Curriculum Vitae

Name- Tirtha Das Banerjee
Gender - Male, **Citizenship** - Indian
Permanent Residency- Singapore
Language- English
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Google Scholar: https://scholar.google.com/citations?user=H2S5ROQAAAAJ&hl=en
LinkedIn: https://www.linkedin.com/in/tirtha-das-banerjee-80114270/
Orchid: https://orcid.org/0000-0002-6092-0824
GitHub: https://github.com/tdblab
Website: https://tirthadasbanerjee.com

h-index: 12
i10-index: 12

Current Positions

Senior Postdoctoral Research Fellow: Department of Biological Sciences, National University of Singapore.
PI: Prof. Antónia Monteiro
Joining Date: 3rd Jan 2025-Present

Research Associate: Institute of Digital Medicine, Yong Loo Lin School of Medicine, National University of Singapore.
PI: Associate Prof. Ajay Sriram Mathuru
Joining Date: 19th May 2025-Present

PhD Thesis

Molecular Mechanisms Underlying Venation and Color Patterning in *Bicyclus anynana* Butterflies. (2020).
https://scholarbank.nus.edu.sg/handle/10635/186943
Supervisor: Prof. Antónia Monteiro

Educational Qualification

	Degree	Year	Institute	CAP/%
1	Doctor of Philosophy (Biological Sciences)	2016-2021	National University of Singapore	4.06/5
2.	Bachelor of Technology (Biotechnology)	2011-2015	National Institute of Technology, Durgapur	8.7/10*
3.	12th (CBSE Board)	2008-2010	Kendriya Vidyalaya, C.R.P.F., Durgapur, India	86.6%**
4.	10th (CBSE Board)	2007-2008	Kendriya Vidyalaya, C.R.P.F., Durgapur, India	83.8%

* First Class with Distinction.
**School Topper in Science Stream.

Technologies developed

RAM-FISH: Spatial mRNA profiling technology that allows multiplexing (~30 genes) in complex biological systems such as whole mount organs of butterflies and zebrafish. doi: 10.1101/2024.12.06.627193

Technologies currently under development

NanoPulse: A nanolitre scale microinjection system for CRISPR-Cas9 and embryonic research application. Developing in collaboration with students from Raffels institution, Singapore.
Corn_AI: A computer vision and AI powered system for smart crop system for maximum yield using CORN-DRIVE (Closed-loop Observation and Robotic Nurture platform).
Multiplex_AI: An AI pipeline to process multiplex-FISH data to detect signal quality, non-specific signals, and signals in abnormal tissue types.
AquaSentinel_AI: AI and computer vision powered closed loop hardware system for neurobehavioral assays.

Publications

Banerjee TD[#], and Monteiro A[#] (2023). Shared regulatory networks link vein positioning and eyespot ring formation in butterflies. **Communications Biology**. ([#]Co-corresponding author). doi: 10.1038/s42003-025-09356-2

Banerjee TD[#], Murugesan SN, Connahs H, and Monteiro A[#] (2023). Spatial and temporal regulation of Wnt signaling pathway members in the development of butterfly wing patterns. **Science Advances.** ([#]Co-corresponding author). Featured in the cover of 28th July 2023 issue. doi: 10.1126/sciadv.adg3877.

Tian, S, Lee, B, **Banerjee, TD**, Murugesan, SN, and Monteiro, A. (2025). A novel Hox gene promoter fuels the evolution of adaptive phenotypic plasticity Shen. **Nature Ecology and Evolution**. doi: 10.1038/s41559-025-02891-5

Raine, J., Kibat, C., **Banerjee, TD**, Mathuru, A. S. and Biology, C. (2025). *chrna3* modulates biphasic response to alcohol. **Journal of Neuroscience**. doi: 10.1523/JNEUROSCI.0304-25.2025

Banerjee, TD[#], Raine, J, Mathuru, A. S. and Chen, K. H., Monteiro A[#] (2025). Spatial mRNA profiling using Rapid Amplified Multiplexed-FISH (RAM-FISH). ([#]Co-corresponding author) **bioRxiv**. doi: 10.1101/2024.12.06.627193

Banerjee, TD[*#], Zhang, L[*]. and Monteiro, A[#]. (2025). Mapping Gene Expression in Whole Larval Brains of *Bicyclus anynana* Butterflies. **Methods Protoc.** 8, 2**. (***Co-first author and [#]Co-corresponding author). Doi: 10.3390/mps8020031. Featured in the cover of Volume 8, Issue 2.

