

Pablo Catalán

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1 Education

- 2017:** Ph.D. in Mathematical Engineering, Universidad Carlos III de Madrid (UC3M)
Graduated *cum laude*, awarded extraordinary prize
Thesis: [Models in molecular evolution: the case of \$t_{cy}\$ LIFE](#)
- 2017:** B.Sc. in Mathematics, Universidad Nacional de Educación a Distancia (UNED)
GPA: 9.5/10 [Studied concurrently with Ph.D.]
- 2012:** M.Sc. in Modeling and Physics of Complex Systems, Universidad Rey Juan Carlos de Madrid
GPA: 9.75/10
- 2011:** B.Sc. in Biology, Universidad Complutense de Madrid (UCM)
GPA: 9.57/10, extraordinary graduation award

2 Work Experience

2.1 Positions Held

- Mar 2025—present:** Associate Professor
Department of Mathematics, UC3M
- Sep 2019—Mar 2025:** Assistant Professor
Department of Mathematics, UC3M
- Sep 2018—Sep 2019:** Ramón Areces Postdoctoral Researcher
Biosciences, University of Exeter
Research topic: Mathematical models of antibiotic resistance
Supervisor: Prof. Robert Beardmore
- Apr 2017—Jul 2018:** Postdoctoral Researcher
Department of Mathematics, UC3M
Research topic: Models of molecular evolution
Supervisor: Prof. José A. Cuesta
- Mar 2016—May 2016:** Visiting Researcher (Pre-doctoral stay)
Biosciences, University of Exeter
Research topic: Mathematical models of antibiotic resistance
Supervisor: Prof. Robert Beardmore
- Mar 2015—Jul 2015:** Visiting Researcher (Pre-doctoral stay)
Institute of Evolutionary Biology and Environmental Studies, University of Zurich
Research topic: Models of molecular evolution
Supervisor: Prof. Andreas Wagner

Dec 2012—Feb 2017: FPI Pre-doctoral Researcher
Department of Mathematics, UC3M
Research topic: Models of molecular evolution
Supervisor: Prof. José A. Cuesta

Oct 2008—Jun 2011: Research Assistant
Department of Ecology, UCM
Research topic: Resource allocation strategies in *Cistus ladanifer*
Supervisor: Dr. Juan Antonio Delgado Sáez

2.2 Awards and Fellowships

Sep 2023 Innovation Prize at the [Vivli AMR Surveillance Open Data Re-use Data Challenge](#) (€10,000).

Nov 2019 Juan de la Cierva Postdoctoral Contract (declined).

Oct 2018 Ramón Areces Postdoctoral Fellowship: Two-year research fellowship at the University of Exeter (€52,800).

Jan 2018 Best Poster Award at the 6th Meeting of the Spanish Society of Evolutionary Biology (SESBE VI, Palma de Mallorca).

Mar 2016 Short-stay grant for a 60-day research visit to Robert Beardmore's lab at the University of Exeter (€4,500).

Mar 2015 Short-stay grant for a 120-day research visit to Andreas Wagner's lab at the University of Zurich (€12,300).

Dec 2012 FPI Pre-doctoral Contract: Four-year research contract for Ph.D. studies at UC3M under the supervision of José A. Cuesta (€88,000).

Sep 2010 One-year research collaboration grant at UCM (€1,000).

Sep 2008, Sep 2009 Excellence Scholarship from the Community of Madrid for top academic performance (€4,500, awarded twice).

3 Teaching Experience

Over 700 hours of teaching experience across seven academic years, all conducted in English. My average teaching evaluation score is **4.44** (out of 5), placing me in the top quartile among all UC3M faculty evaluations. I have been awarded a recognized five-year teaching period (2015/2016 to 2021/2022).

3.1 In-Person Teaching

Mathematics (theory and problems) 6 ECTS credit course taught to first-year students in the Neuroscience program at UC3M. Designed the syllabus for this new degree program. Academic year 2024-2025.

Calculus II (theory and problems) 6 ECTS credit course taught to first-year students in Aerospace Engineering and Telecommunications Engineering at UC3M. Academic years 2023-2024 and 2024-2025.

