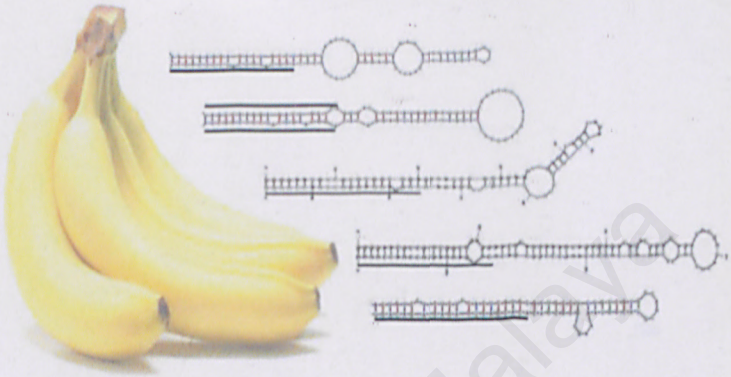
Inaugural Lecture



It's a small world after all: From microbiology to microRNA

Professor Dr. Jennifer Ann Harikrishna
Institute of Biological Sciences,
Faculty of Science
&
Centre for Research in Biotechnology for Agriculture (CEBAR)
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Perpustakaan Universiti Malaya
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3rd November 2017

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It's a small world after all: From microbiology to microRNA

Jennifer Ann Harikrishna
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Synopsis

Microbiology is the study of very small organisms. Molecular genetics is the study of genes at a fundamental level, with an aim to understand how living cells are programmed and also how they change their programme in response to changes in their environment. Among recent discoveries in molecular genetics, the important roles of small RNA molecules, including "microRNA" have enabled new understanding of biology that can help in crop improvement and offer to form part of realistic solutions to challenges of sustainable food production in the face of the twin challenges of dwindling agricultural land resources and climate change. Microbiology to microRNA has been a journey for this English "kampung" girl as she has travelled across the world throughout her training and career, meeting many wonderful Malaysians along the way. What the journey has shown is that small things can be the biggest discoveries, that gene silencing can be powerful and beautiful and that the smallest things, like a friendly Malaysian face, are the biggest treasures in life. It really is a small world!

Biography

Originally from the UK, Prof. Dr. Jennifer Ann Harikrishna completed her Bachelor of Sciences degree in Microbiology at the University of Surrey, U.K. then was awarded a Whitbread Scholarship to pursue her doctoral thesis on the molecular genetics of industrial yeast at the Cranfield Institute of Technology, Cranfield University, U.K. for which she was awarded Chancellors Gold Medal for the most outstanding graduate student of the year in 1990. She followed this with a two-year post-doctoral fellowship at the University of California in San Francisco (UCSF) before moving to Malaysia. After two short post-doctoral research fellowships at the University of Malaya, she joined TropBio Research Sdn. Bhd. as the head of the Molecular Biology Group, where she remained for about five years. This was followed by positions as an Associate Professor at University Putra Malaysia and then at the Malaysia University of Science and Technology (MUST). Prof Jenni returned to the University of Malaya, this time as an Associate Professor in April 2006, where she was the programme coordinator for B.Sc. Genetics and Molecular Biology from 2007 to 2009. Prof Jenni became head of the Centre for Research in Biotechnology for Agriculture (CEBAR) in 2009 then its Director when CEBAR received UMCoE status in 2013. Prof Jenni's contract as a full professor at the Institute of Biological Sciences, Faculty of Science, University of Malaya began in August 2011 and she currently holds dual appointments as a Professor in the Faculty of Science and as the Director of CEBAR, University of Malaya.

It's a small world after all: From microbiology to microRNA

Why microbiology matters

Microbiology – the study of microorganisms – has shaped human history and culture: Many ancient civilizations had some form of bread, fermented foods and either beer or wine, which were (and are often still) important parts of various cultures. In Malaysia we still find tapai, pau and thosai, to name a few. Microorganisms have also shaped history though devastating diseases including the potato blight that led to a million deaths from famine and millions of migrants leaving Ireland, and the Spanish influenza pandemic that cost more lives than the first world war. But it was the study of microorganisms that gave us vaccines, antibiotics and pathogen-derived crop protection, such as from the use of *Bacillus thuringiensis* (Bt) in both organic farming and as a basis of many genetically modified crops. Including eukaryotic cells, prokaryotic cells and viruses, microorganisms are a wonderful resource for fundamental molecular genetic research as well as for many biotechnological applications. It should not be a surprise then that study of microorganisms has been a major player in the understanding of the many roles of ribonucleic acid (better known as RNA) that have led to discovery of new methods for genome editing, to RNA silencing and microRNA in plants.

English "kampung" girl

Born in the city of Nottingham and raised in the beautiful English countryside in a small village (my "kampung") by a nurse and an engineer, I was bound to have a love for science and nature. I had a happy, carefree childhood, nurtured by loving parents and wonderful teachers, full of music and books and excellent British TV documentaries on science. Growing up I learned to play the piano and flute, but by my late teens I had decided that I could always be an amateur musician and that I wanted to be a professional biologist. It was on a train on the way to an interview for a place at the University of Surrey that I first met a Malaysian – a charming and friendly young girl named Yasmin. We ended up on the B.Sc. Microbiology degree course together and now, many years later are still good friends, colleagues and co-researchers. It's a small world.

Loves of my life

As part of my Bachelor's degree, I spent 12 months on industrial placement as a technician in the research division of Beecham Pharmaceuticals, a multinational pharmaceutical company. I loved being part of a research team and decided that's what I wanted to do and

furthermore that I must get a PhD if I wanted to lead my own research teams in the future.

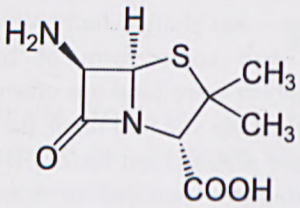


Fig.1. Research carried out by Beecham Pharmaceuticals led to the discovery of 6-aminopenicillanic (6-APA), the nucleus of the penicillin molecule. Work on new formulations of penicillin led to many important new antibiotics with broader spectrum anti-microbial activity.

