

Benjamin M. Woolston, Ph.D.

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Education

Massachusetts Institute of Technology

Cambridge, MA

PhD Thesis: Enabling C1-Based Bioconversion through Metabolic Engineering

Ph.D. in Chemical Engineering

2011–2017

The Pennsylvania State University

University Park, PA, GPA: 3.89/4.00 (*High Distinction*)

Minors: Chemistry, Biochemistry & Molecular Biology

B.Sc. in Chemical Engineering

2006–2011

Appointments

Northeastern University

Boston, MA

Assistant Professor of Chemical Engineering

2020–Present

Professional Preparation

Harvard University

Cambridge, MA

Advisor: Dr. Emily Balskus, Chemistry & Chemical Biology

Post-doctoral Fellow

2018–2019

Massachusetts Institute of Technology

Cambridge, MA

Advisor: Dr. Greg Stephanopoulos, Chemical Engineering

Post-doctoral Associate

2017–2018

Massachusetts Institute of Technology

Cambridge, MA

Advisor: Dr. Greg Stephanopoulos, Chemical Engineering

PhD Student

2011–2017

The Pennsylvania State University

University Park, PA

Advisor: Dr. Wayne Curtis, Chemical Engineering

Undergraduate Researcher

2009–2011

Awards And Honors

2021: Biotechnology and Bioengineering Daniel I.C. Wang Award

2020: AIChE SBE IMES Jay Bailey Young Investigator Award in Metabolic Engineering

2016: Dow Chemical Travel Award

2016: GRS Invited Speaker Travel Relief

2012: John C. Sluder (1941) Fellowship

2011: NSF Graduate Research Fellowship

2010: 1st Place in AIChE National Student Paper Competition

2010: Larry J. Duda Award for Undergraduate Research

Awarded Grants

Northeastern University Mutual Mentoring Advancement Program - PI

NUSynBio - A Research Community to Promote Faculty, Student and Institutional Leadership in Synthetic Biology
\$3,000. January 2022 - December 2022

Northeastern University Center for Research Innovation Spark Fund - PI

A Co-Culture Method for Enhanced Biofuel and Biochemical Production from Untreated Waste Gases
\$50,000. January 2022 - December 2022

MassVentures Acorn Innovation Program - PI

A Co-Culture Method for Enhanced Biofuel and Biochemical Production from Untreated Waste Gases
\$15,000. May 2021 - October 2021

DOE ARPA-E EcoSynBio - Co-PI

Zero-Carbon Biofuels: An Optimized Two-Stage System for High Productivity Conversion of CO₂ to Liquid Fuels
\$670,000. September 2021 - February 2024

Publications

1. KO Hoyt and **BM Woolston**. "Adapting isotopic tracer and metabolic flux analysis approaches to study C1 metabolism" *Curr. Opin. Biotechnol.* Accepted (2022)
2. PA Sanford and **BM Woolston**. "Synthetic or natural? Metabolic engineering for assimilation and valorization of methanol" *Curr. Opin. Biotechnol.* In Press (2022)
3. **BM Woolston***, DJ Jenkins*, MI Hood, S Rakoff-Nahoum, EP Balskus. "Characterization of vaginal microbial enzymes identifies amylopullulanases that support growth of *Lactobacillus crispatus* on glycogen" *bioRxiv* 2021.07.19.452977 (2021)
4. SM Bloom, NA Mafunda, **BM Woolston**, MR Hayward, JF Frempong, AB Abai, J Xu, AJ Mitchell, X Westergaard, FA HUSSAIN, N Xulu, M Dong, KL Dong, T Gumbi, X Ceasar, JK Rice, N Choksi, N Ismail, T Ndung'u, MS Ghebremichael, EP Balskus, CM Mitchell, DS Kwon. "Cysteine dependence in *Lactobacillus iners* constitutes a novel therapeutic target to modify the vaginal microbiota" *bioRxiv* 2021.06.12.448098 (2021)
5. **BM Woolston*** and G Stephanopoulos. "Engineering *E. coli* to Grow on Methanol" *Joule* 4 (10), 2070-2072 (2020)
6. **BM Woolston**. "Efficient C1 Elongation by Reversing α -Oxidation." *Trends in Biotechnology*. 37 (12), 1273-1276 (2019)
7. T Roth*, **BM Woolston***, G Stephanopoulos, and DR Liu. "Phage-Assisted Evolution of *Bacillus methanolicus* Methanol Dehydrogenase 2." *ACS Synthetic Biology*. 8 (4), 796-806 (2019)
8. JO Park, N Liu, KM Holinski, DF Emerson, K Qiao, **BM Woolston**, J Xu, Z Lazar, M Ashanul Islam, C Vidoudez, PR Girguis, and G Stephanopoulos. "Synergistic substrate cofeeding stimulates reductive metabolism." *Nature Metabolism* 1 (6), 643-651 (2019).
9. B Uranukul, **BM Woolston**, GR Fink, G Stephanopoulos. "Biosynthesis of monoethylene glycol in *Saccharomyces cerevisiae* utilizing native glycolytic enzymes." *Metabolic Engineering*. 51, 20-31 (2019)

