

# Aravind Penmatsa, PhD

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## Educational qualifications

**PhD-2009.** Centre for Cellular and Molecular Biology, Hyderabad, India.

**B-Pharmacy-2003.** Osmania University, Hyderabad, India.

## Research Experience

**05/2021-date** – Associate Professor, Indian Institute of Science.

**05/2015- 05/2021** – Assistant Professor, Indian Institute of Science.

**02/2010-03/2015** – Postdoctoral fellow in Dr. Eric Gouaux's lab at the Vollum Institute, OHSU, Portland, USA.

**03/2004-11/2009** – PhD. Graduate student of Dr. Yogendra Sharma and Dr. Rajan Sankaranarayanan at the Centre for Cellular and Molecular Biology, Hyderabad, India.

## Research Interests

X-ray crystallography, electron cryomicroscopy, biophysics and biochemical analyses of integral membrane proteins including

1. Neurotransmitter transporters &
2. Multi-drug efflux transporters

## Professional Qualifications and Awards

1. Qualified in Graduate Aptitude Test in Engineering (GATE) in 2003. subject-pharmaceutical sciences
2. Junior Research fellow of CSIR (GATE). years 2004-2006.
3. Senior Research fellow of CSIR (GATE). years 2006-2009.
4. Runner-up award at the **K.V. Rao Young Scientist award-2008** for Biological Sciences.
5. Abstract selected for the **Finn Wold Travel award-2008** to attend the 22<sup>nd</sup> Protein Society (USA) symposium on "Molecular machines in life".
6. Awarded the **Eli Lilly Asia Outstanding thesis award-2009** (first prize).
7. **American Heart Association** postdoctoral fellow for the duration of **07' 2011 to 06' 2013**.
8. Awarded **Ramanujan fellowship** by the Dept. of Science and Technology (DST), India-2015-2020.
9. Selected for the **DBT-Wellcome Trust India Alliance Intermediate Fellowship**, 03/2016-03/2021.
10. Awarded the **"Innovative Young Biotechnologist Award-2015"** by the Dept. of Biotechnology, 05/2016.
11. Selected for the **TATA Trust Travel fellowship** to attend the **GRC on Multi-drug efflux systems** in Lucca, Italy, 28/04/19 – 03/05/19.
12. Selected as an **"EMBO Global Investigator"** from India-2020. (term 01/2021-12/2024)

13. Selected for the **DBT-Wellcome Trust India Alliance Senior Fellowship** for the duration of 02-2023 to 02-2028.
14. Elected **Fellow of the National Academy of Sciences, India**, based in Prayagraj, **October 2023**.
15. Elected member of the **Guha Research Conference** in November, 2023.
16. Selected for the IISc Research Award 2024.
17. Awarded **Vigyan Yuva-Shanti Swarup Bhatnagar award** in Biological Sciences-2024.