Tian, S., Asano, Y., **Banerjee, TD,** Komata, S., Liang, J., Wee, Q., Lamb, A., Wang, Y., Murugesan, S. N., Fujiwara, H., et al. (2024). A microRNA is the effector gene of a classic evolutionary hotspot locus. **Science** (1141). 1141, 1135–1141. doi: 10.1126/science.adp7899

Goel, T., Raine, J., Kibat, C., Collado, JW., **Banerjee, TD**, Ajay, S. (2025). Role of *chrna5* in multi-substance preference and phenotypes comorbid with the development of substance dependence. **bioRxiv**. doi: 10.1101/2025.07.10.663858

Banerjee TD[*#], Finet C[*#], Seah KS, and Monteiro A[#] (2024). *Optix* regulates nanomorphology of butterfly scales primarily via its effects on pigmentation. (Special issue on structural colors in **Frontiers in Ecology and Evolution**; *Co-first author and [#]Co-corresponding author). doi: 10.3389/fevo.2024.1392050

Prakash A., Dion E., **Banerjee TD**, and Monteiro A (2024). The molecular basis of scale development highlighted by a single-cell atlas of *Bicyclus anynana* butterfly pupal forewings. **Cell Reports.** doi: 10.1016/j.celrep.2022.111052

Banerjee TD[#] and Monteiro A[#], Reuse of a wing venation gene-regulatory subnetwork in patterning the eyespot rings of butterflies. **bioRxiv** (2023). ([#]Co-corresponding author) doi: 10.1101/2021.05.22.445259.

How S*, **Banerjee TD*[#]**, and Monteiro A[#] (2023). *vermilion* and *cinnabar* are involved in ommochrome pigment biosynthesis in eyes but not wings of *Bicyclus anynana* butterflies. **Scientific Reports**, 1–12. (*Co-first author and [#]Co-corresponding author). doi: 10.1038/s41598-023-36491-9

Prakash A, Finet C, **Banerjee, TD**, Saranathan V and Monteiro A. *Antennapedia* and *optix* regulate metallic silver wing scale development and cell shape in Bicyclus anynana butterflies Graphical. **Cell Reports**. (2022), doi: 10.1016/j.celrep.2022.111052.

Banerjee, TD[#], Tian, S., and Monteiro, A[#]. (2022). Laser Microdissection-Mediated Isolation of Butterfly Wing Tissue for Spatial Transcriptomics. **Methods Protocol**. ([#]Co-corresponding author). doi: 10.3390/mps5040067

Wee J.L.Q., **Banerjee TD**., Prakash A., Seah K.S. and Monteiro A (2022). Distal-Less and Spalt Are Distal Organisers of Pierid Wing Patterns. **EvoDevo**, 13, 1–14, doi:10.1186/s13227-022-00197-2.

Banerjee TD[#] and Monteiro A[#] (2020). Molecular mechanisms underlying simplification of venation patterns in holometabolous insects. **Development.** ([#]Co-corresponding author). doi:10.1242/dev.196394.

Banerjee TD[#], Ramos D and Monteiro A[#] (2020) Expression of Multiple *engrailed* Family Genes in Eyespots of *Bicyclus anynana* Butterflies Does Not Implicate the Duplication Events in the Evolution of This Morphological Novelty. **Frontiers in Ecology and Evolution** 8:227. ([#]Co-corresponding author). doi: 10.3389/fevo.2020.00227.

Banerjee TD[#] and Monteiro A[#] (2020) Dissection of Larval and Pupal Wings of *Bicyclus anynana* Butterflies. **Methods & Protocol** 3, 5. ([#]Co-corresponding author). doi: 10.3390/mps3010005.

Connahs H, Tlili S, van Creij J, Loo TYJ, **Banerjee TD**, Saunders TE and Monteiro A (2019) Activation of butterfly eyespots by Distal-less is consistent with a reaction-diffusion process. **Development**, 146, 1–12. doi: 10.1242/dev.169367

Banerjee TD[#] and Monteiro A[#] (2018) CRISPR-Cas9 Mediated Genome Editing in *Bicyclus anynana* Butterflies. **Methods & Protocol**. doi: 10.3390/mps1020016. ([#]Co-corresponding author)

Pal S, Kundu A, **Banerjee TD**, Mohapatra B, Roy A, Manna R, Sar P and Kazy SK (2017). Genome analysis of crude oil degrading *Franconibacter pulveris* strain DJ34 revealed its genetic basis for hydrocarbon degradation and survival in oil contaminated environment. **Genomics** 109, 374–382. doi: 10.1016/j.ygeno.2017.06.002

Pal S, **Banerjee TD**, Roy A, Sar P and Kazy SK (2015) Genome Sequence of Hydrocarbon-Degrading *Cronobacter sp.* Strain DJ34 Isolated from Crude Oil-Containing Sludge from the Duliajan. **Genome Announcement** ,3, 2011– 2012. doi: 10.1128/genomeA.01321-15

Paul D, Kazy SK, **Banerjee TD**, Gupta AK, Pal T and Sar P (2015) Arsenic biotransformation and release by bacteria indigenous to arsenic contaminated groundwater. **Bioresource Technology** 188, 14–23. doi: 10.1016/j.biortech.2015.02.039

Awards and Scholarships

Inspiring Research Mentor Award, 2025. Awarded by NUS High School of Math and Science.
Young Researcher Award, Asia Evo-Devo-2021. Awarded by Asia Evo-devo 2021.
Yale-NUS scholarship (2016-2020). Awarded by Yale University and NUS.