Calculus I (theory and problems) 6 ECTS credit course taught to first-year students in various engineering degrees at UC3M. Academic years 2019-2020 to 2022-2023. I secured an educational innovation project, "Calculus Made Easy," which became the foundation for an online Calculus course on the OCW-UC3M platform.

Advanced Mathematics (theory and problems) 6 ECTS credit course taught to second-year students in various engineering degrees at Universidad Carlos III de Madrid. Academic years 2020-2021 to 2022-2023.

Linear Algebra (problems) 6 ECTS credit course taught to first-year students in various engineering degrees at Universidad Carlos III de Madrid. Academic years 2015-2016, 2017-2018, 2019-2020, and 2020-2021.

3.2 Online Courses

Calculus I An online Calculus I course (in English) hosted on the Open Course Ware platform of Universidad Carlos III de Madrid (OCW-UC3M). I created numerous instructional videos explaining theoretical concepts in Calculus I and solved hundreds of problems applying these concepts. These videos are available [on my YouTube channel](#) and form the core of the online course.

3.3 Supervision of Ph.D. Theses, Bachelor's, and Master's Theses

I have supervised four Bachelor's Theses (TFGs) at UC3M. I have also supervised four Master's Theses (TFMs), two of them co-supervised with Saúl Ares. Currently, I am supervising two TFGs at UC3M, one TFM from the Master's in Applied and Computational Mathematics at UC3M, and co-supervising a Ph.D. thesis with Saúl Ares. Our Ph.D. student, Javier Molina, has recently been awarded [a competitive predoctoral contract under UC3M's internal research program](#).

4 Research Experience

My research has been published in 19 scientific articles indexed in the Journal Citation Reports (JCR), of which 11 have been published in first-quartile journals in their category (8 in the first decile) and 4 in the second tercile. Additionally, I have published two articles in non-indexed journals and one book chapter. According to Google Scholar (as of 21/01/2025), my articles have been cited a total of 407 times, corresponding to 63.8 citations per year over the last five years. My h-index is 12. I have been awarded a recognized research six-year period (2013-2019).

4.1 Scientific Publications

[An asterisk indicates shared first authorship. IF denotes Impact Factor, and R denotes Ranking, both from JCR. The quartile (Q), tercile (T), and decile (D) are also indicated.]

21. CATALÁN, P.*, Díaz-Colunga, J.*, San Román, M.*, Arrabal, A.* and Sánchez, A. **2024**. [Full factorial construction of synthetic microbial communities](#). *eLife* **13**, RP101906.
[IF: 6.4 (2023), R: 8/109 (Q1, T1, D1) (BIOLOGY)]
20. Henao, L., Ares, S. and CATALÁN, P. **2024** [Mathematical Models of the Arabidopsis Circadian Oscillator](#). *Biophysica* **4**, 267.
[not indexed]
19. Zhou, Q.*, CATALÁN, P.*, Bell, H.*, Baumann, P., Evans, R., Yang, J., Zhang, Z., Zappala, D., Zhang, Y., Blackburn, G. M., He, Y. and Jin, Y. **2023**. [An Ion-Pair Induced Intermediate Complex Captured in Class D Carbapenemase Reveals Chloride Ion as a Janus Effector Modulating Activity](#). *ACS Central Science* **9**, 2339.
[IF: 12.7, R: 24/230 (Q1, T1) (CHEMISTRY, MULTIDISCIPLINARY)]
18. CATALÁN, P., García-Martín, J. A., Aguirre, J., Cuesta, J. A. and Manrubia, S. **2023**. [Entropic contribution to phenotype fitness](#). *Journal of Physics A: Mathematical and Theoretical* **56**, 345601.
[IF: 2.0, R:18/60 (Q2, T1) (PHYSICS, MATHEMATICAL), 47/110 (Q2, T2) (PHYSICS, MULTIDISCIPLINARY)]