## Publications (ORCID: [0000-0001-9519-5055](https://orcid.org/0000-0001-9519-5055))

1. Hussain, N., Apotikar, A., Pidathala, S., Mukherjee, S., Burada, A.P., Sikdar, S.K., Vinothkumar, K. R. & **Penmatsa, A.\*** CryoEM structures of Pannexin 1 and 3 reveal differences among Pannexin isoforms, **Nat. Commun.**, (2024) **15**(1):2942.
2. Majumder, P., Ahmed, S., Ahuja, P., Athreya, A., Ranjan, R., **Penmatsa, A.\*** Cryo-EM structure of antibacterial efflux transporter QacA from *Staphylococcus aureus* reveals a novel extracellular loop with allosteric role. **EMBO J.** (2023) **42**: e113418.
3. Singh, M., **Penmatsa, A.**, Nandi, D. Functional characterisation of *Salmonella Typhimurium* encoded YciF, a Domain of Unknown Function (DUF892) family protein, and its role in protection during bile and oxidative stress. **J Bacteriol.** (2023): e0005923.
4. Nayak, S.R., Joesph, D., Hoefner, G., Dakua, A., Athreya, A., Wanner, K.T., Kanner, B., & **Penmatsa, A.\*** CryoEM structure of GABA transporter 1 reveals substrate recognition and transport mechanism. **Nat. Struct. Mol. Biol.** (2023). **30**, 1023–1032.
5. Joseph, D., Nayak, S.R., & **Penmatsa, A.\*** Structural insights into GABA transport inhibition using an engineered neurotransmitter transporter. **EMBO J.** (2022). **41**:e110735.
6. **Penmatsa, A.\*** A (Fab)ulous tool to block efflux. **Nat. Chem. Biol.** (2022). <https://doi.org/10.1038/s41589-022-00999-4> (News & Views)
7. Dubey, S., Majumder, P., **Penmatsa, A.** & Sardesai, A.A.\* Topological analyses of the L-lysine exporter, LysO, reveal a critical role for a conserved pair of intramembrane solvent exposed acidic residues. **J. Biol. Chem.** (2021). **297**(4), 101168. (<https://doi.org/10.1016/j.jbc.2021.101168>)
8. Kumar, S., Athreya, A., Gulati, A. Nair, R.M. Mahendran, Mahendran, I., Ranjan, R. & **Penmatsa, A.\*** Structural basis of inhibition of a putative drug efflux transporter NorC, through a single-domain camelid antibody. **Commun Biol.** (2021) **4**:836 (<https://doi.org/10.1038/s42003-021-02357-x>).
9. Shabareesh, P., Mallela, A.K., Joseph, D. & **Penmatsa, A.\*** Structural basis of norepinephrine recognition and transport inhibition in neurotransmitter transporters. **Nat. Commun.** (2021) **12**:2199. (<https://doi.org/10.1038/s41467-021-22385-9>)
10. Khatri, B., Majumder, P., Nagesh, J., **Penmatsa, A.\*** & Chatterjee, J.\* Increasing protein stability by engineering  $n \rightarrow \pi^*$  interaction at the beta-turn. **Chem. Sci.** (2020). **11**, 9480-9487 (<https://doi.org/10.1039/D0SC03060K>)
11. Kumar, S., Mahendran, I., Athreya, A., Ranjan, R. & **Penmatsa, A.\*** Isolation and structural characterization of a  $Zn^{2+}$ -bound single-domain antibody against NorC, a multi-drug efflux transporter in bacteria. **J. Biol. Chem.** (2020). **295**(1), 55-68. (DOI: 10.1074/jbc.RA119.010902)
12. Joseph, D., Shabareesh, P., Mallela, A. K. & **Penmatsa, A.\*** Structure and Gating Dynamics of  $Na^+/Cl^-$  coupled neurotransmitter transporters. **Front. Mol. Biosci.** (2019), **6**:80. (Review)
13. Majumder, P., Khare, S., Athreya, A., Hussain, N., Gulati, A. & **Penmatsa, A.\*** Dissection of protonation sites for antibacterial recognition and transport in QacA, a multidrug efflux transporter. **J. Mol. Biol.** (2019). **431**, 2163-2179. (DOI: <https://doi.org/10.1016/j.jmb.2019.03.015>)