10. DF Emerson, **BM Woolston**, DH Currie, N Liu, and G Stephanopoulos. "Enhancing H₂-dependent growth of and CO₂ fixation by *Clostridium ljungdahlii* through nitrate supplementation." *Biotechnol. Bioeng.* 116 (2), 294-306 (2019)
11. **BM Woolston**, DF Emerson, DH Currie, and G Stephanopoulos. "Rediverting carbon flux in *Clostridium ljungdahlii* using CRISPRi." *Metabolic Engineering.* 48, 243-253 (2018)
12. **BM Woolston**, JR King, M Reiter, B Van Hove, and G Stephanopoulos. "Improving formaldehyde consumption drives methanol assimilation in engineered *E. coli*." *Nature Communications.* 9, 2387 (2018)
13. **BM Woolston***, T Roth*, I Kohale, DR Liu, and G Stephanopoulos. "Development of a formaldehyde biosensor with application to synthetic methylotrophy." *Biotechnol. Bioeng.* 115, 206-215 (2017). DOI:10.1002/bit.26455
14. JR King, **BM Woolston**, and G Stephanopoulos. "Designing a new entry point into isoprenoid metabolism by exploiting fructose-6-phosphate aldolase side-reactivity of *Eschericia coli*" *ACS Synthetic Biology* 6(7), 1416-1426 (2017)
15. DF Emerson, A Al Ghatta, **BM Woolston**, A Fay, A Kumar, and G Stephanopoulos. "Theoretical analysis of natural gas recovery from marginal wells with a deep well reactor." *AIChE Journal* 63(9) 3642-3650 (2017)
16. P Hu, S Chakraborty, A Kumar, **BM Woolston**, H Liu, DF Emerson, and G Stephanopoulos. "Integrated bioprocess for conversion of gaseous substrates to liquids." *PNAS* 113(14), 3773-3778 (2016)
17. SE Nybo, NE Khan, **BM Woolston**, WR Curtis. "Metabolic engineering in chemolithoautotrophic hosts for the production of fuels and chemicals." *Metabolic Engineering* (30) 105-120 (2015)
18. **BM Woolston***, S Edgar*, and G Stephanopoulos. "Metabolic Engineering: Past and Future" *Annual review of chemical and biomolecular engineering* (4) 259-288 (2013)
19. **BM Woolston**, C Schlagnhauer, J Wilkinson, J Larsen, Z Shi, KM Mayer, DS Walters, WR Curtis, and CP Romaine. "Long-distance translocation of protein during morphogenesis of the fruiting body in the filamentous fungus, *Agaricus bisporus*." *PLoS One* 6(12):e28412 (2011)

Patents

1. **BM Woolston** and A Stohr. "Co-Culture Method for Biofuel and Biochemical Production from Untreated Syngas" Provisional Patent 63/173,756 (2021)
2. CP Romaine, CD Schlagnhauer, and **BM Woolston**. "Strategies for the transgenic manipulation of filamentous fungi." US Patent 8,686,218

