

Gregory Ian Lang

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Education:

Harvard University, Cambridge, MA (2002 – 2007)

Ph.D. Molecular Biology

Thesis: Mutation rate variation in the yeast, *Saccharomyces cerevisiae*

Advisor: Andrew Murray

Thesis Committee: Erin O'Shea (chair), Dan Hartl, Roy Kishony, Matt Michael

Millersville University of Pennsylvania, Millersville, PA (1997 – 2001)

B.S. Molecular Biology

Minors: Physics, Biochemistry

GPA: 3.90, *Magna cum laude*

Professional Employment and Experience:

Assistant Professor (2013 – present)

Lehigh University, Department of Biology

Post-doctoral Researcher (2007 – 2013)

Princeton University, Lewis-Sigler Institute for Integrative Genomics

Advisor: David Botstein

Preprints (* with Lehigh affiliation):

*Fisher KJ, Buskirk SW, Vignogna RC, Marad DA, and Lang GI. 2018. Cause and consequences of genome duplication in haploid yeast populations. *bioRxiv* 247320; doi: <https://doi.org/10.1101/247320>.

Publications (* with Lehigh affiliation, **F1000** Faculty of 1000 recommendation):

*Marad DM, Buskirk SW, and Lang GI. 2018. Altered access to beneficial mutations slows adaptation and biases fixed mutations in diploids. (*in press at Nature Ecology & Evolution*).

*Lang GI. 2018. Measuring mutation rates using the Luria-Delbrück fluctuation assay. *Methods Mol Biol*. 1672:21-31. doi: 10.1007/978-1-4939-7306-4_3.

F1000 *Buskirk SW, Peace RE, and Lang GI. 2017. Hitchhiking and epistasis give rise to cohort dynamics in adapting populations. *Proc Natl Acad Sci U S A*. 2017 Jul 18. pii: 201702314. doi: 10.1073/pnas.1702314114.

*Fisher KJ, and Lang GI. 2016. *Invited Review Article*: Experimental evolution in fungi: An untapped resource. *Fungal Genetics and Biology*. Sep;94:88-94. doi: 10.1016/j.fgb.2016.06.007. Epub 2016 Jun 30.

*Frenkel EM, McDonald MJ, Van Dyken JD, Kosheleva K, Lang GI, and Desai MM. 2015. Crowded growth leads to the spontaneous evolution of semistable coexistence in laboratory yeast populations. *Proc Natl Acad Sci U S A* Aug 3. pii: 201506184.

*Lang GI, and Desai MM. 2014. *Invited Review Article*: The spectrum of adaptive mutations in experimental evolution. *Genomics*. Dec;104(6 Pt A):412-6. doi: 10.1016/j.ygeno.2014.09.011. Epub 2014 Sep 28.

*Lang GI, Rice DP, Hickman MJ, Sodergren E, Weinstock GM, Botstein D, and Desai MM. 2013. Pervasive genetic hitchhiking and clonal interference in forty evolving yeast populations. *Nature*, Aug 29;500(7464):571-4.

*Lang GI, Parsons L, and Gammie A. 2013. Mutation rates, spectra, and genome-wide distribution of spontaneous mutations in mismatch repair deficient yeast. *G3*, Sep 4;3(9):1453-65.

Lang GI, Botstein D, and Desai MM. 2011. Genetic variation and the fate of beneficial mutations in asexual populations. *Genetics*. Jul;188(3):647-61.

F1000 Lang GI, Murray AW. 2011. Mutation rates across budding yeast Chromosome VI are correlated with replication timing. *Genome Biology and Evolution*. 3:799-811.

Lang GI, and Botstein D. 2011. A test of the coordinated expression hypothesis for the origin and maintenance of the *GAL* cluster in yeast. *PLoS ONE*. Sep 22; 10.1371/journal.pone.0025290.

F1000 Lang GI, Murray AW, and Botstein D. 2009. The cost of gene expression underlies a fitness trade-off in yeast. *Proc Natl Acad Sci U S A*. Apr 7;106(14):5755-60.

Lang GI, Murray AW. 2008. Estimating the per-base-pair mutation rate in the yeast *Saccharomyces cerevisiae*. *Genetics*. Jan;178(1):67-82.