14. Majumder, P., Mallela, A. K. & **Penmatsa, A.\*** Transporters through the looking glass. An insight into mechanisms of ion-coupled transport and methods that help reveal them. *J. Ind. Inst. Sci.* (2018), **98**, 283-300. (Review)
15. **Penmatsa, A.<sup>1</sup>**, Wang, K. H.<sup>1</sup> & Gouaux, E. X-ray structures of Drosophila dopamine transporter in complex with nisooxetine and reboxetine. *Nat. Str. Mol. Biol.* (2015). **22**, 506-508.
16. Wang, K. H.<sup>1</sup> **Penmatsa, A.<sup>1</sup>** & Gouaux, E. Neurotransmitter and psychostimulant recognition by the dopamine transporter. *Nature*. (2015). **521**, 322-327.
17. Whittaker, M. M., **Penmatsa, A.** & Whittaker, J. W. The Mtm1p carrier and pyridoxal 5'-phosphate cofactor trafficking in yeast mitochondria. *Arch. Biochem. Biophys.* (2015). **568**, 64-70
18. **Penmatsa, A.** & Gouaux, E. How LeuT shapes our understanding of the mechanisms of sodium-coupled neurotransmitter transporters. *J. Physiol.* (2014), **592**, 863-869. (Review)
19. Wang, H., Goehring, A., Wang, K. H., **Penmatsa, A.**, Ressler, R. & Gouaux, E. Structural basis for action by diverse antidepressants on biogenic amine transporters. *Nature*. (2013). **503**, 141-145.
20. **Penmatsa, A.<sup>1</sup>**, Wang, K. H.<sup>1</sup> & Gouaux, E. X-ray structure of dopamine transporter elucidates antidepressant mechanism. *Nature*. (2013). **503**, 85-90.
21. Rajnikanth, V., Srivastava, S. S., Singh, A. K., Rajyalakshmi, M., Chandra, K., **Aravind, P.**, Sankaranarayanan, R. & Sharma Y. Aggregation-prone near-native intermediate formation during unfolding of a structurally similar nonlenticular  $\beta\gamma$ -crystallin domain. *Biochemistry*. (2012), **51**, 8502-8513.
22. **Aravind, P.<sup>1</sup>**, Mishra, A.<sup>1</sup>, Suman, S. K.<sup>1</sup>, Jobby, M. K., Sankaranarayanan, R. & Sharma, Y. The  $\beta\gamma$ -Crystallin superfamily contains a universal motif for binding calcium. *Biochemistry*. (2009), **48**, 12180–12190.
23. Roy, S.<sup>1</sup>, **Aravind, P.<sup>1</sup>**, Madhurantakam, C., Ghosh, A. K., Sankaranarayanan, R. & Das, A. K. Crystal structure of a fungal protease inhibitor from *Antheraea mylitta*. *J. Struct. Biol.* (2009), **166**, 79-87.
24. **Aravind, P.**, Suman, S. K., Mishra, A., Sharma, Y. & Sankaranarayanan, R. Three-dimensional domain swapping in nitrocellin, a single-domain  $\beta\gamma$ -crystallin from *Nitrosospora multiformis*, controls protein conformation and stability but not dimerization. *J. Mol. Biol.* (2009), **385**, 163-177.
25. **Aravind, P.**, Wistow, G., Sharma, Y. & Sankaranarayanan, R. Exploring the limits of sequence and structure in a variant  $\beta\gamma$ -crystallin domain of the protein absent in melanoma-1 (AIM1). *J. Mol. Biol.* (2008), **381**, 509-518.
26. **Aravind, P.**, Chandra, K., Reddy, P. P., Jeromin, A., Chary, K. V. & Sharma, Y. Regulatory and Structural EF-hand motifs of Neuronal Calcium Sensor-1:  $Mg^{2+}$  modulates  $Ca^{2+}$ -binding,  $Ca^{2+}$ -Induced conformational changes, and Equilibrium unfolding transitions. *J. Mol. Biol.* (2008), **376**, 1100-1115.
27. Mikhaylova, M., Sharma, Y., Reissner, C., Nagel, F., **Aravind, P.**, Rajini, B., Smalla K. H., Gundelfinger, E. D. & Kreutz, M. R. Neuronal  $Ca^{2+}$  signaling via caldendrin and calneurons. *Biochim. Biophys. Acta*. (2006), **1763**, 1229-1237.
28. Roy, S.<sup>1</sup>, **Aravind, P.<sup>1</sup>**, Madhurantakam, C., Ghosh, A. K., Sankaranarayanan, R. & Das, A. K. Crystallization and preliminary X-ray diffraction analysis of a protease inhibitor from the haemolymph of the Indian tasar silkworm *Antheraea mylitta*. *Acta. Cryst. Sect. F*. (2006), **62**, 669-671.
29. **Aravind, P.**, Rajini, B., Sharma, Y. & Sankaranarayanan, R. Crystallization and preliminary X-ray crystallographic investigations on a  $\beta\gamma$ -crystallin domain of absent in melanoma 1 (AIM1), a protein from Homo sapiens. *Acta. Cryst. Sect. F*. (2006), **62**, 282-284.

