



NEWSLETTER July 2018



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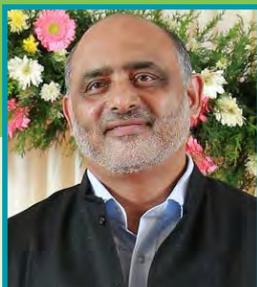
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**It's always better to
lose than to die, and
a successful pathogen
knows it all**



Dr. Bipin Nair
Dean, School of Biotechnology

From the Dean's Desk

As we reach the end of the academic year 2017-2018, the continuing efforts of the students, faculty and staff at the School of Biotechnology, mirror the tag line and theme for the School – 'Inspired by creativity, Driven to Excellence.' From publishing research papers in premier scientific journals to having students from the B.Sc. and M.Sc. programs find internships in laboratories overseas, to faculty being invited to deliver lectures at international conferences to being selected for prestigious national and international awards, the School has certainly taken decisive steps to be recognized as a front-runner in several spheres of highly competitive segments in the academic and research arenas.

The success of our senior faculty in securing grant funding from funding agencies like DBT and DST as well as the selection of our students for prestigious awards like the Khorana Student Fellowship and Indian Academy of Science Fellowship from the Government of India, are a true index of enhanced credibility and recognition of the students and faculty in the academic and research activities being pursued.

Let us continue to persevere in our efforts and strive towards excellence in the pursuit of our goals with an abundance of God's Grace and an ardent desire to achieve our dreams well into the future.

Amrita Faculty Discover the Effect of Natural Product Clove Bud Oil on Pathogenic Bacteria Virulence & Host Response



Amrita Paper

Clove Bud Oil Modulates Pathogenicity Phenotypes of the Opportunistic Human Pathogen Pseudomonas Aeruginosa

Published in High Impact

SCIENTIFIC REPORTS
a nature research journal

School of Biotechnology faculty and students recently published a journal paper titled “Clove Bud Oil Modulates Pathogenicity Phenotypes of the Opportunistic Human Pathogen Pseudomonas aeruginosa” in the high impact Nature publishing group’s Scientific Reports. This publication includes research done by a bright and talented group of Ph. D. students including first author Jayalekshmi H., Muralidharan Vanuopadath, and recently graduated Dr. Athira Omanakuttan along with M. Sc. student Nitasha Menon under the guidance of Dr. Geetha Kumar, Dr. Bipin Nair, and Dr. Sudarslal S. in collaboration with Dr. Victor Nizet and his lab at the University of California, San Diego (UCSD).

The looming global crisis of antibiotic resistance, along with the difficulty in treating recalcitrant infections, creates a critical need for new and intelligent therapeutic modalities and novel means to combat pathogens. Pseudomonas aeruginosa is a major cause of secondary infections in immune-compromised patients and accounts for a significant percentage of total hospital-acquired infections. In fact, the World Health Organization (WHO) considers multidrug-resistant P. aeruginosa as a serious threat to global health. Through this study, Amrita researchers employed a two-pronged approach to testing the effect of clove bud oil on the virulence of P. aeruginosa



as well as the effect of the natural product in enhancing the ability of the host to fight the infection.

All in all, this publication demonstrates that clove bud oil weakens key virulence mechanisms of this important human pathogen, while also enhancing host innate immunomodulatory functions. The authors also suggest a possible application of this work towards using clove bud oil as a topical therapy against antibiotic-resistant infections.

Invited Talk at Netherland Ministry's RIKILT Food Safety Institute



Dr. Shyam Diwakar, Associate Professor, School of Biotechnology was invited to visit and deliver a talk at RIKILT, an organization of the Ministry of Economic Affairs and the Netherlands Food and Consumer Product Safety Authority (NVWA) at Wageningen, Netherlands. RIKILT - Institute of Food Safety was created in 1975 through the merger of the Government Dairy Station in Leiden and the Government Agricultural Testing Station Maastricht. At RIKILT, Prof. Shyam Diwakar delivered a talk on “Modeling, OER, and Open Models - Work at Amrita” on March 26, 2018. He also detailed how data science is changing projects and innovation at Amrita highlighting work on AVIEW, Amrita Virtual Labs project, OceanNet and many more.

RIKILT is co-located with University of Wageningen, which is known for its expertise in food and nutrition. RIKILT



researcher Dr. Anand Gavai who had organized this visit, had also visited Amrita Vishwa Vidyapeetham in 2016 and 2017.

