# Salvador Buse
## Bioengineering PhD Candidate at Caltech

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## Education

**California Institute of Technology (Caltech)**                                        *Pasadena, California*

PhD Candidate in Bioengineering                                                          *Sep 2020 -*

- Theoretical and experimental study of programmable pattern formation in neuromorphic molecular systems
- Funding 1st year: graduate research fellowship from Caltech
- Funding 2nd — 5th years: OpenPhilanthropy Biosecurity Fellowship, covering stipend and fees
- Courses 1st year: data analysis and statistical inference in Python, biomolecular computation, mathematical biology
- Courses 2nd year: networks of relations, probability and stochastic processes, machine learning theory, physical biology of the cell

**University of Cambridge, Trinity College**                                             *Cambridge, UK*

BA and MSci in Natural Sciences – First Class, 76%                                        *Oct 2016 - Jul 2020*

- Part III in Systems Biology (courses in mathematical modelling, biological networks, and synthetic and executable biology)
- Part II in Chemistry (courses in organic, biological, theoretical, and physical chemistry, molecular biology, and mathematics)

## Research Experience

**California Institute of Technology (Caltech)**                                          *Pasadena, California*

PhD Student, Erik Winfree Lab                                                             *Sep 2020 -*

- My main interests are in pattern formation and self-organisation. Motivated by morphogenesis in biology, and using differentiable programming methods inspired by work in neural cellular automata, I study how we can program pattern formation in reaction-diffusion systems, and how we can design new heterogeneous phases in liquid-liquid phase separation systems. Received a grant from the Amazon-Caltech AI4Science Initiative to run reaction-diffusion simulations.

**MRC Laboratory of Molecular Biology**                                                   *Cambridge, UK*

Master's Thesis Student, Jason Chin Lab                                                   *Nov 2019 - Apr 2020*

- To enable bacteria to make proteins containing unnatural amino acids, the Chin lab built 'Syn61', an *E. coli* whose genome uses only 61 of 64 codons, and is the largest yet synthesised. This works by 'recoding': synonymously replacing all instances of certain codons. I found that Syn61 still contains some recoded codons, and studied their implications for future recoded genomes.

Medical Research Council Fellowship Student, Jason Chin Lab                               *Jun 2019 - Sep 2019*

- In Syn61, recoded codons are 'blank': they do not encode natural amino acids, so can be assigned to unnatural amino acids. To enable this, I deleted the tRNAs recognising the recoded codons and found the new Syn61 strain to be viable, but less fit.

**Stanford University, Chemical and Systems Biology**                                      *Palo Alto, California*

Summer Research Intern, Jim Ferrell Lab                                                   *Jun 2018 - Aug 2018*

- Studied the role of an APC/C subunit in cell cycle regulation.

**University of Cambridge, Physiology Department**                                         *Cambridge, UK*

Summer Research Intern, Bill Harris Lab                                                   *Jul 2017 - Sep 2017*

- Collected data and wrote code to study the role of nuclear migration in retinal development.

## Teaching Experience

**Teaching Assistant: Caltech BE / CS 191 a and b, Biomolecular Computation**              *Jan-Jun 2022, 2023, 2024*

- This course is taught by Erik Winfree and explores models of computation, from Turing machines to DNA strand displacement circuits. The emphasis is on understanding how chemical reactions can compute, and how we can use this to explain natural processes and design algorithms in physical systems. Part b of the class focuses on neural computation in chemical systems. I hold office hours, lead discussions, and grade assignments, and gave a lecture on computing with bulk (ODE) models of chemical reactions.

**Teaching Fellow: Harvard Mini-Course on Computation**                                    *Jan 2022*

- Chi-Ning Chou, a Harvard PhD student, arranged this open-access bootcamp as an introduction to theoretical computer science, with three daily lectures over two weeks. Modules explored mathematical, physical, and biological models of computation. I helped to answer student questions, and gave a talk on computing with chemistry, recorded here.

## Leadership and Mentoring Experience

**Mentor: Schmidt Academy for Software Engineering**                                       *Jun 2024 - Jun 2025*

- I am mentoring a recent Caltech graduate on a software engineering project related to my reaction-diffusion research. I was involved in designing the project and writing the funding proposal.

**Mentor: Caltech Undergraduate Senior Theses**                           *Sep 2022 - Jun 2024*

- I have helped to mentor and advise two Caltech undergraduates writing their senior theses in the Winfree lab. Both had previously interned in the lab, and continued their projects, respectively on chemical Boltzmann machines and energy-based probabilistic inference, and on constraint satisfaction problems in surface-based models of chemistry.

**Mentor: Caltech Summer Undergraduate Research Fellowships**             *Jun - Sep 2021, 2022, 2023*

- I have mentored four Caltech undergraduates and one external student over the course of three summers. Their projects included work on constraint satisfaction problems in different models of chemistry, chemical neural networks, and liquid-liquid phase separation.

**Cambridge University Scientific Society**                                *Cambridge, UK*

Co-President                                                              *Mar 2018 - Mar 2019*

- Arranged a lecture series featuring 15 scientists, and co-chaired a research internships event. Helped to renew our relationship with Oxford's Science Society, and jointly arranged a formal dinner in Cambridge and a field trip to the London Natural History Museum.

**Trinity College Science Society**                                       *Cambridge, UK*

President                                                                 *Mar 2017 - Mar 2018*

- Arranged a weekly lecture series featuring 17 scientists, including Sir Paul Nurse & Dame Ottoline Leyser. Organised a research internships event, which now occurs annually, and a symposium showcasing research at Trinity.
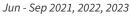
# Publications

- Chalk C., **Buse S.**, Shrinivas K., Murugan A., Winfree E. (Sep 2024). Learning and Inference in a Lattice Model of Multicomponent Condensates. Proceedings of DNA30. DOI: 10.4230/LIPIcs.DNA.30.5

- Alexanian T., **Buse S.**, Grimm S., Siddique M., Hau S., Millett, P. (Apr 2023). A Model Compliance Regime for the Biological Weapons Convention. DOI: 10.2139/ssrn.4430388

- Robertson W., Funke L., De La Torre D., Fredens J., Elliot T., Spink M., Christova Y., Cervettini D., Boge F., Liu K., **Buse S.**, Maslen S., Salmond G., Chin J. (Jun 2021). Sense codon reassignment enables viral resistance and encoded polymer synthesis. Science. DOI: 10.1126/science.abg3029

- Azizi A., Herrmann A., Wan Y., **Buse S.**, Keller P. J., Goldstein R., & Harris W. A. (Oct 2020). Nuclear crowding and nonlinear diffusion during interkinetic nuclear migration in the zebrafish retina. eLife. DOI: 10.7554/eLife.58635

# Talks

- 19th September, 2024 at the 30th International Conference on DNA Computing and Molecular Programming. *Developmental Pattern Formation in Neural Reaction-Diffusion systems*.

- 9th January, 2024 to the Alan Turing Institute (online). *Growing Arbitrary, Stable Patterns with Neural Reaction-Diffusion*.

# Profile

I'm interested in using synthetic biology to understand life and build technologies which benefit humanity. Earlier, I won a Silver Medal at the International Biology Olympiad in 2016, and won Gold Medals in the national Physics, Chemistry, and Biology Olympiads in 2015 & 16. I love to travel and am fascinated by world history, and am lucky enough to have visited more than 40 countries.