My dreams became within reach thanks to the generosity of Whitbread U.K. I was granted a full industrial scholarship to pursue my PhD in Molecular Genetics at the Cranfield Institute of Technology, Cranfield University as it later became. I extended my knowledge of microbiology into the area of molecular genetics, working on industrial strains of yeast. Under a strong collaborative relationship between Cranfield and the University of Leicester, who at that time had many of the rising stars of gene cloning in the UK, I was seconded to the Leicester University Biocenter. It was there I was to meet the love of my life, a rather loud and irritating Malaysian boy called Hari who was studying for his PhD in the Botany Department at Leicester. He finally persuaded me to try some of his curries – a man who could cook something that amazing? – I was soon in love. I had found that I share a love of food with Malaysians! It's a small world.

Fig. 2. A brewing yeast stain with low starch-degrading activity (upper left) shows high starch degrading activity when expressing a wheat alpha amylase gene (lower panel), resulting in more efficient conversion of starch to sugar by yeast. (Harikrishna, PhD Thesis).

More Malaysian connections

Hari and I both graduated and we got married. Twice in fact! Once in Nottinghamshire, U.K. then again in Ipoh, Malaysia where Hari's parents were living at that time. Then we moved to California for post-doctoral training, myself at The University of California San Francisco (UCSF) and Hari at UC Davis. In California, I applied my knowledge on yeast molecular cloning to study enzymes involved in human steroid hormone synthesis.

This work in the lab of a remarkable pediatric endocrinologist and well-reputed research scientist, Professor Walter L. Miller, led to several research publications and two U.S.A. patents. During those years, Hari and I worked hard on the weekdays when we were apart, then made the most of the amazing Californian countryside for hiking on the weekends. Mostly Hari would come to San Francisco, but sometimes I went over to Davis and it was in Davis where we both met another Malaysian plant biologist, who was from the University of Malaya and on sabbatical at UC Davis. Professor Helen Nair was soon to be another good Malaysian friend, but we became friends in the USA. It's a small world.

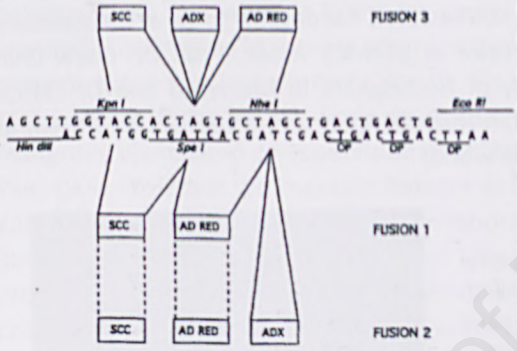
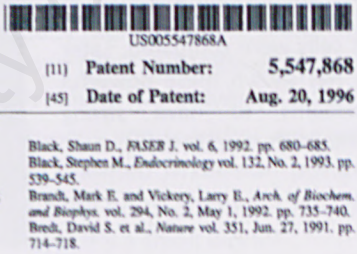


Fig. 3. The recombinant fusion of the human P450 with its electron donor resulted in higher efficiency conversion of cholesterol to metabolic intermediates. The two resulting patents are for the utility of these fusion enzymes for conversion of excess cholesterol in cells to intermediate compounds that can be cleared by the liver.



US005547868A

United States Patent [19]

Miller et al.

[11] **Patent Number: 5,547,868**

[45] **Date of Patent: Aug. 20, 1996**

[54] **CHOLESTEROL DISPOSAL FUSION ENZYMES**

[75] Inventors: **Walter L. Miller**, San Francisco, Calif.; **Jennifer A. Harikrishna**, Selangor, Malaysia; **Stephen M. Black**, San Francisco, Calif.

Black, Shaun D., *FASEB J.* vol. 6, 1992. pp. 680–685.
Black, Stephen M., *Endocrinology* vol. 132, No. 2, 1993. pp. 539–545.
Brandt, Mark E. and Vickery, Larry E., *Arch. of Biochem. and Biophys.* vol. 294, No. 2, May 1, 1992. pp. 735–740.
Bredt, David S. et al., *Nature* vol. 351, Jun. 27, 1991. pp. 714–718.

Back to the "Kampung"

After two and a half years of "honeymoon" we decided that it was time for us to start a family and that the USA would not be the best place for us to do that. Hari was offered a position at Golden Hope Plantations and I moved from the busy bustling city of San Francisco to the middle of an isolated oil palm plantation in Banting, Selangor. I was back in a kampung but have to say it was quite a culture shock! Our spacious bungalow had been empty for a few weeks and some locals had taken the opportunity to move in. These included a family of musang in the roof, an owl in a bedroom, numerous frogs and worst of, since I am an aracnaphobe, some frighteningly large spiders! We gradually reclaimed the place with the assistance of Mr Das, a skilled and indefatigable pest control expert (he

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still is our go to pest man today). But many of the frogs and spiders kept sneaking back in, also the odd centipede, monitor lizard and snake, especially in the rainy season! This may have been part of the motivation for my decision to get back to academic work, and it was our great friend Prof. Helen Nair who took me into her research group at the University of Malaya where I started working on bananas. Later an opportunity came along for me to join TropBio Research Sdn Bhd, a start-up plant biotech firm under Tan Sri Dato' Seri Dr Salleh Mohd Nor. I worked there for around five years on several research projects and helped in the coordination of two DANCED sponsored programmes with biotech companies in Denmark. At TropBio, I made many good friends among my colleagues, among them Dr. Kodisawaran Kandasamy (now at Bioeconomy Corp.), Prof. Fong Mun Yik (now at UMMC), Assoc. Prof. Dr. Chew Chin Foan (now at the University of Nottingham in Malaysia) and Dr Zaiton Ahmad (now at the Malaysian Nuclear Agency). I often run into them at various meetings – it's a small world!