<sup>1</sup>equal contribution, \*corresponding author

## Preprints

1. Sharma, P., Venkatesh, P.H., Paddillaya, N., Shah, N., Rajeshwari, B.R., Dakua, A., Penmatsa, A., Balasubramanian, N., Gundiah, N. Subba Rao, G.; Golgi localized Arl15 regulates cargo transport, cell adhesion and motility; *bioRxiv* 2022.08.18.504432.

## Society memberships.

1. Indian Crystallographic Association
2. Indian Biophysical Society
3. Electron Microscopy Society of India

## Journal Peer-Review

1. *Nature* – 3 no
2. *Nature Chemical Biology* – 1no
3. *eLife* – 3 nos
4. *Journal of Molecular Biology* – 1 no
5. *Scientific Reports* – 2 nos
6. *BioEssays* – 1 no
7. *British Journal of Pharmacology* – 1 no
8. *Journal of Structural Biology* – 2 nos
9. *Frontiers in Molecular Neuroscience* – 1 no
10. *AminoAcids* –(Springer)- 1no
11. *Proteins*
12. *Nature Communications*

## Meeting abstract

1. **Aravind, P.**, Mishra, A., Suman, S. K., Sharma, Y., and Sankaranarayanan, R.  $\beta\gamma$ -crystallins: A universal calcium-binding superfamily. ***Protein Science***. (2008), 17, suppl 1, 173.

## Scientific Presentations

1. Invited speaker for a colloquium at TIFR-Hyderabad on 29<sup>th</sup> April, 2024. Talk on GABA transporter structure and pharmacology.
2. Invited speaker at the Gangeya student chapter talks for MeMapp 2024, at IIER Kolkata.
3. Invited speaker at the RACE-CB organized at IIT Bombay for the inauguration of the national cryoEM centre, March 2024
4. Invited speaker at the 92<sup>nd</sup> Society for Biological Chemists (India) organized by the BITS-pilani Goa campus, 18-20<sup>th</sup> December, 2023.
5. Invited speaker at the first research conference of RGCB, Trivandrum, 20-23<sup>rd</sup> September, 2023
6. Invited speaker at NSC50 organized at IMTECH Chandigarh, 22-24<sup>th</sup> November, 2023.
7. Participated and presented a poster in the GRC on Mechanisms of Membrane Transport in June 2023 at the Les Diablerets Conference Centre, Switzerland.
8. Invited speaker at Indian Biophysical Society organized by National Centre for Biological Sciences (NCBS), March 25<sup>th</sup> to 29<sup>th</sup>, 2023.
9. Invited speaker at Biomembranes symposium organized by Dept. of Chemical Engineering, IISc, September 15<sup>th</sup>-17<sup>th</sup>, 2022.
10. Invited speaker, Frontier Symposium in Biology symposium, School of Biological Sciences, IISER-Trivandrum, 29/04/2022-01/04/2022.
11. Invited speaker at a one-day symposium at University of Mysore on “**Trends in drug-discovery**” organized on 24<sup>th</sup> February 2022.
12. Speaker at the EMBO young investigator meeting held from June 30 to July 2<sup>nd</sup>, 2021.
13. Annual departmental seminar at MBU, “**A tale of two transporters and a channel**”, August 19, 2020.
14. Talk in the Dept of Biotechnology-SAC meeting for the DBT-IISc partnership program titled “**Ion-coupled transport and inhibition in neurons and superbugs**”, June 29-30, 2020.

