Pablo Cárdenas R.

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I develop experimental and computational methods to study infectious disease across scales, from the molecular to the epidemiological. I will use these tools to understand and teach host-pathogen biology and evolution in a bottom-up, quantitative, and predictable manner.

I foster dedicated teaching and mentorship practices
to build student-oriented, inclusive training environments in science.

Education

Massachusetts Institute of Technology (MIT) — Cambridge, MA, USA **Sep 2018 – 2024 (exp.)**
PhD Candidate, Department of Biological Engineering; Advisor: Jacquin C. Niles (GPA: 5.0/5.0)
Graduate Teaching Certificate, MIT Teaching and Learning Lab (received 2023)

Universidad de los Andes (Uniandes) — Bogotá, Colombia **Mar, 2018**
Bachelor of Science *Summa Cum Laude* in Microbiology, minor in Bioinformatics (GPA: 4.84/5.0)

Research

Department of Biological Engineering (BE), MIT — Cambridge, MA, USA
Graduate Research Assistant, Niles Lab **Sep 2018 – ongoing**

- → Created an epidemiological modeling framework for pathogen population genetics and evolution, and applied it to the study of pathogen evolution across fitness valleys (self-led collaboration)
- → Designing molecular and computational tools for transcriptional control, functional genetics, systems biology, and drug discovery in the malarial parasite *Plasmodium falciparum* (Prof. Jacquin C. Niles)
- → Conducted preliminary research and contributed to an NIH R01 grant submission on *P. falciparum* acetyl-coA synthase multi-omics and biology (Profs. Jacquin C. Niles; Dyann Wirth, Harvard SPH)
- → Helped adapt and test in malaria parasites a system for sensing and controlling gene expression (Prof. Katie Galloway, Chemical Engineering)
- → Helped model, construct, and test a control system for managing a shared cell resource in genetic circuits (Prof. Domitilla Del Vecchio, Mechanical Engineering)
- → Designed a mathematical model to guide *in vitro* studies of the efficacy and dynamics of a synthetic probiotic system for prevention of gut dysbiosis (Prof. James J. Collins)

Department of Systems Biology, Harvard Medical School — Boston, MA, USA
Visiting Undergraduate Researcher, Paulsson Lab **Feb – Jul 2018**

- → Helped develop computational workflows for analysis of single-cell imaging (Prof. Johan Paulsson)
- → Constructed and applied microfluidic systems to study bacterial physiology and persister formation

Eligo Bioscience, S.A. — Paris, France
Research Intern in Synthetic Biology, Eligo Bioscience **Aug 2017 – Jan 2018**

- → Screened libraries of synthetic phage candidates against bacterial strains (supervisor Dr. Jesús Fernández R.)
- → Created DNA constructs and bacterial strains for phage production using CRISPR-Cas9 editing

Mathematical & Theoretical Biology Institute, Arizona State University — Tempe, AZ, USA
Visiting Undergraduate Researcher, MTBI (now QRLSSP) **Jun – Jul 2017**

- → Created a 3D, spatially explicit computational model of bacterial resistance to antibiotics in a biofilm

Department of Biological Engineering, MIT — Cambridge, MA, USA
Visiting Undergraduate Researcher, Niles Lab **May – Aug 2016**
→ Assembled CRISPR-Cas9 constructs for gene editing in the malaria parasite (Prof. Jacquin Niles)
→ Carried out a computational genome-wide scan and analysis of Cas9 and Cas12a sites in *P. falciparum*

Department of Biological Sciences, Uniandes — Bogotá, Colombia
Undergraduate Researcher, CIMIC and BCEM Labs **May 2015 - Aug 2017**
→ Designed and experimentally tested an ODE model of phage-host dynamics (Prof. Martha Vives)
→ Applied Hidden Markov Models to identify phage in human gut metagenomes (Prof. Alejandro Reyes)

Publications

Peer-reviewed research: **Contributed equally to the work* *†Corresponding author*

Genomic epidemiological models describe pathogen evolution across fitness valleys **2022**
P. Cárdenas†, V. Corredor, M. Santos-Vega
Science Advances. doi: 10.1126/sciadv.abo0173