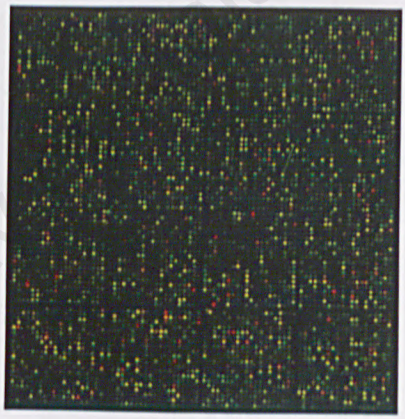

Fig. 4. My first cDNA microarray. Yeast were treated with tocotrienol extracts from oil palm and the RNA population from these and from untreated control yeast cells were compared. Later work has shown these powerful antioxidants to have strong benefits for human health.

From microbiology to microarray

At that stage of my career I was enjoying being involved in research, but felt that I really wanted an academic career. I joined Universiti Putra Malaysia (UPM) as an Associate Professor and also followed Hari on his sabbatical to MIT, Cambridge, USA where I spend a three-month attachment as a visiting scientist in the Lab. of Professor Chokyun Rha. It was there that I met many amazing and talented people including Nobel prize winners and of course a lot of Malaysians who were doing some great work over there (I later went on to collaborate with Dr Meilina Ong Abdullah on microRNA in oil palm). My MIT project involved using microarray to measure the effects of tocotrienols (antioxidant compounds that are in high concentrations in palm oil) on cell biology, using yeast as a

model. I enjoyed working on yeast again and was highly impressed by the teaching models and interdisciplinary interaction at MIT. So when I was offered an opportunity to join the newly established Malaysia University of Science & Technology (MUST), which was to offer MIT curricula for Mixed Mode Master's degree programmes, it was an opportunity I had to follow. From MIT back to Malaysia again – it's a small world!

Collaboration is key

Joining academia as an Associate Professor was not without challenges and during my years at UPM and while helping to set up the Biotechnology laboratories at MUST, many important research collaborations that were to boost my career were developed, thanks to wonderful colleagues in various other institutions. Those to whom I owe a massive thank you include Professor Dr. Ho Chai Ling at Universiti Putra Malaysia for collaborative work on abiotic stress gene discovery from mangrove plants, and co-supervision of Dr Nguyen Phuoc Dang and Yeen Yee; UKM Professor Wickneswari Ratnam and Assoc. Prof. Dr. Song Beng Kah (now at Monash University) for collaborative work on rice molecular genetics and co-supervison of Tan Pui Ling and John Keen Chubo; and Professor Yasmin Othman & Professor Norzulaani Khalid, still my colleagues at the University of Malaya, for collaborative work on plant-made proteins and co-supervision of the PhD candidate and now UM Professor, Chua Kek Heng as well as many more students since. My MUST colleagues Assoc. Prof. Dr. Lim Saw Hoon (now in Melbourne) and Assoc. Prof. Dr. Yeo Chew Chieng (now a Professor at Universiti Sultan Zainal Abidin (UniSZA)) were also my good friends and together we taught and supervised research projects for many talented Malaysian postgraduate students. Many MUST graduates have gone on to complete PhD degrees, some with me at the University of Malaya. It's a small world!

Fig. 5. A model of an anti-cucumber mosaic virus scFv (single chain) antibody made using pair-wise homology methods. Expression of synthetic antibodies and other peptides in plants can be used both towards crop protection (as in the case with CMV and other studies by our group with cymbidium mosaic virus) and as an alternative production system for veterinary and human therapeutics. (Chua, PhD Thesis).

Other important local and international collaborations

Through a network of colleagues and peers met at various scientific meetings, myself and other members of CEBAR have many productive linkages around the world. These include studies on microRNA related to cancer with Prof Dr Noor Hasima; microRNA in giant freshwater prawn with Associate Prof Dr Subha Bhassu; genomic studies on bananas, gingers and oil palm with Prof. Pat Heslop-Harrison (University of Leicester), Dr Mark Davey (KU Leuven), Dr Meilina Ong Abdullah (MPOB) and the team at Sime Darby Technology Centre (Drs Martti Tammi, David Appleton & Harikrishna), and on orchid with Dr Trude Schwarzacher (University of Leicester). Collaboration on bacterial toxin-antitoxin systems, driven by Prof Dr Yeo Chew Chieng from MUST, and now at UniSZA, have also been very enjoyable and productive, leading to two University of Malaya PhD graduates, Dr Chan Wai Ting and Dr Fauziah Abu Bakar, and a further MSc graduate, Ng Shet Lee.

Fig. 6. Although a bacterial toxin, YoeB protein causes apoptoptic-like cell death in transgenic Arabidopsis plants when its expression is induced. The plants can be "rescued" by co-expression of the cognate bacterial anti-toxin protein YefM demonstrating that both of these prokaryotic proteins function in eukaryotic (plant) cells (Abu-Bakar et al., 2015 & 2016).

Musical interlude

I grew up surrounded by the music of nature and of human creation. My parents to this day sing with their local choral society and my only sibling Martin sings with a Barber Shop group in Aberdeen, Scotland and still plays the clarinet. My daughters Anna and Melanie both sing and write songs. Anna, my older daughter and a mathematician has some cool pieces on Soundcloud and Melanie is training as a classical soprano in London. One of the joys of being in the University of Malaya is the richness of the academic breadth. Among the many treasures, we have a wonderful cultural centre led by the highly talented Associate Prof. Dr. Mohd Nasir Bin Hashim, and it has been a privilege for me to be able to join the University of Malaya Symphony Orchestra (UMSO) and play my

flute and piccolo with this wonderful group of musicians, including in the Royal Palace of our UM Chancellor and Patron, His Royal Highness Sultan Nazrin Muizzuddin Shah Ibni Almarhum Sultan Azlan Muhibbuddin Shah Al-Maghfur-Lah. Another connection I should mention here is that my late father-in-law, Dato' Dr Kulaveerasingam, another staunch supporter of my career, had his Perak Dato'ship bestowed by the late Sultan Azlan Shah at the same Palace where I performed with the UMSO (small world!). At this point I want to thank my musical mentors who include my parents and grandparents, my Sunday school teachers (especially Ruth Saywell) and teachers at the Nottingham Schools of Music, where I spent Saturday mornings from ages 12 to 18. Most of all I acknowledge the multitalented George Bradbury who could play everything woodwind and brass from piccolo to bassoon and trombone, but was first and foremost a flautist.