Hepfer CE, Arnold-Croop S, Fogell H, Steudel KG, Moon M, Roff A, Zaikoski S, Rickman A, Komsisky K, Harbaugh DL, Lang GI, Keil RL. 2005. *DEG1*, encoding the tRNA:pseudouridine synthase Pus3p, impacts *HOT1*-stimulated recombination in *Saccharomyces cerevisiae*. *Mol Genet Genomics*. Dec;274(5):528-38.

Competitively Awarded Research Support

Source: **Faculty Innovation Grant, Lehigh University 459664 (active)**

Direct Costs: \$30,000

Name: Host-virus coevolution and the resolution of intragenomic conflict (09/01/17 – 08/31/18)

Major Goals: The goals of this proposal are to (1) isolate and sequence the yeast Killer virus and (2) determine the mechanism of Killer loss in yeast experimental evolution.

Description: Research support and 50% salary support for my post-doctoral fellow Sean Buskirk in order to perform pilot experiments and generate preliminary data for a future grant submission to either the NIH or NSF.

Role: PI

Source: **The Charles E. Kaufman Foundation of The Pittsburgh Foundation KA2014-73925 (completed)**

Direct Costs: \$150,000

Name: Epistatic interactions and constraints on evolutionary outcomes in yeast experimental evolution (09/01/14 – 12/31/17)

Major Goals: The goals of this proposal are to (1) determine how individual fitness effects and epistatic interactions contribute to the fitness gains during experimental evolution and (2) determine how epistasis constrains evolutionary paths.

Description: Research support for consumables and equipment usage fees. This grant also provided graduate student summer support, travel expenses, and support for publication costs.

Role: PI

Source: **Biosystems Dynamics Summer Institute, a Lehigh University grant from HHMI (completed)**

Direct Costs: \$44,375

Name: Identification of driver mutations in experimental evolution (05/21/14 – 06/31/14)

Major Goals: The goals of this proposal are to identify biological pathways that regularly yield mutations that drive adaptation and to develop bioinformatics tools for the analysis of whole-genome whole-population sequencing data from long-term experimental evolution.

Description: Summer stipend and research support for graduate students D. Marad (Molecular Biology, Lehigh) and M. Messersmith (Computer Science, Lehigh), and undergraduate students R. Peace (Bioengineering, Lehigh), K. Trinh (Bioengineering, Lehigh), D. Auth (Bioinformatics, Gannon), and T. Tavolara (Computer Science, Rochester).

Role: Co-PI with Daniel Lopresiti, Department of Computer Science, Lehigh University

Pending Research Support

Source: **National Institutes of Health 1R01GM127420-01**

Score: Impact score: 34, Percentile: 19

Direct Costs: \$1,250,000 (*requested*)

Name: Mapping genetic interactions between growth-promoting mutations in yeast (02/01/18 – 01/31/23)

Major Goals: The major goals of this proposal are to (1) leverage the power of evolutionary “replay” experiments to identify a local network of genetic interactions, (2) to extend this analysis genome-wide, and (3) to determine the extent to which genetic interactions persist across environments.

Description: Annual salary support for PI (3 mo.), one post-doctoral fellow, and two graduate students. Research support for consumables, equipment usage fees, travel expenses, and support for publication costs.

Role: PI

Professional Societies, Honors, and Awards:

Nominated for Lehigh University Graduate Mentorship Award, 2017

Class of '68 Junior Faculty Fund Award, 2017

Eugene Mercy, Jr. President and Provost's Fund for Faculty Development Travel Grant, 2016

EMBO CPP Travel Fellowship, 2016

Member of the American Society of Microbiology, 2015 – present

GSA Chair's Choice Plenary Talk at the Fungal Genetics Meeting, 2015

Charles E. Kaufman New Investigator, 2014

Member of the Society for Molecular Biology and Evolution, 2014 – present

Eugene Mercy, Jr. President and Provost's Fund for Faculty Development Travel Grant, 2014

EMBO CPP Travel Fellowship, 2014

Member of the Genetics Society of America, 2010 – present

Scholarly Presentations at National and International Scientific Conferences with Lehigh affiliation (Since 2013):