15. Poster Presentation at the **Gordon Research Conference on Ligand recognition and molecular Gating**, 2020 to be held at Lucca, Italy from 15<sup>th</sup> to 20<sup>th</sup> March, 2020.
16. Invited talk at the 12<sup>th</sup> Asia Pacific Microscopy Conference in Hyderabad 3<sup>rd</sup> to 7<sup>th</sup> February, 2020. Talk Title "**CryoEM structure of an ATP-release channel at sub-nanometer resolution**".
17. Abstract selected for poster presentation at the **Gordon Research Conference on Multi-drug efflux systems**, 2019 held at Lucca, Italy from 28<sup>th</sup> April – 3<sup>rd</sup> May 2019.
18. Invited lecture at the National Institute of Mental Health and Neurosciences (NIMHANS) on 29<sup>th</sup> January, 2019. Talk title "**Neurotransmitter transporters: Neurotransmission through structural biology**".
19. Invited speaker at a workshop on "Accelerator based photon sources as a versatile tool to probe matter: Present scope and outlook", organized by SSCU, IISc, 27-29 March, 2018.
20. Invited speaker at the National seminar on structural biology-2018, Centre for Advanced Study in Crystallography & Biophysics, University of Madras held on 21<sup>st</sup>, March 2018. Talk title- "**Structure and pharmacology of neurotransmitter transporters**",
21. Invited speaker at the Frontiers in Modern Biology-2018 meeting organized at IISER-Kolkata held from 19<sup>th</sup>- 21<sup>st</sup> January 2018. Talk title- "**Ion-coupled transport in neurons and superbugs**".
22. Invited speaker at the annual Indian Biophysical Society symposium at IISER-Mohali held from 22<sup>nd</sup>-25<sup>th</sup> March, 2017. Talk title "**Mechanisms and Pharmacology of Neurotransmitter transport**".
23. Organizer of "**Practical aspects of membrane protein crystallization**" workshop at the Indian Institute of Science, December 15<sup>th</sup>-16<sup>th</sup>, 2016.
24. Invited speaker at the IRB-Barcelona Biomed Conference on "**Transporters and other Molecular Machines**", held from 17-19 November, 2014.
25. Poster presentation titled "**Dopamine transporter structure reveals mechanism of neurotransmitter transport inhibition**" at the **Gordon Research Conference** on "Ligand Recognition and Molecular Gating" held at Ventura, CA between April 23<sup>rd</sup>-28<sup>th</sup>, 2014.
26. Invited speaker at **Experimental Biology (EB-2013)** symposium in Boston held from April 19<sup>th</sup> – 24<sup>th</sup>, 2013, for a talk on "**Structural insights into the mechanism of sodium coupled neurotransmitter transporters**", during the session, "Fishing with flies, worms and bacteria. Emerging models for mammalian membrane transport and trafficking", organized by the American Physiological Society (APS).
27. Participant at the **Gordon Research Conference** on "**Mechanisms of membrane transport**" held at University of New England, ME from June 19-24, 2011.
28. Participant at the first LCP workshop and in the **NIH roadmap meeting** on "**Membrane protein technologies**" held at the Scripps's research institute, La Jolla, San Diego from November 16<sup>th</sup>-18<sup>th</sup> 2010.
29. Registered participant of a two-day symposium on "**Bio Nano-technology and Pharmaceuticals- A glimpse into the future**", held at CCMB during March, 2008.
30. Attended a "**Workshop on Structural Biology**", organized by the **Indian National Science Academy & Chinese Academy of Sciences** at Indian Institute of Science (IISc) December, 2007 in Bangalore.
31. Presented a poster entitled " **$\beta\gamma$ -Crystallins: A novel class of calcium-binding proteins**", at the ADNAT-07 international conference held on "Recent advances in structure prediction and structure determination" at CCMB during February, 2007.
32. Abstract entitled "**Molecular characterization of Neuronal calcium sensor-1**", selected for oral presentation at the Indian Biophysical Society-2007, meeting held on "Trends in Biomedical Research" in New Delhi.
33. Presented a poster entitled "**Structure of AIM1g1, a variant non-lens  $\beta\gamma$ -crystallin domain from a human protein, Absent in melanoma-1 (AIM1)**" at the **National symposium on Crystallography** held at Chennai during January 2007.
34. Poster presentation titled "**Crystallization and structure determination of a  $\beta\gamma$ -crystallin domain of Absent in melanoma 1(AIM1) protein from Homo sapiens**", at the National symposium on Macromolecular Crystallography held at the Centre for DNA Finger printing and Diagnostics (CDFS), Hyderabad during November 2005.