UM and research intensification

During my five years as an Associate Professor of Biotechnology at MUST, a strong research collaboration developed between myself and Professor Yasmin Othman. Due to retirement of some senior professors, there were opportunities at the Genetics department under the Institute of Biological Sciences and I started by teaching a few lectures whilst still academic staff of MUST. Then in 2006 I joined the University of Malaya as an Associate Professor in the Genetics programme. It was around this time that UM took up the challenge to place a strong focus on research excellence, so I found myself in a very supportive environment for establishing new research areas. The year 2006 was also a big year for small RNA. As not too many people were working in that area for tropical plants at that time, I used this as a basis for my many, many research proposals. Happily, some of these proposals were selected for funding and my work on small RNA began. I had entered into another small world!

What's happening? It's in our RNA!

Science is all about new knowledge and new ideas, and biology is especially complicated. As molecular biology and its tools developed, there was often a naivety that humans had "cracked the genetic code" and we'd soon know everything about the life sciences. How wrong that has turned out to be. Instead we find that the more we learn, the more complicated things are – probably why, despite what you might have heard, a great many scientists do believe in a supreme being. "It's in our DNA" has become a common phrase, but DNA is just a code, it is RNA and proteins that do the hard work in living cells and it turns out that RNA is a lot busier than people had previously thought. The study of RNA, or "transcriptomics", has been especially powerful as this gives us

information on how a living system is making developmental changes and /or responding to the environment. It was also soon understood that a lot of the RNA in cells does not encode proteins and many of these molecules, especially the small RNA molecules, change the way that genes work. It's a small world!

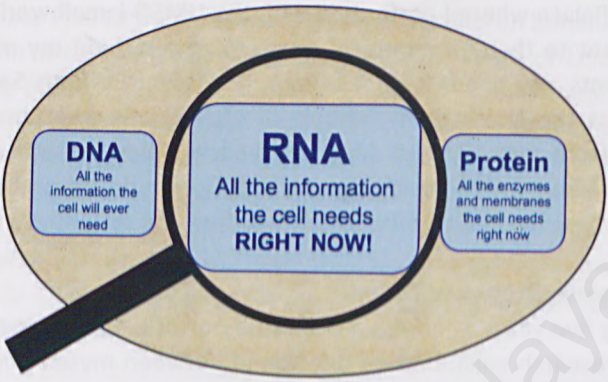

Fig. 7. Transcriptomics – the study of all the RNA in a biological sample - provides a "snapshot" of what proteins the cells are likely to make, from which we can infer functional information. High-throughput sequencing techniques have made this technology more accessible and led to many useful discoveries.

Silence is golden

One of the important biological roles of small RNA is RNA silencing, also known as RNA interference. In this process, the volume of gene expression (essentially, the amount of an encoded protein made from the gene) is turned down or even turned off. As this is very specifically directed by the RNA sequence, scientists can predict which genes will be turned off by a particular RNA sequence. This is not only a fascinating area of interest for research, but also has some very practical uses as a tool of biotechnology, because if we know a gene sequence, we can selectively turn off that gene, or a whole set of genes using RNA silencing technology. In plants, the first scientifically reported observations of RNA silencing were in virus-infected plants, where mild strains of virus could result in a kind of plant "immunity". Although the mechanisms were not understood, the phenomenon was effectively used in crop protection. Many years later when gene-cloning technology became available, researchers were surprised when their attempt to add colour to petunia flowers had the opposite effect, a phenomena they named "co-suppression". It was later shown that the culprit behind such gene silencing was small double-stranded RNA, science that won the 2006 Nobel Prize in Physiology or

Medicine for Andrew Fire and Craig Mello. While it was a disappointment that the researchers who had shown the same thing in plants (and had actually reported this earlier) could not win the award, as there is no Nobel prize for plant sciences, the British team of David Baulcombe and Andrew Hamilton were smart enough to be the first to file a patent in the area and later, Sir David Baulcombe was knighted by Queen Elizabeth II in recognition of his work on RNA silencing in plants. Small RNA, big rewards.

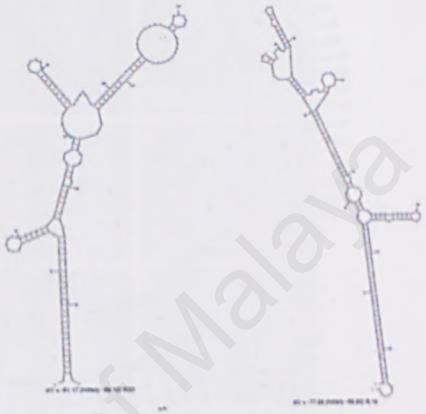

Fig. 8. Secondary structure predictions for two of six precursors for microRNA172 (mir172) found in RNA from oil palm. This highly conserved gene family has important roles in flower development in plants. In this study it was found that some gene family members are expressed in other tissues such as leaf and root in oil palm (Mehrpooyan, Othman & Harikrishna 2012).

Small RNA discovery in topical plants

My own research on small RNA started by identifying a type of small RNA known as "microRNA" in plants that are important to Malaysia and in other tropical countries. The study of microRNA is important, as it is now known that microRNAs control the expression of genes that regulate plant development and responses to stress from the environment and from pests and diseases. Understanding which genes are involved in the processes of development and stress responses, and how they are regulated can help address sustainable food production in crops. My group has studied microRNA and RNA silencing in bananas (the most widely consumed fruit in the world), oil palm (the most productive oil crop in the world and literally the largest crop in Malaysia) and orchids (the most beautiful crop in Malaysia and loved the world over). Together with my colleagues and students we have discovered many novel microRNA genes and their functions related to abiotic stress induced by salinity treatment of banana and to flowering in oil palm. Our studies continue, with an aim that the knowledge we are generating supports the development of more sustainable crops in the face of diminishing agricultural land and climate change. We believe these to be important

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goals, because we all share this one planet and should remember that we live in a small world.