- *Genetics Society of America, Fungal Genetics Meeting. (14 – 19 March, 2017)
Pacific Grove, CA
Invited Speaker: [Lang GI](#), Fitness and epistasis in yeast experimental evolution.
- *Experimental Approaches to Evolution and Ecology using Yeast and other Model Systems. (19 – 23 October, 2016)
Heidelberg, Germany
Talk: [Lang GI](#), Linking the emergence of epistatic interactions to the dynamics of adaptation.
- *American Society for Microbiology: 2nd Conference on Experimental Microbial Evolution. (4 – 7 August, 2016)
Washington, DC
Talk (presented by *Sean Buskirk*): Buskirk SW, Peace RE, [Lang GI](#), Characterizing patterns of epistasis in experimentally-evolved yeast.
Poster (presented by *Daniel Marad*): Marad DA, [Lang GI](#), Rate of adaptation and spectrum of beneficial mutations in haploids and diploids.
Poster (presented by *Chris Graves from Brown University*): Graves CJ, Bauer C, Siegal ML, [Lang GI](#), Weinreich DM, Yeast populations adapted to periodic stress trade fast growth for stress resistance.
- *Genetics Society of America, The Allied Genetics Conference. (13 – 27 July, 2016)
Orlando, FL
Talk: [Lang GI](#), Buskirk SW, Peace RE, Characterizing patterns of epistasis in yeast experimental evolution.
Poster (presented by *Katie Fisher*): Fisher K, [Lang GI](#), Quantifying host genome response to gene drive.
- *Genetics Society of America, Fungal Genetics Meeting. (17 – 22 March, 2015)
Pacific Grove, CA
Chair's Choice Plenary Talk: [Lang GI](#), Genome sequence evolution in experimental populations of *S. cerevisiae*.
- *Experimental Approaches to Evolution and Ecology using Yeast and other Model Systems. (12 – 16 October, 2014)
Heidelberg, Germany
Talk: [Lang GI](#), Genome sequence evolution in experimental populations of *S. cerevisiae*
- *American Society for Microbiology: 1st Conference on Experimental Microbial Evolution. (19 – 22 June, 2014)
Washington, DC
Invited Speaker: [Lang GI](#), The dynamics of genomic sequence evolution in experimental populations of *S. cerevisiae*.
- *Annual Meeting for the Society of Molecular Biology and Evolution. (8 – 12 June, 2014)
San Juan, Puerto Rico
Symposium Organizer: *Genome Scale Approaches to Experimental Evolution*.
Poster: [Lang GI](#), The dynamics of genomic sequence evolution in experimental populations of *S. cerevisiae*.
- *Comparative Genomics of Eukaryotic Microorganisms: Patterns of Complexity in Eukaryotic Genomes. (19 – 24 October, 2013)
San Feliu de Guixols, Spain
Invited Speaker: [Lang GI](#), Hickman M, Parsons L, Desai MM, Weinstock GM, Botstein D. The dynamics of genomic sequence evolution in experimental populations of *S. cerevisiae*.
- Gordon Research Conference on Microbial Population Biology. (21 – 26 July, 2013)
Proctor Academy, Andover, NH
Poster: [Lang GI](#), Rice DP, Hickman MJ, Sodergren E, Weinstock GM, Botstein D, and Desai MM. The dynamics of genomic sequence evolution in experimental populations of *Saccharomyces cerevisiae*.
- EMBO Conference Series: Experimental Approaches to Evolution and Ecology using Yeast. (17 – 21 October, 2012)
EMBL Heidelberg, Germany
Talk: [Lang GI](#), Hickman M, Parsons L, Desai MM, Weinstock GM, Botstein D. Sequencing reveals the dynamics of adaptation in asexual populations.
- Genetics Society of America, Yeast Meeting. (31 July – 5 August, 2012)
Princeton, NJ
Talk: [Lang GI](#), Desai MM, Weinstock G, Botstein D. Sequencing reveals the dynamics of adaptation in asexual populations.
Talk (presented by *A. Gammie*): [Lang GI](#), Parsons L, Gammie A. Mutation rates, spectra, and genome-wide distribution of spontaneous mutations associated with clinically significant *msh2* variants.
- Gordon Research Conference on Ecological and Evolutionary Genomics. (10 – 15 July, 2011)
University of New England, Biddeford, ME
Talk: [Lang GI](#), Desai MM, Botstein D. Genetic variation and the fate of beneficial mutations in asexual populations.
- The Biology of Genomes. (10 – 14 May, 2011)
Cold Spring Harbor Laboratory, NY
Talk: [Lang GI](#), Desai MM, Botstein D. Genetic variation and the fate of beneficial mutations in asexual populations.