Grants Awarded

Integrating Reaction-Diffusion and Positional-Information in patterning the wing veins of *Bicyclus anynana* butterflies. (MOE Tier 1, primarily written, PI: Antónia Monteiro).

Investigating a transcriptional role of primary cilia in striatal neural computation mediating cognitive flexibility. (MOE Tier 2, as collaborator, PI: Siew Cheng Phua).

The evolution of novel complex traits from preexisting traits: Identifying shared cellular identities and gene regulation across traits. (MOE Tier 2, co-written with Antónia Monteiro and Suriya Narayanan Murugeshan).

Reviewed papers in the following journals

PloS genetics, eLife, BMC Biology, Cells, Journal of Insect Physiology, Insect sciences, Biology, and Molecules.

Past Positions

Industrial

Orchid Chemicals and Pharmaceuticals Ltd., R&D Center, Sholinganallur, Chennai, India (acquired by Pfitzer).
Field of research: Large scale bacteria-based enzyme production and recombinant DNA technology.
Date: August 2015-June 2016

Academic

Research Scholar: Department of Civil Engineering, Curtin University, Perth, Western Australia.
Project: Development of self-healing concrete using cyanobacteria.
Date: January 2016-July 2016

Postdoctoral research Fellow: Department of Biological Sciences, National University of Singapore. PI: Prof. Antónia Monteiro
Projects: 1) Evolution and Development of novel complex traits.
2) Development and application of spatial transcriptomics technologies (in collaboration with GIS-Singapore).
Date: November 2020-June 2024

Senior Postdoctoral research Fellow: Department of Biological Sciences, National University of Singapore. PI: Prof. Antónia Monteiro
Project: Development and application of next generation spatial transcriptomics technologies.
Date: June 2024-October 2024

Senior Postdoctoral research Fellow: Center for Life Sciences, National University of Singapore.
Project: *chrna3* modulates alcohol response in zebrafish. PI: Associate Prof. Ajay Sriram Mathuru.
Date: October 2024- January 2025

Conferences

14th Zebrafish conference, Singapore, 2025. Spatially resolved mRNA profiling using Rapid Amplified Multiplexed-FISH (AAA-FISH)

Spatial Biology Congress, 2024, Singapore. Spatially resolved mRNA profiling using Automated Accelerated Amplification based multiplex-FISH (AAA-FISH).

Biology of Butterflies 2023, Prague, Czech Republic. Presentation. **Banerjee TD**, Murugesan SN, Connahs H, and Monteiro A. Spatial and temporal regulation of Wnt signaling pathway members in the development of butterfly wing patterns.

Euro-evo-devo 2022, Naples, Italy. Poster: **Banerjee TD** and Monteiro A: Reuse of a Wing Venation Gene-Regulatory Network in Patterning the Eyespot Rings of Butterflies.

2nd Asia Evo-Devo 2021, Japan. Presentation: **Banerjee TD** and Monteiro A. Molecular mechanism underlying wing venation is reused to pattern the eyespot rings in *Bicyclus anynana* butterflies.

GYSS 2021, Singapore. Video presentation: **Banerjee TD** and Monteiro A. Molecular mechanisms underlying simplification of venation patterns in holometabolous insects.

Biology of Butterflies 2018, Bangalore. Poster: **Banerjee TD** and Monteiro A. Differential expression of *engrailed* paralogs elucidates gene duplication events in butterflies.

Biological model systems
Bicyclus anynana, Danio rerio, Nothobranchius furzeri.

Skills and expertise
Spatial biology, Laser Capture Microdissection, Multiplex-FISH, Single cell and bulk RNA-Seq, CRISPR-Cas9, computer vision, closed loop hardware system, immunohistochemistry, qPCR, gene cloning, western blotting, microbial gene and protein expression, and advanced bioinformatics.

Hardware
Arduino (ATMega328p, ATMega2560), Esp32, Raspberry Pi4/5, AMB82-mini

Products developed
Multiplexer, Geneplexer, RemBot, AquaSentinel, NanoPulse, and FISHER (Feedback-driven, Intelligent System for Hunger-aware Environmental Response).