GeneTargeter: automated, in silico *design for genome editing in the malaria parasite, P. falciparum* **2022**
P. Cárdenas, L.Y. Esherick, G. Chambonnier, S. Dey, C.V. Turlo, A.S. Nasamu, J.C. Niles†.
The CRISPR Journal. doi: 10.1089/crispr.2021.0069

Preventing antibiotic-induced dysbiosis with an engineered live biotherapeutic **2022**
A. Cubillos-Ruiz, M.A. Alcantar, N.M. Donghia, **P. Cárdenas**, J. Ávila-Pacheco, J.J. Collins†.
Nature Biomedical Engineering. doi: 10.1038/s41551-022-00871-9

Resolving drug selection and migration in an inbred South American Plasmodium falciparum *population with identity-by-descent analysis* **2022**
M. Carrasquilla*, A.M. Early*, A.R. Taylor, A. Knudson, D.F. Echeverry, T.J.C. Anderson, E. Mancilla, S. Aponte, **P. Cárdenas**, C.O. Buckee, J.C. Rayner, F.E. Sáenz, D.E. Neafsey†, V. Corredor†
PLoS Pathogens. doi: 10.1371/journal.ppat.1010993

dCas9 regulator to neutralize competition in CRISPRi circuits **2021**
H.-H. Huang*, M. Bellato*, Y. Qian, **P. Cárdenas**, L. Pasotti, P. Magni, D. Del Vecchio†.
Nature Communications; doi: 10.1038/s41467-021-21772-6.

Host resistance, genomics and population dynamics in a Salmonella *Enteritidis and phage system* **2019**
A.V. Holguín, **P. Cárdenas**, C. Prada-Peñaranda, L. Rabelo Leite, C. Buitrago, V. Clavijo, G. Oliveira, P. Leekitcharoenphon, F. M. Aarestrup, & M.J. Vives†
Viruses. doi: 10.3390/v11020188

Preprints: *†Corresponding author*

Using Big Data to Inform decision-making on COVID-19 in Colombia: a framework of micro-territorial experimental design for urban interventions and policy evaluation **2022**
A. Feged-Rivadeneira†, F. González-Casabianca, A. Parra-Salazar, J. Salcedo-Ortiz, F. Andrade-Rivas, **P. Cárdenas**, A. Morales, J.M. Damelines-Pareja, D.S. Ríos-Oliveros, C. Salazar, S. Usma, M. Muñoz, L.H. Patiño, N. Ballesteros, J.D. Ramírez, A. Ángel, T. Rodríguez, J. Cascante, H. Galindo-Silva, S. Majerowicz, & V. Corredor.
In review. doi:10.21203/rs.3.rs-2148358/v1

Technical reports: **Contributed equally to the work*

Cheating the cheaters: spatial dynamics in the evolutionary stability of antibiotic resistance. **2018**
D. Akman*, L. Callaway III*, **P. Cárdenas***, J. Nieve-Silva*, J. Chen, B. Espinoza, L. Arreola, & C. Castillo-Garsow
Technical report available from MTBI, Arizona State University.

Reviews and commentary:

Starting from scratch: a workflow for building truly novel proteins **2021**
P. Cárdenas. *Synthetic Biology 6*(1), ysab005, doi: 10.1093/synbio/ysab005

Designing for durability: new tools to build stable, non-repetitive DNA **2020**
P. Cárdenas. *Synthetic Biology, 5*(1), ysaa016, doi: 10.1093/synbio/ysaa016

Research Talks & Seminars

Invited talks:

Genomic models describe epidemiological determinants of pathogen evolution **20 Apr 2023**
1 h invited seminar for the Max Planck Institute for Infection Biology, Berlin, Germany (online)

Opqua, a tool for modeling genomic epidemiology **20 Feb 2023**
1 h invited seminar for Novodan Ltd. & the Department of Biotechnology and Biomedicine, Danmarks Tekniske Universitet (DTU), Kgs. Lyngby, Denmark (online)

Opqua, a tool for genomic epidemiological modeling **13 Jan 2023**
1 h invited seminar at Global Pervasive Computational Epidemiology NSF Expedition in Computing, University of Virginia Biocomplexity Institute (online)

Computational models describe parasite evolution across fitness valleys **17 Oct 2022**
30 min invited seminar for the Boston Area Parasitology Seminar (Cambridge, MA, United States)