- Genetics Society of America, Yeast Meeting. (27 July – 2 August, 2010)
University of British Columbia, Vancouver, B.C.
Talk: Lang GI, Botstein D, Desai MM. Observing the dynamics of adaptation: Emergence and fate of beneficial mutations.
- Gordon Research Conference on Microbial Population Biology. (19 – 24 July, 2009)
Proctor Academy, Andover, NH
Poster: Lang GI, Murray AW, Botstein D. The cost of gene expression underlies a fitness trade-off in yeast.
- 74th Symposium: Evolution - The Molecular Landscape. (27 May – 1 June, 2009)
Cold Spring Harbor Laboratory, NY
Poster: Lang GI, Murray AW, Botstein D. The cost of gene expression underlies a fitness trade-off in yeast.
- EMBO Workshop on Evolutionary and Environmental Genomics of Yeasts. (1 – 5 October, 2008)
EMBL Heidelberg, Germany
Talk: Lang GI, Murray AW, Botstein D. An evolutionary trade-off between growth rate and mating efficiency in yeast.
- Gordon Research Conference on Mutagenesis. (6 – 11 August, 2006)
Salve Regina University, Newport, RI
Poster: Lang GI, Murray AW. Mutation rate across *Saccharomyces cerevisiae* Chromosome VI is correlated with replication timing.
- 6th International Conference on Systems Biology. (19 – 24 October, 2005)
Harvard Medical School, Boston, MA
Poster: Lang GI, Murray AW. Variation in mutation rate along yeast Chromosome VI.

Scholarly Presentations at Regional Meetings (number of presentations from our lab):

- Three Rivers Evolution Event, University of Pittsburgh, 9 September 2017 (1 talk)
Evolution in Philadelphia Conference, University of Pennsylvania, 15 April 2017 (4 talks)
Lehigh Valley Ecology and Evolution Symposium, Desales University, 8 April 2017 (4 talks)
Lehigh Valley Ecology and Evolution Symposium, Muhlenberg College, 18 April 2015 (2 posters)

Invited Seminars (* with Lehigh affiliation):

- **Upcoming Seminar:* Millersville University. Millersville, PA. 28 March 2018.
- **Upcoming Seminar:* Carnegie Mellon University. Pittsburgh, PA. 11 April 2018.
- * University of Michigan, Ann Arbor. *Departmental Seminar:* Genome Evolution in Laboratory Populations of Yeast. 18 January 2018.
- *University of California, San Diego. *Departmental Seminar:* Genome Evolution in Laboratory Populations. 3 November 2017.
- *Georgetown University. *Departmental Seminar:* Genome Evolution in Laboratory Populations. 12 October 2017.
- *DuPont. Wilmington DE. *Seminar:* Genome Evolution in Laboratory Populations. 29 September 2017.
- *Kavli Institute of Theoretical Physics, University of California, Santa Barbara. *Seminar:* Yeast experimental evolution: sequence dynamics, targets of selection, an example of synergistic epistasis, and maybe some ploidy stuff too. 3 August 2017.
- *Cold Spring Harbor, Yeast Genetic Course. *Seminar:* Genome Evolution in Laboratory Populations of Yeast. 28 July 2017.
- *Stony Brook University. *Departmental Seminar:* Genome Evolution in Laboratory Populations of Yeast. 12 May 2017.
- *Villanova University. *Departmental Seminar:* Genome Evolution in Laboratory Populations of Yeast. 2 February 2017.
- *Dartmouth College. *Graduate-student Invited Departmental Seminar:* The dynamics of genomic sequence evolution in experimental yeast populations. 19 December 2016.
- *Penn State, Hershey Medical Center. *Departmental Seminar:* The dynamics of genomic sequence evolution in experimental yeast populations. 5 December 2016.
- *Brown University. *Departmental Seminar:* The dynamics of genomic sequence evolution in experimental yeast populations. 15 November 2016.
- *Cornell University. *Departmental Seminar:* Genome Sequence Evolution in Experimental Populations of Yeast. 15 April 2016.
- *Rowan University. *Departmental Seminar:* Experimental Evolution in Yeast. 11 November 2015.
- *Princeton University. *Princeton Area Yeast Meeting:* Experimental Evolution. 4 April 2015.
- *University of Alabama, Birmingham. *Departmental Seminar:* The dynamics of genomic sequence evolution in experimental yeast populations. 1 April 2015.
- *Calico (California Life Company). South San Francisco. *Seminar:* Genome sequence evolution in experimental populations of *S. cerevisiae*. 5 March 2015.