Service, Activities, and Leadership

NEU Department of Chemical Engineering Graduate Committee

Assistant Chair of Graduate Admissions

2020-Present

NEU Department of Chemical Engineering Graduate Student Council

Co-Advisor

2020-Present

Panelist

National Academies of Engineering

2018

"Developing a Research Agenda for Utilization of Gaseous Carbon Waste Streams". Presented guidance to the committee on-the-record on the merits and challenges of gas fermentation

Conference Chair

Gordon Research Seminar in C1 Metabolism

2016-2018

Organized, led and fund-raised for a 2-day seminar for early-career researchers in the C1 research community. Duties included technical program development, selection of invited speakers, abstract review, event co-ordination, and budget management

Editorial Board Member

Metabolic Engineering Communications, Journal of Industrial Microbiology & Biotechnology 2018-Present

Peer Review

Over 30 manuscripts in:

2011-Present

Nature Biotechnology, Nature Chemical Biology, PNAS, Metabolic Engineering, ACS Synthetic Biology, Synthetic and Systems Biology

President

MIT Cycling Team

2014-2015

Teaching

CHME 5630: Biochemical Engineering

Northeastern University

Fall 2021

CHME 5630: Biochemical Engineering

Northeastern University

Spring 2021

CHME 7340: Graduate Chemical Engineering Kinetics & Reactor Design

Northeastern University

Summer 2020

CHME 5630: Biochemical Engineering

Northeastern University

Spring 2020

Kaufman Teaching Certificate Program

MIT

2017

Guest Lecturer

MIT and Harvard

2014-2019

- Biological Synthesis (Prof. Emily Balskus, Harvard Chemistry and Chemical Biology)
- Microbial Physiology (Prof. Anthony Sinskey, MIT Microbiology)
- Metabolic and Cell Engineering (Profs. Greg Stephanopoulos and Kristala Prather, MIT Chemical Engineering)

Teaching Assistant

MIT and Penn State

2009-2013

- 10.28: Bioprocess Engineering Lab (MIT)
- CHEM 535: Advanced Organic Mechanisms (PSU)
- CH E 340: Introduction to Biomolecular Engineering (PSU)
- CH E 438: Bioprocess Engineering (PSU)

Mentorship

Research Mentor

Northeastern, Harvard and MIT

2015-Present

- Northeastern: Currently run a lab with 4 PhD students and 4 undergraduate researchers
- Harvard: Mentored three graduate student rotators, and a research assistant
- MIT: Mentored and supervised four MIT undergraduate students, one visiting Master's student (TU Munich), and one visiting PhD student (University of Ghent), three of whom successfully co-authored papers with me.

Communication Fellow

MIT ChemE Department Communication Lab

2017-2018

Provided one-on-one peer coaching on technical writing, presentation, and other communication skills to Chemical Engineering undergraduate and graduate students, and post-docs, as well as designed and led workshops to help Chemical Engineering community members with various aspects of technical communication