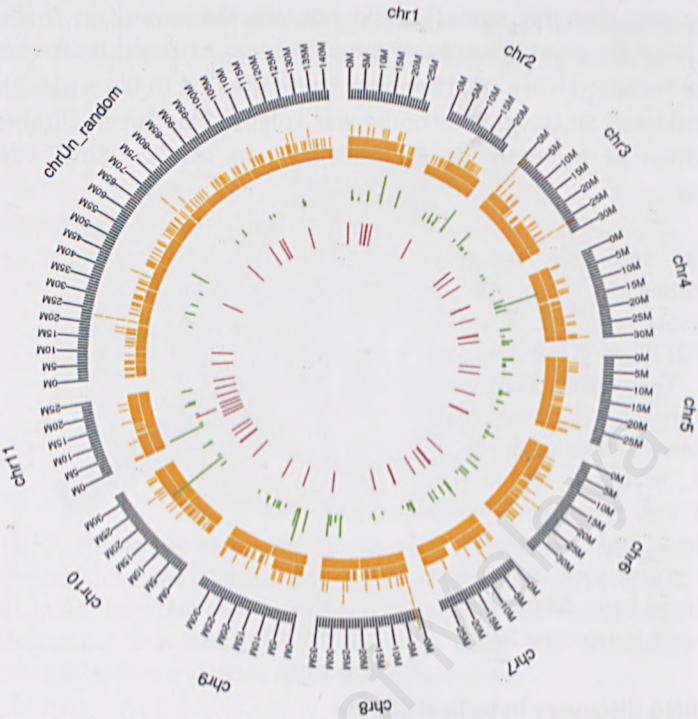

Fig. 9. Mapping small RNA in the banana genome. The outer circle is a map of the banana chromosomes (DNA), yellow indicates the messenger RNA being made in roots, green indicates the orthologous microRNA and red the banana specific microRNA (Lee et al., 2015).

Small RNA in biotech

While studying small RNAs, our group was also fascinated with the possibilities to use small RNA-mediated gene silencing for crop improvement. We won a few small grants to support research on orchids that also allowed me to involve some more work with microbes. We studied the use of double-stranded RNA (dsRNA) made in bacteria for its ability to inhibit infection of tissue cultured orchid plants by Cymbidium Mosaic Virus. To our delight, the results were impressive and resulted in a patent. We furthered the work by testing the same approach for silencing orchid genes during flowering. The method we use is more rapid and less costly than developing transgenic plants and also means that we can alter gene expression without using transgenic plant varieties, which are still restricted in application in many countries. So far, we have shown that the direct application of dsRNA can change the expression of orchid genes, but are still looking for the best gene for increasing the value of the

flowers. Perhaps it is fate that to see the changes in the petals, we had to use an electron microscope to view the cells on the petal surface; the changes were small but very real. It's a small world.

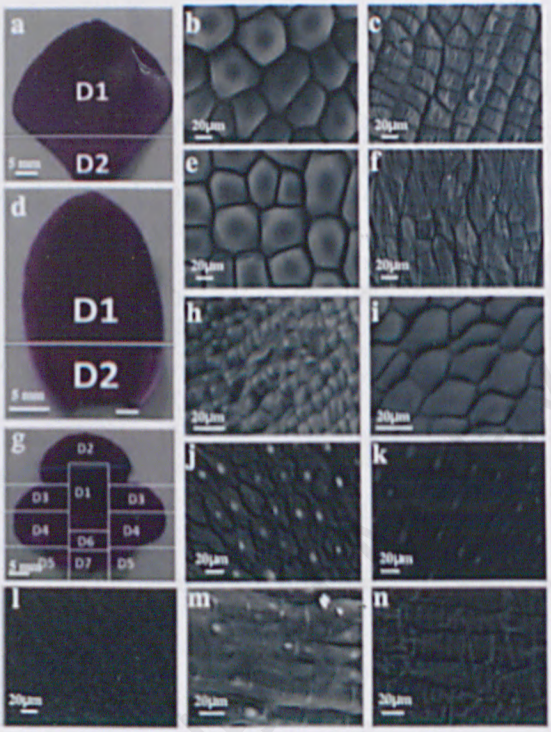

Fig. 10. Characterisation of the epidermal cells in flowers of Dendrobium Orchid (SEM 400 x magnification). Above: A total of seven different domains (areas which show one type of cell shape) were identified. The unique labellum (lip) of the orchid flower was the only part of the flower with conical epidermal cells (Lau et al., 2015).

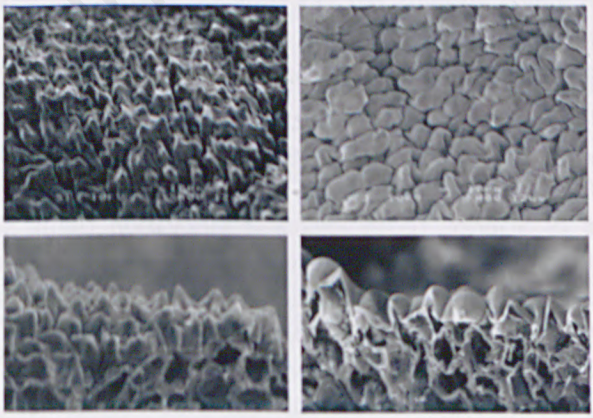

Fig. 11. Treatment of developing flower buds with dsRNA of the transcription factor dhMYB1, resulted in the conical cells of the lip (control in left panels) becoming flattened (treated cells in right panels) (Lau et al., 2015).

Curriculum matters

My progress at the University of Malaya has been made possible by the support I have within the Institute of Biological Sciences and the Faculty of Science. I really enjoy teaching and am constantly learning more and improving both as a scientist and mentor though my interactions with the undergraduate and postgraduate students of the University of Malaya. As a B.Sc. programme coordinator previously and as a constant member of teams involved in curriculum development, I experience both the challenges and opportunities of the changing face of higher education. I want to thank ADEC for their support, especially in the earlier years, when eLearning was a suggestion and not well taken up, that they assisted me to get my courses online. While often uncomfortable, change is essential and new methods of information exchange and delivery require new curricula. I have been blessed to be surrounded by colleagues in genetics and at CEBAR who have passion for teaching as well as research and are wonderful to work with.