This visit was also on behalf of Amrita Center for International Programs that has been facilitating University-wide collaborations and exchange of students through Live-in-Labs® and other agreements towards building sustainable solutions in India and abroad.

 <p>Top 500 Clinical and Health</p> <p>Top 500 International Outlook</p>	 <p>No. 1 Private University in India</p>	 <p>No. 8 Among All Universities in India</p>	 <p>No. 1 Private University in India</p>	 <p>No. 1 Private University in India</p> <p>Top 200 in BRICS</p>
www.amrita.edu/ranking				

Aegis Graham Bell Awards 2017 in the Innovation in mHealth category



Innovation in mHealth
Amrita Vishwa Vidyapeetham & Wipro Technologies

Amrita Vishwa Vidyapeetham and Wipro Limited, a leading global information technology, consulting and business process services company, jointly won the Aegis Graham Bell Awards (AGBA) 2017 in the Innovation in mHealth category. They were recognized for their joint initiative- 'Redefining Primary Comfort Using mHealth' at the eighth edition of the Aegis Graham Bell Awards.

The School of Biotechnology, Amrita Vishwa Vidyapeetham, in collaboration with Wipro, has developed a mobile health solution using a novel glucose monitoring system integrated with a cloud-based monitoring application for providing more efficient and effective diabetes care. The initiative was supported by Biotechnology Industry Research Assistance Council (BIRAC), Government of India.

The jointly-developed Wipro-Amrita Diabetes Management Solution will provide a cost-effective, non-enzymatic glucose sensing solution for diabetes care, while promoting a healthy diet and active lifestyle, which are vital to manage diabetes. The solution will also enhance health screening and early diagnosis; contribute towards better adherence to drug and dietary regimen;

encourage diabetes self-care activities and help prevent complications in patients with diabetes. This end-to-end diabetes management solution requires a robust digital backbone and is based on proven algorithms that leverage the expertise of Wipro Digital.

Dr. Bipin Nair
Dean, School of Biotechnology
Amrita Vishwa Vidyapeetham

"We are honored to receive this award. It is a testimony to not just the novel, first-of-its kind diabetes management solution that has been developed, but also underscores the potential of what can be achieved in the healthcare sector through unique partnerships such as the one we have with Wipro. We are grateful for the support provided by BIRAC and happy to be recognized for our efforts to address the growing issue of diabetes in India, and help patients avail treatment at an affordable cost."

The team for the project, led by Dr. Bipin Nair, includes researchers from Amrita Vishwa Vidyapeetham, Amritapuri, including Dr. Satheesh Babu T. G., Associate Professor,

Sciences, School of Engineering, Coimbatore; Dr. John Stanley, Assistant Professor, Sciences, School of Engineering, Coimbatore; and K. Guruvayurappan, as well as Dr. Harish Kumar and team from the Department of Endocrinology, Amrita Institute of Medical Sciences, Kochi.

The Aegis Graham Bell Award is the largest innovation award for the ICT domain in India. The Aegis School of Business, Data Science, Cyber Security and Telecommunication has established the Aegis Graham Bell Award as a tribute to the father of the telephony, Alexander Graham Bell. This award is intended to promote innovation, entrepreneurship in the field of telecom, social, mobility, analytics, cloud, and security to provide recognition for outstanding contributions by the innovators. The award is organized with support of the Cellular Operators Association of India (COAI), and Telecom Centres of Excellence (TCOE), Convergence India and Deloitte are knowledge partners. The Aegis Graham Bell Awards recognize organizations that have made a significant contribution to promote innovation and entrepreneurship in the fields of telecom, social, mobility, analytics and cloud.



Virtual Labs Project Receives the 2018 GOLC Online Lab Award

On March 23, 2018, Amrita's Virtual Laboratories and its deployment outcomes won the GOLC Online Lab Award 2018 for visualized experiment category. The nomination was titled "vlab - Sustainable Laboratory Skill Education through Free Online Labs and Connecting Teachers and Students across the Country" and recognizes the efforts in deploying free educational tools and promoting its outreach across students, professors and institutions and included Dr. Shyam Diwakar, the Institute Integration Coordinator of Amrita Virtual Labs; Dr. Krishnashree Achuthan, the Principal Investigator of the project; Dr. Bipin Nair, the Discipline-wise National Coordinator of Biotechnology and Biomedical Engineering Virtual Labs for the National Mission Project; Dr. Prema Nedungadi, Director of Amrita CREATE and Dr. Raghu Raman, Chairman, Amrita School of Business, Coimbatore, who had jointly led the project, its design, implementation and studies.