17. Nieto, C.*, CATALÁN, P.*, Luengo, L. M., Legris, M., López-Salmerón, V., Davière, J. M., Casal, J. J., Ares, S. and Prat. S. **2022.** [COP1 dynamics integrate conflicting seasonal light and thermal cues in the control of *Arabidopsis* elongation.](#) *Science Advances* **8:eabp8412**.
[IF: 13.6, R: 7/73 (Q1, T1, D1) (MULTIDISCIPLINARY SCIENCES)]
16. Manrubia, S., Cuesta, J.A., Aguirre, J., Ahnert, S.E., Altenberg, L., Cano, A.V., CATALÁN, P., Diaz-Uriarte, R., Elena, S.F., García-Martín, J.A., Hogeweg, P., Khatri, B.S., Krug, J., Louis, A.A., Martin, N.S., Payne, J.L., Tarnowski, M.J. and Weiß, M. **2022.** [The long and winding road to understanding organismal construction: Reply to comments on “From genotypes to organisms: State-of-the-art and perspectives of a cornerstone in evolutionary dynamics”.](#) *Physics of Life Review* **42:19-24**.
[IF: 11.7, R: 1/92 (Q1, T1, D1) (BIOLOGY), 4/70 (Q1, T1, D1) (BIOPHYSICS)]
15. CATALÁN, P., Wood, E., Blair, J. M. A., Gudelj, I., Iredell, J. R. and Beardmore, R. **2022.** [Seeking patterns of antibiotic resistance in ATLAS, an open, raw MIC database with patient metadata.](#) *Nature Communications* **13:2917**.
[IF: 16.6, R: 6/73 (Q1, T1, D1) (MULTIDISCIPLINARY SCIENCES)]
14. Manrubia, S., Cuesta, J.A., Aguirre, J., Ahnert, S.E., Altenberg, L., Cano, A.V., CATALÁN, P., Diaz-Uriarte, R., Elena, S.F., García-Martín, J.A., Hogeweg, P., Khatri, B.S., Krug, J., Louis, A.A., Martin, N.S., Payne, J.L., Tarnowski, M.J. and Weiß, M. **2021.** [From genotypes to organisms: State-of-the-art and perspectives of a cornerstone in evolutionary dynamics.](#) *Physics of Life Review* **38:55**.
[IF: 9.833, R: 5/94 (Q1, T1, D1) (BIOLOGY), 5/72 (Q1, T1, D1) (BIOPHYSICS)]
13. Reding, C., CATALÁN, P., Jansen, G., Bergmiller, T., Wood, E., Rosenstiel, P., Schulenburg, H., Gudelj, I. and Beardmore, R. **2021.** [The Antibiotic Dosage of Fastest Resistance Evolution: gene amplifications underpinning the inverted-U.](#) *Molecular Biology and Evolution* **38:3847**.
[IF: 8.8, R: 5/51 (Q1, T1, D1) (EVOLUTIONARY BIOLOGY), 15/175 (Q1, T1, D1) (GENETICS & HEREDITY)]
12. CATALÁN, P., Manrubia, S. and Cuesta, J. A. **2020.** [Populations of genetic circuits are unable to find the fittest solution in a multilevel genotype-phenotype map.](#) *Journal of the Royal Society Interface* **17:20190843**.
[IF: 4.118, R: 19/72 (Q2, T1) (MULTIDISCIPLINARY SCIENCES)]
11. CATALÁN, P., Elena, S. F., Cuesta, J. A. and Manrubia, S. **2019.** [Parsimonious Scenario for the Emergence of Viroid-Like Replicons De Novo.](#) *Viruses* **11:425**.
[IF: 3.816, R: 12/37 (Q2, T1) (VIROLOGY)]
10. García-Martín, J.A., CATALÁN, P., Manrubia, S. and Cuesta, J. A. **2018.** [Statistical theory of phenotype abundance distributions: a test through exact enumeration of genotype spaces.](#) *Europhysics Letters* **123:2800**.
[IF: 1.886, R: 37/81 (Q2, T2) (PHYSICS, MULTIDISCIPLINARY)]
9. Aguirre, J., CATALÁN, P., Cuesta, J. A. and Manrubia, S. **2018.** [On the networked architecture of genotype spaces and its critical effects on molecular evolution.](#) *Open Biology* **8:180069**.
[IF: 3.890, R: 92/299 (Q2, T1) (BIOCHEMISTRY & MOLECULAR BIOLOGY)]
8. CATALÁN, P., Wagner, A., Manrubia, S. and Cuesta, J. A. **2018.** [Adding levels of complexity enhances robustness and evolvability in a multi-level genotype-phenotype map.](#) *Journal of the Royal Society Interface* **15:20170516**.
[IF: 3.224, R: 16/69 (Q1,T1) (MULTIDISCIPLINARY SCIENCES)]
7. CATALÁN, P., Arias, C.F., Cuesta, J. A. and Manrubia, S. **2017.** [Adaptive multiscapes: an up-to-date metaphor to visualize molecular adaptation.](#) *Biology Direct* **12:7**.
[IF: 2.649, R: 21/85 (Q1, T1) (BIOLOGY)]