- *University of Nebraska, Lincoln. *Departmental Seminar*: The dynamics of genomic sequence evolution in experimental yeast populations. 5 March 2015.
- *Bryn Mawr College. *Departmental Seminar*: Experimental Evolution in Yeast. 29 October 2014.
- *University of New Hampshire. *Departmental Seminar*: The dynamics of genomic sequence evolution in experimental populations of *Saccharomyces cerevisiae*. 6 March 2014.
- *Princeton Plasma Physics Laboratory. *Departmental Seminar*: Chance and determinism in experimental evolution. 26 February 2014.
- *Cedar Crest College. *Departmental Seminar*: The dynamics of genomic sequence evolution in experimental populations of *Saccharomyces cerevisiae*. 20 February 2014.
- New York University. *Evening Evolution Group*: Pervasive genetic hitchhiking and clonal interference in 40 evolving yeast populations. 5 February 2013.

Courses Taught:

- BIOS 325 (formerly BIOS 398). *Microbiology Lab* (Lehigh, Spring 2017, Spring 2018)
- BIOS 324. *Microbiology* (Lehigh, Fall 2014, Fall 2015, Fall 2016, Fall 2017)
- BIOS 396/496. *Molecular Evolution*. (Lehigh, Spring 2014, Spring 2015, Spring 2016).
- Lecturer/Practical Session. *EMBO Practical Course: Measuring intra-species diversity using high-throughput sequencing* (Instituto Gulbenkian de Ciência, Lisbon, Portugal, 27-31 August 2015).
- BIOS 090. *Understanding the Human Genome*. (Lehigh, Fall 2013).
- Lecturer, *Project Lab in Molecular Biology*. (Princeton, August 2011).
Lecturer: Alison Gammie
- Teaching Fellow, *A Systems Approach to Biology*. (Harvard, Spring 2005).
Lecturers: Marc Kirschner, Lewis Cantley, Walter Fontana, and Jeremy Gunawardena
- Curriculum-Development Committee, *A Systems Approach to Biology*. (Harvard, Fall 2004 – Spring 2005)
- Teaching Fellow. MCB/HHMI Outreach, *Fly learning and memory* (Harvard, March 2004)
- Teaching Fellow. *Introduction to Genetics and Genomics*. (Harvard, Fall 2003).
Lecturer: William Gelbart

Guest Lectures:

- BIOS 010. *Bioscience in the 21st Century*. Lecture: “Genome Evolution” (Fall 2013, Fall 2014, Fall 2015, Fall 2016)
- BIOS 388. *Biological Sciences Honors Seminar*. Lecture: “Yeast Experimental Evolution” (Spring 2014).
- BIOS 340. *Molecular Basis of Disease*. Lecture: “Evolution of a Bacterial Pathogen” (Fall 2013).

Undergraduate Research Advising:

- Completed*: Kenneth Brill. Fall 2014 (1 credit BIOS 161), Spring 2015 (2 credits BIOS 161), Fall 2015 (2 credits BIOS 161), Spring 2016 (2 credits BIOS 391), Fall 2016 (3 credits BIOS 391 as a writing intensive course), Spring of 2017 (3 credit Thesis).
- Completed*: Rebecca Unterborn. Fall 2016 (2 credits BIOS 391), Spring 2017 (2 credits of BIOS 391).
- Completed*: Ali O'Donnell. Spring 2015 (1 credit BIOS 161), Fall 2015 (2 credits BIOS 161).
- Completed*: Ryan Emily Peace. Spring 2014 (2 credits, BIOE 142), Fall 2014 (2 credits, BIOE 132), Spring 2015 (4 credits, BIOE 242). Ryan is currently a graduate student in bioengineering at Boston University (#9 in bioengineering according to U.S. News & World Report's national ranking).
- Completed*: Jessica Moore, Primary Healthcare Accessibility for Patients with Trisomy 21. Summer of 2014. Jessica was supported by a Grants for Experiential Learning in Health (GELH) Grant from Lehigh University.
- Jasper Jeffrey. Fall 2017 (3 credits BIOS 391), Spring 2018 (2 credits of BIOS 391).
- Alecia Rokes. Spring 2018 (2 credits of BIOS 391).