Invited Talks

1. **BM Woolston**. "Metabolic Engineering for Production of Biofuels and Bioproducts from Methanol" *European Society of Applied Biocatalysis Seminar Series*. October 22, 2021. Virtual.
2. **BM Woolston**. "Metabolic Engineering for Production of Biofuels and Bioproducts from Methanol" *ACS Annual Conference - Bioengineering Award Session*. August 25, 2021. Virtual.
3. KO Hoyt, PA Sanford, **BM Woolston**. "Establishing *Eubacterium limosum* as a model methylotrophic acetogen" *43rd Annual SIMB Symposium on Biomaterials, Fuels, and Chemicals*. April 26, 2021. Virtual Conference.
4. **BM Woolston**, DF Emerson, DH Currie, and G Stephanopoulos. "Rediverting carbon flux in *Clostridium ljungdahlii* using CRISPR Interference (CRISPRi)" *Clostridium XV*. September 18, 2018. TU Munich, Friesing, Germany.
5. **BM Woolston** and G Stephanopoulos. "Biochemical Production from C1 Feedstocks Through Metabolic Engineering." *Gordon Research Seminar on C1 Metabolism*. August 2nd, 2018. Newry, ME.
6. **BM Woolston** and G Stephanopoulos. "Indirect microbial electrosynthesis using reducing gases." *NRL/ARPA-E Microbial Electrosynthesis Workshop*. November 4, 2016. Washington, D.C.
7. **BM Woolston**, DF Emerson, DH Currie, and G Stephanopoulos. "Heterologous Production of 3-Hydroxybutyric Acid in *Clostridium ljungdahlii*." *Gordon Research Seminar on C1 Metabolism*. July 30, 2016. Waterville Valley, NH.
8. **BM Woolston**. "Enabling the Utilization of Non-traditional C1 Feedstocks for Fuel and Chemical Bioproduction via Metabolic Engineering." *MIT iGEM Team Seminar*. July 17, 2015. Cambridge, MA.
9. **BM Woolston**. "Metabolic Engineering for Biofuels using Alternative Substrates." *MIT Energy Club: BioEnergy Seminar*. November 18, 2014. Cambridge, MA.
10. **BM Woolston**. "Advanced Biofuels and Non-traditional Feedstocks." *HHMI Summer Workshop for High School Science Teachers*. July 24, 2014. Cambridge, MA.
11. **BM Woolston**, C Schlagnhauer, WR Curtis, and CP Romaine. "Development of a Mushroom-Based Platform for Large-Scale Production of Heterologous Proteins." *AIChE National Student Paper Competition*. November 8, 2010.

12. **BM Woolston**, C Schlagnhauer, WR Curtis, and CP Romaine. "Long-Distance Movement of Protein in *Agaricus bisporus*." *Plant Pathology Departmental Seminar*. October 11, 2010. University Park, PA.
13. **BM Woolston**, C Schlagnhauer, WR Curtis, and CP Romaine. "Spawn vs CI: Battle for Control of Mushroom Formation" *52nd Annual Mushroom Industry Conference*. June 14, 2010. University Park, PA.

Conference Presentations

1. **A Stohr** and **BM Woolston**. "Syntrophic Consortia Enables *Clostridium ljungdahlii* Growth under Microaerobic Conditions " *AICHE*. Boston. Nov. 11, 2021
2. PA Sanford, KO Hoyt and **BM Woolston**. "Establishing *Eubacterium limosum* as a Model Methylophilic Acetogen " *AICHE*. Boston. Nov. 8, 2021
3. SM Bloom, NA Mafunda, **BM Woolston**, MR Hayward, JF Frempong, J Xu, A Mitchell, X Westergaard, JK Rice, N Choksi, EP Balskus, CM Mitchell, DS Kwon. "Combining standard bacterial vaginosis treatment with cystine uptake inhibitors to block growth of *Lactobacillus iners* is a potential target for shifting the cervicovaginal microbiota towards health-associated *Lactobacillus crispatus*-dominant communities" *IDWeek*. Virtual Conference. October 21-25, 2020
4. **BM Woolston** DF Emerson, DH Currie, and G Stephanopoulos. "Development and Application of a CRISPRi System for the Syngas-Fermenting Microbe *Clostridium ljungdahlii*." *AICHE Annual Meeting*. October 30, 2017
5. **BM Woolston**, T Roth, I Kohale, DR Liu, and G Stephanopoulos. "Development of a Formaldehyde Biosensor and its Application to Engineering of Methanol Metabolism in *E. coli*." *AICHE Annual Meeting*. October 31, 2017
6. **BM Woolston**, JR King, M Reiter, B Van Hove, and G Stephanopoulos. "Engineering *E. coli* to consume methanol." *AICHE Annual Meeting*. November 2, 2017
7. **BM Woolston** and G Stephanopoulos. "Synthetic Methylophilicity: Understanding the bottlenecks." *ARPA-E REMOTE Meeting*. February 15, 2017. Houston, TX.
8. **BM Woolston**, DF Emerson, DH Currie, and G Stephanopoulos. "Using *Clostridium ljungdahlii* to enhance heterotrophic carbon yields." *AICHE Annual Meeting*. November 15, 2016. San Francisco, CA.
9. **BM Woolston** and G Stephanopoulos. "Engineering *C. ljungdahlii* for Fuels and Chemicals Production." *ARPA-E REMOTE Meeting*. January 21, 2016. LaJolla, CA.
10. **BM Woolston**, DF Emerson, and G Stephanopoulos. "Methane-Derived Biofuels: Choosing Among Options." *AICHE Annual Meeting*. November 8, 2013. San Francisco, CA.
11. **BM Woolston**, H Rismani, E Vasile, and G Stephanopoulos. "A Flow Cytometry Method for Optimizing Transformation Conditions and Assessing Nuclease Activity in Bacteria". November 6, 2013. San Francisco, CA.
12. **BM Woolston**, C Schlagnhauer, WR Curtis, and CP Romaine. "Toward the Development of a Mushroom-Based Platform for Large-Scale Production of Heterologous Protein." *AICHE Regional Student Conference*