6. CATALÁN, P., Delgado, J.A., Jiménez, M.D. and Balaguer, L. 2016. Sink strength manipulation in branches of a Mediterranean woody plant suggests sink-driven allocation of biomass in fruits but not of nutrients in seeds. *Acta Physiologiae Plantarum* 38:193.
[IF: 1.364, R: 104/212 (Q2, T2) (PLANT SCIENCES)]
5. Planchuelo, G., CATALÁN, P. and Delgado, J.A. 2016. Gone with the wind and the stream: Dispersal in the invasive species *Ailanthus altissima*. *Acta Oecologica* 73:31-37.
[IF: 1.652, R: 90/153 (Q3, T2) (ECOLOGY)]
4. Planchuelo, G., CATALÁN, P., Delgado, J.A. and Murciano A. 2016. Estimating wind dispersal potential in *Ailanthus altissima*: The need to consider the three-dimensional structure of samaras. *Plant Biosystems*, 151:316-322.
[IF: 1.390, R: 102/212 (Q2, T2) (PLANT SCIENCES)]
3. CATALÁN, P., Seoane, J.M. and Sanjuán, M.A.F. 2015. Mutation-selection equilibrium in finite populations playing a Hawk-Dove game. *Communications in Nonlinear Science and Numerical Simulations* 25:66-73.
[IF: 2.834, R: 5/254 (Q1, T1, D1) (APPLIED MATHEMATICS), 9/101 (Q1, D1) (MATHEMATICS, INTERDISCIPLINARY APPLICATIONS), 2/53 (Q1, D1) (MATHEMATICAL PHYSICS)]
2. Arias, C.F., CATALÁN, P., Manrubia, S.M. and Cuesta, J.A. 2014. *toyLIFE*: a computational framework to study the multi-level organization of the genotype-phenotype map. *Scientific Reports* 4: 7549.
[IF: 5.578, R: 5/57 (Q1, T1, D1) (MULTIDISCIPLINARY SCIENCES)]
1. CATALÁN, P., Vázquez de Aldana, B.R., De las Heras, P., Fernández-Seral, A. and Pérez-Corona, M.E. 2013. Comparing the allelopathic potential of exotic and native plant species on understory plants: are exotic plants better armed? *Anales de Biología* 35: 65-74.
[not indexed]

4.2 Book Chapters

1. Rodríguez-Maroto, G.*, CATALÁN, P.*, Nieto, C., Prat, S. and Ares, S. 2024. Mathematical Modeling of Photo- and Thermomorphogenesis in Plants. En: Chen, M. (Ed.), *Thermomorphogenesis. Methods in Molecular Biology, vol 2795* (capítulo 23). Humana, New York, NY.

4.3 Conference Presentations

11. CATALÁN, P. 2025. Optimization of Sequential Therapies to Maximize Extinction of Resistant Bacteria through Collateral Sensitivity. **XXI GISC Workshop, 31 de Enero de 2025, Madrid (España).**
10. CATALÁN, P. 2024. De biólogo a matemático... and vuelta a biólogo. **XX GISC Workshop, 19 de Enero de 2024, Madrid (España).**
9. CATALÁN, P. 2022. COP1 dynamics integrate conflicting seasonal light and thermal cues in the control of *Arabidopsis* elongation. **IV BioinfoCAM. 20 de Octubre de 2022, Madrid (España).**
8. CATALÁN, P. 2019. Phenotypic bias and evolutionary predictability in a pattern-formation genotype-phenotype map. **CECAM Workshop: From sequences to functions: challenges in the computation of realistic genotype-phenotype maps. 13 al 15 de Marzo de 2019, Zaragoza (España)** (charla invitada).
7. CATALÁN, P. 2019. Phenotypic bias and evolutionary predictability in a pattern-formation genotype-phenotype map. **Colloquium on Predictability and Programmability in Biology. 11 de Febrero de 2019, Madrid (España)** (charla invitada).