The Centre for Research in Biotechnology for Agriculture

The Centre for Research in Biotechnology for Agriculture (CEBAR) was formed in 2005 as an initiative to bring together UM academics with an interest in applications of biotechnology to agriculture. First headed by Professor Yasmin then by Professor Norzulaani, as each of them went on to take up senior positions (Yasmin at the Ministry of Science Technology and Innovation, later as assistant deputy vice chancellor and Norzulaani as a Cluster Dean, then later head of UMCares), it fell to me to take over as head of CEBAR in 2009. I had tremendous support from the team within CEBAR, both academic and some wonderful support staff as well as enthusiastic students. Here I must give a special mention two amazing ladies who were pivotal to the early years of CEBAR and especially the commissioning and running of the Plant Biotech Facility (PBF); Pn. Akmal Adilah (now at UMP) and Ms. Lau Su Ee, my former MSc student and current Research Officer at CEBAR. CEBAR has also always been well supported by senior management at UM. This support was crucial for the establishment of the Plant Biotech Facility, the first (and still the only) internationally certified plant biosafety facility in Malaysia, opened by the Honourable Minister of Science Technology and Innovation Datuk Seri Panglima Maximus Johnity Ongkili in December 2009. In 2013, based on the MyRA data contributed to the University of Malaya by CEBAR, the centre was recognized by University top management as a University of Malaya Centre of Excellence. Today, the tremendous support from above and below me continues to drive CEBAR. Our team has been joined by

energetic early career researchers in the form of post-doctoral fellows and new lecturers who work closely in teams with senior colleagues and students to contribute in the areas of training, technology development and outreach with a mission "to be at the forefront in generating and disseminating scientific idea and knowledge in biotechnology research relevant to support a sustainable agriculture bioeconomy". I certainly can't take all the credit, but am none the less very proud to be a part of a team that is producing highly cited research papers, well trained biotechnologists, intellectual property and biotechnological applications with very real applications to the local agricultural sector.

Ongkili (dua, kanan) menandatangani plak perasmian PBF sambil diperhatikan Ghauth (kiri), Jennifer (dua, kiri) dan Arshad (kanan) di Kuala Lumpur, semalam.

Sinar Harian, 2nd December 2009

Where next?

It is a privilege and an honour to be an academic at the University of Malaya, but it is not the buildings that make it so. It is the wonderful academic and support staff and the amazing young minds that come to learn from us and to challenge us. We each may only be able to contribute a small part of the answers to the big questions of science, but, if we work together, as a Malay proverb says:

"Sedikit-sedikit, lama-lama, jadi bukit"

The challenges facing all of us are great and require all the best minds and ideas to find workable solutions. It is my firm belief that we can achieve the best results by working together regardless of age, race or creed – it's a small world!

An English pantun...

Small organisms and small RNA
Powerful forces in life and history
From England so long I have been away
Malaysia, no longer to me a mystery

Live as if you were to die tomorrow.
Learn as if you were to live forever.
Mahatma Gandhi

Acknowledgements

I have been very fortunate to have worked with many wonderful colleagues and students. The grants, papers, intellectual property and degrees earned and listed in my CV below, would not have been possible without the tremendous support from many others.

Last, but never least, I thank my family, especially my parents Alan and Margaret Kirkham, parents-in-law, Datuk Dr K Kulaveerasingam and Datin Neela Rajaratnam, husband, Hari and lovely daughters Anna and Melanie. I am also supported by a wonderful lady we know as "Gellie", an amazing home manager for us for over 20 years now. I also have faithful support from my extended family that reaches from UK, via Malaysia to Australia. Without a doubt, it really is a small world.

University of Malaya

CURICULUM VITAE

Professor Dr Jennifer Ann Harikrishna

Education

PhD Molecular Genetics, Cranfield University, U.K. (1990)

BSc (Hons) Microbiology, University of Surrey, U.K. (1985)

Professional Experience

Professor of Genetics, Institute of Biological Sciences, Faculty of Science, &Director of the Centre for Research in Biotechnology for Agriculture &University of Malaya, 2011 – present

Associate Professor, University of Malaya, 2006 – 2011

Administrative Head of the Centre for Research in Biotechnology for Agriculture, University of Malaya 2009 - 2011

Associate Professor, Malaysia University of Science and Technology 2002 – 2006

Associate Professor, Universiti Putra Malaysia 2001 – 2002

Head of Molecular Biology, TropBio Research Sdn Bhd 1996 – 2001

Post-Doctoral Research Fellow, University of Malaya 1995 – 1996 and 1991 – 1992

Post-Doctoral Research Fellow, University of California, San Francisco, U.S.A. 1989 – 1991

Industrial PhD studentship 1985 – 1989

Research Scientist, Beecham Pharmaceuticals (Smith Kline Glaxo Group), U.K. 1983 – 1984

Selected Publications

(During appointment at the University of Malaya)

Mazumdar P, Othman R.Y, Mebus K. Ramakrishnan N., Harikrishna J.A. (2017). Codon usage and codon pair patterns in non-grass monocot genomes. Annals of Botany (in press).

Gan K. S., Tan C. S., Othman R. Y. & Harikrishna J. A. (2017). Transient expression of an immunogenic envelope attachment glycoprotein of nipah virus in *Nicotiana benthamiana*. Sains Malaysiana (in press).

University of Malaya

Qi Bin Kwong, Ai Ling Ong , Chee Keng Teh, Fook Tim Chew , Martti Tammi, Sean Mayes, Harikrishna Kulaveerasingam, Suat Hui Yeoh, Jennifer Ann Harikrishna &David Ross Appleton (2017). Genomic Selection in Commercial Perennial Crops: Applicability and Improvement in Oil Palm (*Elaeis guineensis* Jacq.) Scientific Reports 7: 2872.

Jennifer Ann Harikrishna, Rofina Yasmin Othman, Muhamad Shakirin Mispan, Sadia Iqbal and Yong Han and Michael G. K. Jones (2017). Biosafety of RNA silencing and genome editing technologies in crop plants: Malaysian and Australian research perspectives. Asia-Pacific Journal of Molecular Biology and Biotechnology (in press).