Presented by Dr. Alexander Kist of University of Southern Queensland, Australia and Dr. Michale Auer, the Founding President of IAEO, on behalf of Global Online Laboratory Consortium (GOLC), the GOLC Online Lab award (Visualized Experiments category) to Amrita Vishwa Vidyapeetham, the award was received by Dr. Shyam Diwakar at the 15th International Conference on Remote Engineering and Virtual Instrumentation (REV 2018) held at the University of Applied Sciences, Dusseldorf, Germany, from March 21-24, 2018.

The International Association of Online Engineering (IAOE) is an international non-profit organization with the objective of encouraging the wider development, distribution, and application of Online Engineering (OE)

technologies and its influence on society. The recognition puts Amrita on top of all of the world's online laboratory resources. It recognizes Amrita's role in promoting the development, sharing, and research into remotely accessible laboratories for educational use and for increasing interest in developing and deploying online labs for sustainable goals in education.

Dr. Shyam Diwakar also presented a talk titled, "Using Learning Theory for Assessing Effectiveness of Laboratory Education Delivered via a Web-based Platform", at the event on March 24, 2018. Amrita Vishwa Vidyapeetham has developed over 360 virtual labs now freely available online that are being used by more than three hundred and eight thousand registered users across India for higher education and laboratory skill training. The paper was authored by Dr. Shyam Diwakar, Rakhi Radhamani, Nijin Nizar, Dhanush Kumar, Dr. Bipin Nair of Amrita School of Biotechnology and Dr. Krishnashree Achuthan of Amrita School of Engineering.

Virtual Amrita Laboratories Universalizing Education (VALUE) project is a multi-faculty, interdisciplinary project and has not only implemented these online educational resources but also connected to 104+ colleges across the country through its nodal center program. Many research publications suggest how these virtual labs act as interactive textbooks and improve teaching and student learning in and outside classrooms. The paper at REV conference showcased that virtual lab-based learning enhanced classroom education and variations in thinking processes among learners.



Amrita at CUSAT's NCODDR Conference



Dr. Shyam Diwakar, Associate Professor, School of Biotechnology, and Director of Computational Neuroscience and Neurophysiology, Amrita Vishwa Vidyapeetham, Amritapuri, was invited to talk at Cochin University of Science and Technology (CUSAT)'s National Conference on Open Data and Data Repositories (NCODDR) on March 6, 2018.

The invited talk at NCODDR was on "Challenges for OER and Open Medical Models - Case Studies from Big Data and Virtual Laboratory Environments" and covered Amrita Vishwa Vidyapeetham's ongoing efforts to create and maintain open data and online educational resources. Amrita's Virtual Laboratories, a National Mission project, now provides 360+ online labs for University-level higher education. Such online labs generate significant usage data

that has been allowing new pedagogical practices and studies.

Additionally, Dr. Diwakar and the Computational Neuroscience Laboratory have been working on mathematical models of brain circuits, software tools and data that are openly and publicly available. The talk highlighted the need for FAIR (Findable Accessible Interoperable and Reusable) standards in research data and the challenge for librarians to curate such data in India's Universities.

The conference also included Dr. Neeta Varma, Director General, NIC, Government of India. Organised by CUSAT's University library, the talk and the conference was attended by librarians, data curators, corporate sector representatives, academicians and students.

School of Biotechnology signs MoU with ID Genomics towards ARMADA



your worldwide shield against drug-resistant superbugs

ARMADA (Antibiotic Resistance Monitoring, Analysis, and Diagnostics Alliance) is a flagship project of ID Genomics, focused on products designed to personalize the treatment of infectious diseases, and improve the lives of patients. School of Biotechnology, Amrita Vishwa Vidyapeetham signs a MoU with ID Genomics, based in Seattle, Washington, USA.



Dr. Sujay Chattopadhyay
Associate Professor,
School of Biotechnology,
Amrita Vishwa Vidyapeetham

It's always better to lose than to die, and a successful pathogen knows it all

Genes in bacteria are often targeted by stop codon mutations resulting in premature truncation. These truncation mutations either accumulate independently, or follow the frameshift mutations upstream. This process leads to gene inactivation, followed by pseudogenization and finally gene deletion. This is a common mode of evolution in bacteria. The underlying dynamics is widely accepted as of 'use-or-lose' nature that allows purging of traits that are of no use in the organism. Therefore, it is termed reductive evolutionary process.