Contributed talks:

Genomic models describe epidemiological determinants of pathogen evolution **30 Jul 2023**
20 min contributed talk at the Gordon Research Conference seminar on Dynamics of Ecological and Evolutionary Change (forthcoming, Smithfield, RI, United States)

Genomic models describe epidemiological determinants of pathogen evolution **28 Feb 2023**
20 min contributed talk at the Society for Mathematical Biology's conference on Mathematical Epidemiology and Population Dynamics, Ecology, & Evolution (SMB Epi-PDEE) (online)

Teaching, Mentorship, & Community

Teaching and Learning Lab, MIT — Cambridge, MA, USA

Teaching Development Fellow, MIT Teaching and Learning Lab **Sep 2022 – Jun 2023**
→ Developing resources to support teaching and mentorship skills for graduate students across MIT
→ Designing and conducting teaching and mentorship workshops and recitation class observations

Teaching Track Certificate, MIT Teaching and Learning Lab **Jul 2022 – Nov 2022**
→ Certified courses on Subject Design, Lesson Planning, Microteaching, and Inclusive Teaching
→ Designed and rehearsed an original course, "Fighting, Harnessing, and Reshaping Evolution"

Department of Biological Engineering (BE), MIT — Cambridge, MA, USA

Guest Lecturer in Evolution and Malaria Biology and Genomics **2022**
→ Prepared and taught a lecture on malaria biology and genomics for a course of ≈30 undergraduates; course MBIO2304 *Parasitology* at Uniandes taught by Prof. Camila González (Jan 2022)
→ Prepared and taught a lecture on designing for evolution in infectious disease for a course of ≈15 senior undergraduates; course 20.380 *Senior Design Course in Biological Engineering* taught by Prof. Christopher Voigt, Instructors Dr. Sean Clarke and Dr. Prerna Bhargava (Nov 2022)

Coding Fellow, Biological Engineering Data Lab **Mar 2020 – ongoing**
→ One of the inaugural fellow at the Biological Engineering Data Lab, created to support computational teaching and learning in bioscience at MIT during the COVID-19 pandemic lockdown and beyond
→ Providing 1-on-1 coaching for programming and biological data analysis to undergraduates, graduate students, and postdocs; >80 sessions done to date

- → Designed and conducted workshops for 10–40 students on Introductory Python, Ordinary Differential Equation Modeling, and Statistical Curve Fitting (taught each one twice)
- → Mentored an undergraduate student through a semester-long individual project in SARS-CoV-2 phylogenomics and epidemiology as an Experiential Learning Opportunity course (student: Dawit Girma; expecting to graduate in 2024)

Teaching Assistant, Principles of Molecular Bioengineering **Sep – Dec 2019**

- → Helped design and grade assignments and exams, conducted review lecture sessions, and provided one-on-one tutoring for 40 students (mostly graduate students) as one of three course teaching assistants (Prof. Ernest Fraenkel and Prof. Alan Jasanoff)
- → Received an overall instructor rating of 6.9/7.0 (18 responses) with student feedback including "*really tried to help us understand not just get the problem set done*", "*has a fantastic grasp of the material*", and "*hands-down one of the best TAs I have ever had*"
- → Awarded best Fall 2019 teaching assistant at MIT BE (out of 25) based on student and faculty input

Graduate Research Assistant, Niles Lab **Mar 2019 – ongoing**

- → Trained incoming postdoc Dr. Shubhra Saha in parasite tissue culture and molecular cloning
- → Mentored three first-year graduate students in 6- or 8-week experimental research rotation projects, varying from experienced experimental molecular biologists to students with limited wet lab experience; students: Mirna Kheir Gouda (MIT Biological Engineering; now in Prof. Christopher Voigt's group), Allison Rojas (MIT-Harvard Health Science and Technology, committing to a lab in May 2023), Alyssa Haynes (MIT Microbiology, now in Prof. Tami Lieberman's group)

Peer Counselor, BE Resources for Easing Friction and Stress (REFS) **Jan 2019 – Jun 2023**