6. CATALÁN, P. 2019. Modelling the evolution of antibiotic resistance in *Escherichia coli*. **XV GISC Workshop**, 11 de Enero de 2019, Madrid (España).
5. CATALÁN, P., Manrubia, S. and Cuesta, J.A. 2018. Non-Markovian jumping times and evolutionary irreversibility in a computational genotype-phenotype map. **XXII Congreso de Física Estadística (FISES '18)**. 18 al 20 de Octubre de 2018, Madrid (España).
4. CATALÁN, P. 2016. t_{toyLIFE} , or the importance of being promiscuous. **International Workshop on Genotype-Phenotype Maps 2016 (IWGP 2016)**. 8 al 9 de Septiembre de 2016, Cambridge (Reino Unido) (charla invitada).
3. CATALÁN, P. 2015. t_{toyLIFE} : the complexities of the genotype-phenotype map. **Modelling Biological Evolution 2015 (MBE '15)**, 28 de Abril al 1 de Mayo de 2015, Leicester (Reino Unido) (charla invitada).
2. CATALÁN, P. 2014. t_{toyLIFE} : a toy Universe for gaining insight into biological evolution. **XI GISC Workshop**, 7 de Febrero de 2014, Madrid (España).
1. CATALÁN, P., Fernández-Arias, C. y Cuesta, J. A. 2013. t_{toyLIFE} : a toy Universe for gaining insight into evolution. **4th SESBE Meeting**. 27 al 29 de Noviembre de 2013, Barcelona (España).

4.4 Posters

11. CATALÁN, P., Rodríguez-Maroto, G., Nieto, C., Prat, S. y Ares, S. 2025. Integrating conflicting seasonal light and thermal cues in the control of *Arabidopsis* elongation. **3rd Meeting of the Spanish Society of Complex Systems CS³**. 19 al 21 de Febrero de 2025, Madrid (España).
10. CATALÁN, P., Rodríguez-Maroto, G., Nieto, C., Prat, S. and Ares, S. 2024. Integrating conflicting seasonal light and thermal cues in the control of *Arabidopsis* elongation. **XXIV Congreso de Física Estadística (FISES '23)**. 25 al 27 de Octubre de 2024, Pamplona (España).
9. CATALÁN, P., Manrubia, S. and Cuesta, J. A. 2021. Populations of genetic circuits are unable to find the fittest solution in a multilevel genotype-phenotype map. **EMBO Workshop Predicting Evolution**. 4 al 6 de Junio de 2021, online.
8. CATALÁN, P., Nieto, C., Prat, S. and Ares, S. 2018. A non-linear model to explain how plants integrate light and temperature to decide how much to grow. **XXII Congreso de Física Estadística (FISES '18)**. 18 al 20 de Octubre de 2018, Madrid (España).
7. CATALÁN, P., Manrubia, S. and Cuesta, J. A. 2018. Adding levels of complexity enhances robustness and evolvability in a multi-level genotype-phenotype map. **6th SESBE Meeting**. 17 al 19 de Enero de 2018, Palma de Mallorca (España).
6. CATALÁN, P., Manrubia, S. and Cuesta, J. A. 2017. The evolution of pattern formation in t_{toyLIFE} , a multi-level model of the genotype-phenotype map. **EMBO Conference Quantitative Principles in Biology**. 2 al 4 de Noviembre de 2017. Heidelberg (Germany).
5. CATALÁN, P., Manrubia, S. and Cuesta, J. A. 2017. Evolutionary dynamics on shifting environments suggest new antibiotic therapies. **Gordon Research Conference: Molecular Mechanisms in Evolution**. 11 al 17 de Junio de 2017, Easton (Estados Unidos de América).
4. CATALÁN, P., Fernández-Arias, C. and Cuesta, J. A. 2014. t_{toyLIFE} : un universo de juguete para comprender mejor la evolución. **XIX Congreso de Física Estadística (FISES '14)**. 2 al 4 de Abril de 2014, Ourense (España).
3. CATALÁN, P., Jiménez, M.D., Delgado, J.A. and Balaguer, L. 2011. Variation in sink strength affects size-mediated competition within the crown. **12 th EEF Congress**. 25 al 29 de Septiembre de 2011, Ávila (España).