But what happens if, in the course of habitat differentiation, the function of one gene appears detrimental in the new environmental conditions? To survive in the new situation, the organism would then need to inactivate the expression of that gene. This would follow the 'die-or-lose' dynamics where truncation mutation accumulates in response to

adaptive pressures, as indicated by the preliminary analysis of systemically invasive serovars of *Salmonella enterica* subspecies I.

This 2-year project funded by Department of Biotechnology, Government of India is led by Dr. Sujay Chattopadhyay, Associate Professor, School of Biotechnology, Amrita Vishwa Vidyapeetham. Dr. Sujay is collaborating with Prof. Evgeni Sokurenko, Department of Microbiology, University of Washington, on the project which aims to develop an analytical approach to distinguish the adaptive fraction of truncation mutations from the reductive ones in a microbial species, using *Salmonella* as a case study. Also, a public database planned to incorporate the analysis results will allow comparative functional studies of variants with intact and truncated candidate genes in this critically important pathogen, offering insights on the role of gene truncation in pathoadaptation.

Decoding the barcode of bacterial pathogen - a clonal identifier of antimicrobial resistance

Misuse and overuse of antimicrobial drugs against pathogens results from drug-bug mismatch, worsening the threat of antibiotic resistance worldwide. Dr. Sujay Chattopadhyay, Associate Professor, School of Biotechnology, is leading a project that tests the clonal evolution hypothesis of antibiotic resistance on ID Genomics' database of urinary tract infection (UTI) causing *Staphylococcus aureus* isolates with known antibiograms.

The goal of this project is to detect a set of discriminatory single nucleotide polymorphisms (SNPs) in *S. aureus*'

multilocus sequence typing (MLST) loci that may be linked to discrete antibiotic resistance/susceptibility profiles. Presence or absence of marker SNPs will be used to generate a high-resolution binary barcode for each antibiotic profile, especially for the major clones showing multidrug resistance phenotypes. Such a barcoding scheme will eventually enable ID Genomics to monitor and detect antibiotic resistance in *S. aureus* isolates from patient urine samples. ID Genomics is based in Seattle, Washington, USA.



Genetic Engineering at University College Dublin

The following is an excerpt from Ivy Rose Sebastian, MSc. Biotechnology 2016-2018 batch, about her research internship at the Animal Cell Culture Engineering Laboratory at the School of Chemical and Bioprocess Engineering, University College Dublin under Dr. Ioscani Jimenez del Val.



Chinese Hamster Ovary (CHO) cells are regarded as the workhorse for the biopharmaceutical industry due to their adaptability to high density suspension culture, their ability to produce human-like post translational modifications and their ease of maintenance. These cells are being continuously genetically engineered; however, current strategies have not been flexible in terms of modulation.

An everyday analogy is that current CHO cell genetic engineering strategies are like on/off light switches, and thus cannot be dimmed easily. My research project aims to create a genetic engineering strategy where the switches are designed to be dimmable to cater for the specific requirements of gene expression.

Synthetic Biology is an upcoming field which uses artificial biological components, such as networks or genetic circuits, to perform logical functions within living organisms. By designing and using such modules in animal cells, we could essentially fine tune the expression of genes and, hence, convert them into engineered biological machines capable of performing a range of desired functions. Therefore, we plan to use Synthetic Biology as a platform to create genetic circuits that will allow us to tightly control gene expression as a linear function of an inducer molecule (doxycycline) concentration in CHO cells using the tetracycline repressor (TetR) 'Lineariser' gene expression circuit developed by Nevozhay et al (2013). The central concept underlying this project is that, by fine-tuning the expression of key genes in CHO cells, we can define and control how they behave in culture.

Through the above mechanisms, we can improve various aspects of the manufacturing process for therapeutic proteins. For example, lactate is

one of the major by-products of CHO fed-batch culture during the production of monoclonal antibodies (mAbs). In pH-controlled bioreactors, accumulation of high levels of lactate is accompanied by high osmolality due to the addition of base to control pH of the cell culture medium, potentially leading to lower cell growth and lower mAb production during manufacturing. Therefore, by fine-tuning the expression of pyruvate carboxylase (a mitochondrial enzyme), formation of lactate can be reduced. This would result in increased CHO cell culture longevity and, consequently, in enhanced mAb production. In the context of biopharmaceutical manufacturing, the use of Synthetic Biology has the potential of reducing the high costs of life-saving treatments for healthcare providers and, ultimately, for patients.