- → Providing 1-on-1 confidential counseling for graduate students at MIT BE as a member of BE REFS
- → Co-developed and conducted workshops on finding and joining research labs, managing expectations as a teaching assistant, graduation, and job search
- → Working with the MIT BE Department leadership, Graduate Student Board, and BE working groups on Diversity, Equity, & Inclusion to improve student experience and PhD program policy
- → Underwent a week-long training course on conflict coaching and support resources for grad students, including training from the office of the Institute Discrimination & Harassment Response (IDHR)

Department of Biomedical Engineering, Uniandes — Bogotá, Colombia

Teaching Assistant, Quantitative Human Physiology I and II **Jan – Dec 2016**

- → Designed and graded assignments, provided review sessions, and taught main lectures during two professor absences for ≈100 students (Prof. Juan Manuel Cordovez)

Department of Student Affairs, Uniandes — Bogotá, Colombia

Teaching Assistant, Social Practice Program **Jul – Dec 2015**

- → Trained, guided, and evaluated 60 Uniandes students serving as tutors for low-income high school students in Bogotá (Instructors David Parga and María del Pilar Pérez)

Volunteer Tutor, Social Practice Program **Jan – Jun 2015**

- → Provided academic tutoring and review sessions three hours a week for a group of 10 low-income high school students in Bogotá
- → Designed a semester-long tutoring curriculum to reinforce high school classes and prepare students for the ICFES-Saber 11 state exam

Department of Biological Sciences, Uniandes — Bogotá, Colombia

Teaching Assistant, Parasitology Laboratory **Jan – Jun 2015**

- → Provided review sessions and tutoring, helped develop and grade assignments, and prepared and presented microscopy slides for various human pathogens (Prof. Camila González)

Association of Students with Financial Aid (ANDAR), Uniandes — Bogotá, Colombia

Co-leader, First Year Mentorship Program **Jul 2016 – May 2017**

→ Provided individual tutoring and calculus review sessions for Uniandes students with financial aid
→ Designed integration and counseling activities, helped develop student housing networks
→ Coordinated up to eight teams of Uniandes students mentoring 20 incoming students receiving financial aid through their first semester

First Year Mentor & Academic tutor **Jul – Dec 2015**

→ Mentored 20 first-year students receiving financial aid through their first semester (with a second co-mentor), helping navigate access to academic, financial, and social resources when needed

Awards & Fellowships

Graduate:

Teaching Development Fellowship (Teaching and Learning Lab, MIT) **Jul 2022**
Awarded by competition to 21 applicants across all MIT to develop training materials and support for graduate student teaching (2000 USD)

Social Justice in Infectious Disease Award (EEID Conference) **May 2022**
Travel award for applicants to the 2022 Ecology and Evolution of Infectious Disease Conference (Atlanta, GA) combining research and social justice in their work (lodging, food, and registration + 500 USD in travel costs)

S. & P. Eurnekian Biotechnology Fellowship (Office of Graduate Education, MIT) **Apr 2021**
Awarded by competition to one MIT student pursuing research in biotechnology per year (1 semester tuition, insurance, stipend; ≈43,000 USD)

Teaching Assistant Excellence Award (Department of Biological Engineering, MIT) **Dec 2020**
Awarded to the best teaching assistant in the department during the Fall 2019, based on student and faculty feedback (1000 USD)

Viterbi Graduate Fellowship (Department of Biological Engineering, MIT) **Sep 2018**
Awarded at admission to select students in the MIT Biological Engineering PhD program (1 semester tuition, insurance, stipend; ≈42,000 USD)

Undergraduate:

Summa Cum Laude (Faculty of Sciences, Uniandes) **Mar 2018**
Awarded to top 1% of historic graduates in the Faculty of Sciences who also demonstrate strong community service

Best Saber Pro Graduate National Exam, Biology (Ministry of Education, Colombia) **Nov 2017**
Awarded to nation-wide top scores on the Colombian ICFES-Saber Pro exam for university graduates

Ramón de Zubiría Awards (4) (Uniandes) **Nov 2015–Oct 2017**
For the highest cumulative GPA, won in Microbiology (1x) and Biomedical Engineering (3x)

Excellence Distinction (8) (Uniandes) **Mar 2014–Oct 2017**
For the highest semester GPA in Microbiology (4x), Biomedical Engineering (1x), and Biology (3x)

Alberto Magno Award (Uniandes) **Oct 2013**
Given to the top ten application scores among admitted students university-wide in a semester