Paper Competition. April 7, 2010. Baltimore, MD.

Poster Presentations

1. **KO Hoyt** and BM Woolston "Investigation of Co-Substrate Utilization by *Eubacterium limosum* for Biofuel Applications" *AIChE*. Nov. 8, 2021. Boston, MA.
2. **MT Fernez** and BM Woolston "Development of a Transcriptional Biosensor for Interrogating the Role of Hydrogen Sulfide in IBD Onset" *AIChE*. Nov. 8, 2021. Boston, MA.
3. **BM Woolston** "*Clostridium ljungdahlii* as a Platform for Syngas Bioconversion." *CCNET*. February 11-12, 2020. Nottingham, UK.
4. **BM Woolston**, M Reiter, JR King, and G Stephanopoulos. "Engineering *Escherichia coli* to Consume Methanol." *AIChE Annual Meeting*. November 15, 2016. San Francisco, CA.
5. DF Emerson, **BM Woolston**, DH Currie, and G Stephanopoulos. "Nitrate reduction occurs simultaneously to growth of *Clostridium ljungdahlii* on CO₂ and H₂." *Clostridium XIV*. August 29. Hanover, NH.
6. **BM Woolston**, DF Emerson, DH Currie, and G Stephanopoulos. "Toward high-yield production of 3-hydroxybutyric acid (3HB) in the acetogen *Clostridium ljungdahlii*". *Gordon Research Conference on C1 Metabolism*. August 4, 2016. Waterville Valley, NH.
7. JR King, **BM Woolston**, and G Stephanopoulos. "Plasmid transfer and genetic engineering in *Thiobacillus denitrificans*". *Gordon Research Conference on C1 Metabolism*. August 4, 2016. Waterville Valley, NH.
8. **BM Woolston** and G Stephanopoulos. "Evaluation of MCR-Based Methane Bioconversion." *ARPA-E REMOTE Meeting*. January 21, 2016. LaJolla, CA.
9. **BM Woolston**, DH Currie, and G Stephanopoulos. "Engineering *C. ljungdahlii* for Fuels and Chemical Production." *ARPA-E REMOTE Meeting*. January 21, 2016. LaJolla, CA.
10. **BM Woolston**, DF Emerson, A Kumar, and G Stephanopoulos. "Evaluation of Biosynthetic Pathways for Conversion of Natural Gas to Liquid Fuels". *Metabolic Engineering X*. June 17, 2014. Vancouver, CA.
11. **BM Woolston**, DH Currie, H Rismai, DF Emerson, and G Stephanopoulos. "Development of Genetic Tools for the Metabolic Engineering of the Thermophilic Acetogen *Moorella thermoacetica*". *Metabolic Engineering X*. June 16, 2014. Vancouver, CA.
12. S Chakraborty, P Hu, H Rismai, A Silverman, **BM Woolston**, and G Stephanopoulos. "Gas-To-Liquid Biofuels using a Two-Stage Fermentation System". *MIT Energy Night*. October 19, 2012. Cambridge, MA.

Professional Membership

- American Institute of Chemical Engineers
- American Chemical Society
- American Association for the Advancement of Science