Programming language
C++, html, and Python

Apps
https://tdblab.github.io/hcrprobedesigner/hcr_22.1.html
https://tdblab.github.io/rgbhcr/rgb_2.html
Merge: A python based tool to create composite 2D images of z-slices or maximum projection of in-situ data for multiplex-FISH applications. Github: https://github.com/tdblab/RAMFISH

Area of Interest
Developmental Biology, Evolutionary Biology, Artificial Intelligence, Robotics, Molecular Biology, and Spatial Biology.

Teaching and mentorship
Current students
Research Assistant: Mr. Jeriel Lee Cheng Hock
Project: Investigating the spatial-temporal expression of leg gap genes during the embryonic and larval wing development of *Bicyclus anynana* butterflies.

FYP: Mr. Javen Tan Yih Ruay
Project: Modeling reaction-diffusion based mechanisms patterning the wing veins of *Bicyclus anynana*.

Raffles Institution. JayaVardhan Harihar Prasad and Chan Sum Ngai Jeff. Project: Design and implementation of nanolitre scale microinjector for CRISPR-Cas9 injection on embryos. Project under MOE.

Past students
UROPS: Ms. Gianella Pacho
Project: Exploring FGF signaling in biological patterning using *Bicyclus anynana.*

Master Student: Ms. Emily Zhang Linwan.
Project: Spatial transcriptomics of developing *Bicyclus anynana* brain.

UROPS: Ms. Lara Chal
Project: Co-localization of multipleeyespot centre-specific mRNA andprotein targets in larval wings of *Bicyclus Anynana*.

FYP: Ms. Dorothy Lau Shi Min
Project: Involvement of EGFR signaling in biological patterning of butterfly wings.

FYP: Mr. Jeff Winxin Collado
Project: Implementation of automated fluidics system for in-situ hybridization experiments in the larval and adult brains of *Danio rerio*.

FYP: Ms. Teesha Basak
Project: Designing an optimized autofeeder for behavioral experimentation in Zebrafish.

Master Student: Ms. Zhang Yu.
Project: Spatial interaction of *frizzled* receptors in patterning butterfly wing tissues.

Amgen and UROPS summer student: Mr. Jeriel Lee Cheng Hock.
Project: i) Functional role of *optix* and *spalt* CREs in the development of venation and eyespot color patterns.
ii) Spatial-temporal expression of leg gap genes during the embryonic and larval wing development of *Bicyclus anynana* butterflies.

URPOS student: Mr. How Hong Chuen Shaun
Project: Regulatory Interactions of *engrailed*, *optix* and Ommochrome Genes in *Bicyclus anynana* butterflies.

Summer Intern: Ms. Tirunagari Praveenya
Report: The role of Homothorax (Hth) and Dachshund (Dac) in the eyespot center formation in *Bicyclus anynana* butterflies.

High School students: 1) NUS High School. Lim Jun Hui Solomon and Isaac Sim Jing Xiang. Project: Reaction diffusion modeling on wing patterns of butterflies.

Teaching Assistant duties: Five semesters at Department of Biological Sciences, NUS. Worked with Prof. Antónia Monteiro; Assoc. Prof. Ryan Chisholm; Asst. Prof. Roman Carrasco; Assoc. Prof. Li Diaqin; and Asst. Prof. Nalini Puniamoorthy.

Hobbies
Microelectronics, aquarium, cycling, computer hardware, guitar, gym, running, tennis, badminton, and photography.

Other Research/Industry Experience and Projects Undertaken
Summer Intern at the Lab of Microbiology, East India Pharmaceuticals Works Ltd., Durgapur Plant. Worked on detection and analysis of *S. abony, E. coli, P. aeruginosa,* and *S. aureus* in water samples.

Winter Research Intern 2013, Department of Biotechnology, Indian Institute of Technology – Kharagpur (2013-14). 'Utilization of Petroleum Hydrocarbon and Oxidation of As(III) by Bacterial Strains Isolated from Arsenic Contaminated Sites in West Bengal (India)'.

Summer Research Intern 2014, Department of Biological Sciences, National University of Singapore. Project title 'A Study on Expression of *engrailed* and *spalt* in Developing Wings of African Butterfly *Bicyclus anynana*'.

Other Participations and awards
Genomics, Metagenomics and Metabolic Engineering: Workshop organized by Indian Institute of Technology – Kharagpur, India'; December 2014.

EduHeal Foundation Interactive Olympiad (National Biotechnology Olympiad) 2009 and secured National Rank-389**.**

Advance Functional Material at CSIR-CMERI, Durgapur on 24th Jan 2013.

Won numerous awards in academics during school days.

Carrier Goal

Gain knowledge and apply it for the wellbeing of humanity.

Last updated on 5th Jan 2026