermo Averboch, “A System for Document Analysis, Translation, and Automatic Hypertext Linking,” 1995.
- [13] Fred L. Drake, Jr., “odb/Tools Project Report,” 1995.

- [14] Dennis J. Brueni, “Minimal PMU Placement for Graph Observability: A Decomposition Approach,” 1993.
- [15] John Paul A. Vergara, “Edge-packing by Isomorphic Subgraphs,” 1990.
- [16] Thurman W. Tunnell, “Development of New Heuristics for the Euclidean Traveling Salesman Problem,” 1989.

PROFESSIONAL ORGANIZATIONS

Association of Computing Machinery, Member

Institute of Electrical and Electronics Engineers (IEEE), Lifetime Senior Member

IEEE Computer Society, Lifetime Member

Models of Infectious Disease Agent Study (MIDAS) Network, Member

Society for Industrial and Applied Mathematics (SIAM), Lifetime Member

SIAM Activity Group on Discrete Mathematics

SIAM Activity Group on Life Sciences

PROFESSIONAL SERVICE

2021 Program Committee Member, IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2021.

2020 Program Committee Member, IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2020.

2017–20 Associate Editor, Mathematical Foundations of Computing (MFOC).

2017– Managing Editor, Journal of Interconnection Networks (JOIN).

2017 Guest editor-in-chief of the **Special Issue of the Proceedings of the IEEE on Bioinformatics of DNA**, March, 2017. Other guest editors are Hector Corrada Bravo, Mario Caccamo, and Michael Schatz. “Scanning the Issue: Bioinformatics of DNA,” Lenwood S. Heath, Hector Corrada Bravo, Mario Caccamo, and Michael Schatz. Guest editor introduction. Proceedings of the IEEE 105, 2017, 419–421.

2013–17 Editor, New Journal of Science.

2011–14 Editor, ISRN Computational Mathematics

2011 Member of program committee of **First IEEE Conference on Healthcare Informatics, Imaging, and Systems Biology (HISB) 2011**.

2010 Member of program committee of **33rd Annual ACM SIGIR Conference 2010**.

2005 Member of program committee of **Brazilian Symposium on Bioinformatics 2005**.

Moderator for panel on systems biology at the Biomedical Engineering Research and Science Conference, March 4, 2005. Sponsored by the Virginia Tech National Capital Region and College of Engineering and by the Wake Forest University School of Medicine.

2003–16 Editor, Journal of Interconnection Networks (JOIN).

2002 Guest editor, with Naren Ramakrishnan, of the **Special Issue of IEEE Computer on Bioinformatics Software**, July, 2002.

Member of program committee of **High Performance Computing Symposium 2002 (HPC 2002)**, accepted six papers for two tracks on Bioinformatics Applications.

1995–2000

ACM Special Interest Group on Automata and Computability Theory (SIGACT) Theory Calendar. Maintained WWW calendar of conferences and other events of interest to the theory community. Calendar also appeared as a column four times a year in **SIGACT News**.

HONORS AND AWARDS

Sigma Xi, The Scientific Research Honor Society, 1991

Department of Computer Science, Virginia Tech, Outstanding Department Contributor Award for Exemplary Faculty Service, 2019

Institute of Electrical and Electronics Engineers, Lifetime Senior Member, 2018

Institute of Electrical and Electronics Engineers, Senior Member, 1999

Board of Governor's Fellowship in Science and Technology, University of North Carolina, Chapel Hill, 1984

Archibald Henderson Prize for outstanding undergraduate in mathematics, University of North Carolina, Chapel Hill, 1975

Phi Beta Kappa, University of North Carolina, Chapel Hill, 1973

Jackson Tuition Scholarship, University of North Carolina, Chapel Hill, 1971

National Merit Scholarship, 1971

Westinghouse Science Talent Search winner, 1971

National Science Foundation Student Science Training Program, University of North Carolina, Chapel Hill, Summer 1970; first in mathematics class

Governor's School, Winston-Salem, NC, Summer, 1969