Graduate Research Advising:

- Completed*: Thesis committee member for Bitu Khalili (Physics). Bitu was advised by Dimitrios Vavylonis, 2015 – 2017.
- Completed*: External thesis committee member for Christopher Graves in the Department of Ecology and Evolutionary Biology, Brown University. Chris was advised by Daniel Weinreich, 2016 – 2017.
- Completed*: External thesis committee member for Marcus Dillon in the Department of Molecular, Cellular, and Biomedical Sciences at the University of New Hampshire. Marcus was co-advised by Vaughn Cooper (UNH) and Michael Lynch (Indiana University), 2013 – 2016.
- Completed*: Hamidu Mohammed. Rotation Student (Molecular Biology), Spring 2017.
- Completed*: Joseph Rozek. Rotation Student (Integrative Biology), Fall 2014.

Ryan, Vignogna, Graduate Student (Biochemistry), 2016 – present.

Daniel Marad, Graduate Student (Molecular Biology), 2014 – present.

Kaitlin Fisher, Graduate Student (Integrative Biology), 2014 – present.

Thesis committee member for Katie Mageeney (Molecular Biology). Katie is advised by Vassie Ware.

Thesis committee member for Donglai Shen (Molecular Biology). Donglai is advised by Robert Skibbens.

Thesis committee member for Michael McQuillan (Integrative Biology). Mike is advised by Amber Rice.

Thesis committee member for Alex Huynh (Integrative Biology). Alex is advised Amber Rice.

Thesis committee member for Caitlin Zuilkoski (Molecular Biology). Caitlin is advised by Robert Skibbens.

External thesis committee member for Stephanie Lauer in The Center for Genomics and Systems Biology, New York University. Stephanie is advised by David Gresham, 2015 – present.

Departmental Service:

Faculty Search Committee, Infectious Disease, Assistant Professor, 2016.

Graduate Committee, 2015 – present.

Coordinator for the Cell & Molecular graduate student qualifying exam, 2015 – 2018.

Infrastructure Committee, 2014 – present.

Organizer of the Lehigh Yeast Group Meetings, Spring 2014 – Spring 2016.

Co-organizer (with graduate student Katie Mageeney) of the Graduate Research Seminar Series, Fall 2013 – Spring 2016.

University Service:

Data X Innovation Grant Committee, 2015.

Faculty Search Committee, DataX/Connected Health, Assistant Professor, 2015.

Speaker, Lehigh Research Cafe on Boundaries and interfaces, 5 August 2015.

Professional Service:

Instructor for the Cold Spring Harbor Laboratory Yeast Genetics and Genomics Course, 2018 – present.

Symposium Organizer for *Genome Scale Approaches to Experimental Evolution* at the Annual Meeting for the Society of Molecular Biology and Evolution in San Juan, Puerto Rico. June 2014.

Reviewer for *BioEssays*, *Bioinformatics*, *BMC Genomics*, *BMC Molecular Systems Biology*, *Current Biology*, *eLife*, *Evolution*, *G3*, *Genetics*, *Genome Biology and Evolution*, *Molecular Biology and Evolution*, *Nature Communications*, *Nature Ecology and Evolution*, *PLoS Genetics*, *PLoS ONE*, *PNAS*, *Proceedings of the Royal Society B*, and *Science*. I have served as an *ad hoc* grant reviewer for the Medical Research Council, NSF DEB, NSF MCB, NSF CAREER, NSF LTREB, and I have served on an NSF DEB DDIG review panel. I will serve on the NIH GVE study section in February 2018.

Professional Development:

2nd Avida-ED Active LENS Workshop. 9 – 11 June 2016. NSF BEACON Center for the Study of Evolution in Action, Michigan State University, East Lansing, MI