Previous work done by Nevozhay's group was conducted on MCF-7 and HEK-293 cell lines (well-known for research purposes). In this project, the synthetic gene circuit was transfected into CHO cells to study the linear gene expression behaviour in an industrially relevant cell line. As part of the ongoing project, I have successfully transfected the CHO DP12 cell line with the Lineariser using the Amaxa Nucleofector device and have isolated the transfected cells following multiple rounds of selection using an antibiotic as well as the inducer molecule, doxycycline to confirm the transfection of the cells. Currently, cells are being maintained for Flow Cytometric analysis in order to quantify and reconfirm the linear gene expression in response to increasing concentrations of doxycycline. In addition, I have conducted in silico cloning studies on the gene circuit for the insertion of any key gene into the Lineariser. This, in turn, will behave as a platform for the fine-tuning of that particular gene's expression. The cloning design has yet to be tested experimentally in order to successfully confirm the design and this is currently in progress.

School of Biotechnology celebrates Annual Athletic Meet 2018



The annual sports meet, held on February 16-17, 2018, unfolded with a colorful parade of different houses namely Amritamayi, Anandamayi, Chinmayi, and Jyothirmayi. The unique feature of this year's sports day was the grouping of students into houses, unlike into batches, as was done previously. As the contingents settled at the center of the ground, the flaming torch, a symbol of undying sports spirit, was taken around the sports ground by 'who's who' of sports at School of Biotechnology after receiving it from Dr. Bipin Nair, Dean, School of Biotechnology. It was exhilarating to see all female athletes doing the torch relay.

The divine was invoked with the lighting of the kuthuvilakku by the Dean and faculty members, followed by a soulful rendition of the prayer. Then Dr. Bipin Nair addressed the gathering expressing his happiness and appreciating the unprecedented turnout of students. He also emphasized the importance of sportsman/woman spirit and advised not to attach too much importance to the outcome, as participation is paramount. After the event was declared open by the Dean, the flag was hoisted by Dr. Asoke Banerji, Distinguished Professor, School of Biotechnology. Under the fluttering flag, group leaders took the oath promising to unflinchingly adhere to the tenets of sportsman/woman spirit and play fair.

The morning session of the first day commenced with the taxing 1500 meter race, followed by swift 100m, 200m, 400m and long jump. The events were marked by intense competition and active participation from the students and faculty members. The afternoon session began with relay events and ended with a cricket match between faculty members and the students' cricket team. Though a closely contested match, the students decisively outplayed the faculty team and regained the trophy.

The second day started with even more zest and passion. Supreme athleticism was on display during 100m, 200m and 800m track events. The day was dotted with events for the faculty members as well, such as Bombing in the City, musical chairs and 100m sprint that drew active and enthusiastic participation. The morning session came to an end with medley relay, shotput, discus throw, javelin throw and hammer throw.

The afternoon session kicked off with the much-awaited football match between faculty members and students. The students, with their agility, stamina and teamwork, defeated the faculty members and regained the trophy that was the proud possession of the faculty last year. Students and faculty, united by sports, stood witness to the winners as they climbed the victory stand and received their medals. Amidst resounding cheers, the Chinmayi group received the overall trophy from Dr. Bipin Nair. Tired and content, the students and faculty members sang the national anthem as the sun plunged into the sea and Sports Day 2018 slipped into memories.



*Congrats
MEGH*

Congratulations!

Anu Susan Kurian [B.Sc. Microbiology 2016-2019]
for being selected for the **SUMMER RESEARCH FELLOWSHIP PROGRAMME 2018** by the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)



Student Life at ASBT



Congratulations
for being selected for the
POBE Fellowship 2018

Gokul Karthik
B.Sc. Biotechnology 2017-2020



Congratulations!
Gurudatt
for the prestigious
Rhoarana Fellowship



Congrats
BHARANI



Manjitha



**Amrita Biotechnology Students
Selected for
Indian Academy of Sciences'
Summer Research
Fellowship 2018**

Ms. Shree Vibha

Mr. Thotla Vinay Kumar



K. M. Alka
M.Sc. Biotechnology 2016-2018

Amritha Rajeev
M.Sc. Biotechnology 2016-2018

Drishya Mohan
M.Sc. Microbiology 2016-2018

Congratulations!
for being placed at the
VWR Labs
Part of Avantor



Congratulations!
Athira, Nayana, Nithya, Darshana

Listing of student achievements:

- **Gurudatt Patra, MSc BT**
Khorana Program for Scholars
- **Anu Kurian, BSc MB**
JNCASR Summer Research Fellowship Programme 2018
- **Shree Viba & Thotla Vinay Kumar, BSc BT**
Indian Academy of Sciences' Summer Research Fellowship 2018
- **Trisha Ghosh, BSc**
Amrita BRITE internship at National Ilan University, Taiwan
- **Bharani, Megh, Manjitha**
Accepted for MSc in Belgium University
- **Bharani S. S., Lakshmi P., Aiswarya N., K. U. Meera, Angitha N., Vysakh Vishwanath and Shantam Yagnik, BSc BT**
JNU Combined Entrance Examination for Masters in Biotechnology
- **K.M. Alka, Amritha Rajeev, Drishya Mohan, MSc**
Placement in VWR Labs
- **Gokul K, BSc BT**
POBE Fellowship in JNCASR
- **Athira Radhamony Murali, Nayana Sudish, Nithya K, Darshana M. M., MSc**
Placement in Omics International Pvt Ltd



A semester in Taiwan Trisha Ghosh, BSc final year student



The Student Exchange Program during my final year BSc project as a part of BRITE program has given me an opportunity to explore and enhance my skills in the field of Biotechnology. As an Undergraduate student, it is very important to build one's skill set and gather as much hands on experience as possible. Being a part of this four months internship program at National Ilan University, Taiwan has given me a platform to gain first-hand experience and learn more about research methodology. I am a part of a team in Protein Structure and Function (PSF) Laboratory at Department of Biotechnology and Animal Science, College of Bioresources. I am working on the project "Anti-cancer mechanism of novel cationic antimicrobial peptides (AMP) against colon cancer cell line" under the supervision of Dr. Wei-Jung Chen and Dr. Kuo-Feng Hua. The project focuses on the efficacy of AMP as a potent drug against colorectal cancer cell line HCT116. GW-Q4a and GW-Q4-15a are two novel cationic AMPs designed by the PSF (Protein Structure and Function) lab. With our studies, we conclude that AMP can kill and inhibit the HCT116 cancer cell line. We also found that when AMPs are added in combination with existing chemotherapeutic drugs like Oxaliplatin and 5-FU, the effect is synergistic. Thus, these two AMPs show a promising aspect as a potent anti-cancer drug. Along with the research project, I am also taking additional courses like Tumor Biology and Cellular Signaling in order to deepen my knowledge in Cancer Biology.

Internship programs are challenging and competitive, hence a stronghold on the basics is mandatory. This foundation has been provided by Amrita School of Biotechnology. The framework of the curriculum has enabled me to comprehend the theoretical aspect of research and the extensive lab courses at School of Biotechnology at undergraduate level is prepared me with all the required knowledge to work in a research lab. The program gives a much needed exposure for an enthusiastic biotechnologist. As Taiwan is called the Mountain island, living here has been a wonderful experience because of its pristine beauty. National Ilan University, revered as the highest institution in Taiwan, provides a stepping stone and a promising future for aspiring scientists in the field of Biotechnology.

Recent Publications

1. Rajendran A, Vijayan A, Chaitanya M, Nair B, Diwakar S., Computational Modelling of Cerebellum Granule Neuron Temporal Responses for Auditory and Visual Stimuli. *International Journal of Advanced Intelligence Paradigms*, 2018, 10.
2. Parasuram H, Nair B, Naldi G, D'Angelo E, Diwakar S, Understanding Cerebellum Granular Layer Network Computations through Mathematical Reconstructions of Evoked Local Field Potentials. *Ann Neurosci* 2018, 25:11-24.
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4. Nair D, Krishna J, Panikkar M, Nair B, Jayashree G, Nair SS. Identification, purification, biochemical and mass spectrometric characterization of novel phycobiliproteins from a marine red alga, *Centroceras clavulatum*. *International Journal of Biological Macromolecules*. 2018, 114: 679-691.
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7. Nedungadi D, Binoy A, Pandurangan N, Pal S, Nair B, Mishra N. 6-Shogaol induces caspase-independent paraptosis in cancer cells via proteasomal inhibition. *Experimental Cell Research*. 2018, 364(2): 243-251.
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