Ho, H., Gudimella, R., Ong-Abdullah, M. and Harikrishna, J. A. (2017). Expression of microRNAs during female inflorescence development in African oil palm (*Elaeis guineensis* Jacq.).Tree Genetics & Genomes 13: 35.

Harikrishna, J.A., Lee, W.S., Gudimella, R., Khalid, N. and Davey, M.W. (2016). The banana salt stress transcriptome: large and small RNA expression in stressed banana. Acta Hortic. 1114, 125-132.

Gaurav Sablok, Antonio J. P rez-Pulido, Thac Do, Tan Y. Seong, Carlos S. Casimiro-Soriguer, Nicola La Porta, Peter J. Ralph, Andrea Squartini, Antonio Mu oz-Merida and Jennifer A. Harikrishna (2016). PlantFuncSSR: Integrating First and Next Generation Transcriptomics for Mining of SSR-Functional Domains Markers. Frontiers in Plant Science doi: 10.3389/fpls.2016.00878

Shet Lee Ng, Jennifer Ann Harikrishna, Fauziah Abu Bakar, Chew Chieng Yeo and Thye San Cha (2016). Heterologous expression of the *Streptococcus pneumoniae* yoeB and pezT toxin genes is lethal in *Chlorella vulgaris*. ALGAL Research 19, 21-29

Theresa Lee Mei Ng, Rezaul Karim, Yew Seong Tan,Huey Fang Teh, Asma Dazni Danial, Li Sim Ho, Norzulaani Khalid, David Ross Appleton, and Jennifer Ann Harikrishna (2016). Amino acid and Secondary Metabolite Production in Embryogenic and Non-Embryogenic Callus of Fingerroot Ginger (*Boesenbergia rotunda*) PLOS ONE, PONE-D-16-05249R1

Fauziah Abu Bakar , Chew Chieng Yeo and Jennifer Ann Harikrishna (2016). Neutralization of YoeBSpn toxicity and enhanced plant growth in Arabidopsis thaliana via co-expression of *Streptococcus pneumoniae*-encoded yoeBSpn toxin and yefMSpn antitoxin. International Journal of Molecular Sciences 17, 321

Huili Ho, Joel Zibin Low, Ranganath Gudimella, Martti Tapani Tammi and Jennifer Ann Harikrishna (2016). Expression patterns of inflorescence- and sex- specific transcripts in male and female inflorescences of African oil palm (*Elaeis guineensis* Jacq.) Annals of Applied Biology 168, 274–289

R. Karim, M. Nuruzzaman, N. Khalid & J.A. Harikrishna (2016). Importance of DNA and histone methylation in in vitro plant propagation for crop improvement: A review. Annals of Applied Biology 169 (1), 116

Chew Chieng Yeo, Fauziah Abu Bakar, Wai Ting Chan, Manuel Espinosa and Jennifer Ann Harikrishna (2016). Heterologous Expression of Toxins from Bacterial Toxin-Antitoxin Systems in Eukaryotic Cells: Strategies and Applications. Toxins 8, 49

Wan Sin Lee, Ranganath Gudimella, Gwo Rong Wong, Martti Tapani Tammi, Norzulaani Khalid, Jennifer Ann Harikrishna (2015). Transcripts and microRNAs responding to salt stress in *Musa acuminata* Colla (AAA Group) cv. Berangan roots. PLoS ONE 10(5): e0127526

Su-Ee Lau, Trude Schwarzacher, Rofina Yasmin Othman and Jennifer Ann Harikrishna (2015). dsRNA silencing of an R2R3-MYB transcription factor affects flower cell shape in a Dendrobium hybrid. BMC Plant Biology 15:194

Bakar FA, Yeo CC, Harikrishna JA (2015). Expression of the *Streptococcus pneumoniae* yoeB Chromosomal toxin gene causes Cell Death in the model plant Arabidopsis thaliana. BMC Biotechnology 15(1):26.

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Noor Diyana Md-Mustafa, Norzulaani Khalid, Huan Gao, Zhiyu Peng, Mohd Firdaus Alimin, Noraini Bujang, Wong Sher Ming, Yusmin Mohd-Yusuf, Jennifer A Harikrishna and Rofina Yasmin Othman (2014). Transcriptome profiling shows gene regulation patterns in a flavonoid pathway in response to exogenous phenylalanine in *Boesenbergia rotunda* cell culture. BMC Genomics 15:984.

S. E. Lau, P. Mazumdar, T. W. Hee, A. L. A. Song, R. Y. Othman, J. A. Harikrishna (2014). Crude extracts of bacterially expressed dsRNA protect orchid plants against cymbidium mosaic virus during transplantation from in vitro culture. Journal of Horticultural Science & Biotechnology. 89 (5) 569-576.

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Tian Tian Tan, Maoshan Chen, Jennifer Ann Harikrishna, Norliana Khairuddin, Maizatul Izzah Mohd Shamsudin, Guojie Zhang and Subha Bhassu (2013). miRNAs in gill and hepatopancreas of giant freshwater prawn. Fish and Shellfish Immunology 35 (2013) 1061e1069

The Efficacy of Molecular Markers Analysis with H. Y. Yeap, G. Faruq, H. P. Zakaria, and J. A. Harikrishna (2013). Integration of Sensory Methods in Detection of Aroma in Rice. The Scientific World Journal Volume 2013, Article ID 569268, 6 pages http://dx.doi.org/10.1155/2013/569268

Sher Ming Wong, Nursafina Salim, Jennifer Ann Harikrishna, and Norzulaani Khalid (2013). Highly efficient regeneration via somatic embryogenesis from cell suspension of *Boesenbergia rotunda*. In vitro cellular and development – plant 49: 665-673

Sablok G, Harikrishna JA, Min XJ (2013). Next Generation Sequencing for Better Understanding Alternative Splicing: Way Ahead for Model and Non-Model Plants. Transcriptomics 1: e103. doi:10.4172/toa.1000e103 (editorial).