2. Pérez-Corona, M.E., CATALÁN, P., Fernández-Seral, A., De las Heras, P., Castro-Díez, P. and Vázquez de Aldana, B.R. **2011**. Effect of riverine invasive species in germination and radicle growth of understory species. **12 th EEf Congress. 25 al 29 de Septiembre de 2011, Ávila (España)**.
1. Pérez-Borrero, B., CATALÁN, P., Aguilar, E.Y., Fontecha, G., Trabanino, R., Gallego, F.J., Figueiras, A.M. and Benito, C. **2010**. Identificación con diferentes marcadores moleculares de cepas de *Beauveria bassiana* utilizadas en la lucha biológica contra la broca del café (*Hypothenemus hampei*). **XII Congreso Internacional de manejo integrado de plagas / XX reunión anual de la Sociedad americana de fitopatología (APS-CD). 24 al 27 de Agosto de 2010, Managua (Nicaragua)**.

4.5 Participation in Research Projects

Patterns of Growth and Evolution (PGE). Coordinated project funded by MICINN from 01/09/2023 to 31/08/2026. Coordinator: Saúl Ares. **PI of subproject 1 (CNB):** Saúl Ares (PID2022142185NBC21). **PIs of subproject 2 (UC3M):** Pablo Catalán and Javier Muñoz-García (PID2022142185NBC22). Funding: €150,000 (CNB), €37,000 (UC3M).

Physics of Bacterial and Developing Systems (BADS). Project funded by MICINN (PID2019-109320GB-I00) from 01/06/2020 to 29/02/2024. **PIs:** Saúl Ares and Javier Muñoz. Funding: €52,030.

Biological and Social Complexity (BASIC). Project funded by MICIU (PGC2018-098186-B-I00) from 01/01/2019 to 31/12/2022. **PI:** José A. Cuesta. Funding: €123,783.

Variation, Replication, and Adaptation in Evolutionary Processes (VARIANCE). Project funded by MINECO (FIS2015-64349-P) from 01/06/2016 to 31/05/2019. **PI:** José A. Cuesta. Funding: €59,290.

Evolutionary Dynamic Processes: Viruses, Ecosystems, and Social Behaviors (PRODIEVO). Project funded by MINECO (FIS2011-22449) from 01/01/2012 to 31/12/2014. **PI:** José A. Cuesta. Funding: €39,390.

Modeling and Simulation of Complex Systems (MODELICO). Project funded by the Community of Madrid (S2009/ESP-161), from 01/01/2010 to 31/12/2013. **PI:** Enrique Lomba. Funding: €125,580.

4.6 Software Development as a Result of Research Activity

toyLIFE **toyLIFE** is a model that allows us to simulate evolutionary trajectories in a genotype-phenotype framework inspired by cellular biology. The model simulates cells containing analogs of genes, proteins, and regulatory networks. **toyLIFE** is simple enough for us to understand the microscopic details of evolutionary dynamics, yet complex enough to generate behaviors similar to those observed in biology. The model has been featured in three high-impact publications. Both the model and the code (written in C++) were developed by myself during my doctoral studies.

ATLAS **ATLAS** is an antibiotic resistance database maintained by the pharmaceutical company Pfizer. During my analysis of **ATLAS**, I developed extensive Python code to facilitate result extraction, which is freely available on GitHub.

Hypocotyl This code simulates and fits the hypocotyl growth model I developed with Saúl Ares. Jupyter Notebooks enable easy exploration of the model and the generation of figures to visualize the results.

OXA48 This code simulates and graphically represents the results of a chemical reaction model that describes the inhibition of the OXA-48 enzyme by chlorine. The Jupyter Notebooks provide a detailed explanation of the model creation process and the parameter estimation that best approximates the data.

4.7 Other Contributions

Reviewer for JCR journals, including: *Nature Communications*, *Journal of the Royal Society Interface*, *PLoS Computational Biology*, *Scientific Reports*, *EPL*, *Bulletin of Mathematical Biology*, *Proceedings of the Royal Society B*.

Member of the Interdisciplinary Group on Complex Systems (GISC).

Organizer of joint seminars on evolutionary dynamics, theoretical ecology, and systems biology between UC3M and CNB (2017-present).