Mehrpooyan F, Othman, RY and Harikrishna JA (2012). Tissue and temporal expression of miR172 paralogs and the AP2-like target in Oil Palm (*Elaeis guineensis* Jacq.). Tree Genetics and Genomes Volume 8, Issue 6 (2012), Page 1331- 1343.

Yee-Song Law, Ranganath Gudimella, Beng-Kah Song, Wickneswari Ratnam and Jennifer Ann Harikrishna (2012). Molecular Characterization and Comparative Sequence Analysis of Defense-Related Gene, *Oryza rufipogon* Receptor-Like Protein Kinase 1. Int. J. Mol. Sci. 13, 9343-9362.

Lee Wan Sin, Leong Pei Li, Ho Chai Ling and Jennifer Ann Harikrishna (2011). Identification of microRNA precursors in *Bruguiera* spp. Botanica Marina 54: 313-324

Yong SYC, Choong CY, Cheong PL, Pang SL, Nor Amalina, R, Harikrishna JA, Mohd MNI, Hedley P, Milne L, Vaillancourt R, Wickneswari R (2011). Analysis of ESTs generated from inner bark tissue of an *Acacia auriculiformis* x *A. mangium* hybrid. Tree Genetics and Genomes 7:143 152

Wai Ting Chan, Concha Nieto, Jennifer Ann Harikrishna, Seok Kooi Khoo, Rofina Yasmin Othman, Manuel Espinosa and Chew Chieng Yeo (2011). Genetic Regulation of the yefM-yoeBSpn Toxin-Antitoxin Locus of *Streptococcus pneumoniae*. J. Bacteriol. 193(18):4612

Faruq Golam, K. NorZulaani, A. H. Jennifer, B. Subha, M. Zulqarnain, Mohamad Osman A. M. Nazia, M. Zulqarnian and O. Mohammad (2010). Evaluation of kernel elongation ratio and aroma association in global popular aromatic rice cultivars in tropical environment. African Journal of Agricultural Research 5(12) pp. 1515 - 1522

Harikrishna, J.A., Miin, D.O.J., Lian, A.S.A., Dzulkurnain, A., Othman, R.Y., Hoon, L.S. (2010). Biotechnological approaches to protection against cymbidium mosaic virus.

Asia-Pacific Journal of Molecular Biology and Biotechnology. Volume 18, Issue 1, 2010, Pages 179-182

Chee How Teo, Han Pin Pui, Rofina Yasmin Othman and Jennifer Ann Harikrishna (2010). Comparative analysis of Argonaute gene sequences in bananas (*Musa* sp.) shows conserved species-specific Ago-7 PIWI domains. Genetic Resources and Crop Evolution (first online 2 October 2010) DOI: 10.1007/s10722-010-9614-0

Sivakumar Paramasivam, Yee Song Law, Chai-Ling Ho and Jennifer Ann Harikrishna (2010). High frequency plant regeneration from mature seed of elite, recalcitrant Malaysian indica rice (*Oryza sativa* l.) Cv. MR219. Acta Biologica Hungarica 61 (3): 313-321

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Nguyen, P.D., Ho, C.-L., Teo, S.-S., Harikrishna, J.A., Rahim, R.A. (2008). Sequence and transcript analyses of antioxidant genes from *Acanthus ebracteatus* Vahl. Tree Genetics & Genomes, 4(4):705-713

Wong, Y.Y., Ho, C.L., Nguyen P.D., Teo, S.S., Harikrishna, J.A., Raha A. R. and Wong, M. V.L. (2007). Isolation of salinity tolerant genes from the mangrove plant, *Bruguiera cylindrica* (L.) Blume by using suppression subtractive hybridization (SSH) and bacterial functional screening. Aquatic Botany 86: 117- 122

Nguyen P.D., Ho C.-L. , Harikrishna, J.A., Wong, M. V.- L., and Raha A. R. (2007). Functional Screening for Salinity Tolerant Genes from *Acanthus ebracteatus* Vahl using *Escherichia coli* as a host. Trees 21: 515-520

Nadirah Md Nasaruddin, K.Harikrishna, Rofina Yasmin Othman, Lim Saw Hoon and Jennifer Ann Harikrishna (2007). Computational prediction of microRNAs from Oil Palm (*Elaeis guineensis* Jacq.) expressed sequence tags (ESTs). Asia Pacific Journal of Molecular Biology and Biotechnology 15: 107-113

Diana Ooi Jia Miin, Adriya Zulqurnain, Rofina Yasmin Othman, Lim Saw Hoon and Jennifer Ann Harikrishna (2006). Use of superparamagnetic beads for the isolation of a peptide with specificity to Cymbidium Mosaic Virus (CymMV). Journal of Virological Methods, Volume 136(1-2). 160-165

Nguyen Phuoc Dang, Chai Ling Ho, Jennifer Ann Harikrishna, Michael C.V.L. Wong, Raha Abdul Rahim (2006). Generation and Analysis of Expressed Sequence Tags from the Mangrove plant, *Acacnthus ebracteatus* Vahl. Tree Genetics and Genomes 2 (4), 196-201

University of Malaya

Research Grants

(during appointment at the University of Malaya)

Ongoing

Investigation into the role of R2R3 MYB transcription factors related to flower shape and colour in Dendrobium orchids. September 2017 – August 2019. FRONTIER RESEARCH GRANT (FRG) Frontier Science Research Cluster, University of Malaya.

Development of a DNA-free genome editing platform for banana and its use to develop an abiotic stress tolerant banana line via null mutation of mac-MiR6. August 2017 - February 2020. FRGS (MOHE).

Biosafety and Biosecurity for Agriculture. 2015 – December 2017. CEBAR-RU (MOHE).

IRU-MRUN Collaborative Research Programme: Emerging viruses in agriculture: Development of a network for biosecurity and biosurveillance to support food security Principal Investigator(PI). 2015 – December 2017. UM-Latrobe-Murdoch (IRU-MRUN).

Completed (2006-2016)

Exploring the Molecular basis of Recalcitrance to Plant Regeneration in the Model Medical Ginger *Boesenbergia rotunda*. Principal Investigator (PI). 2013 – 2016. UM- HIR (MOHE).

Banana as a model for systems biology of abiotic stress: functional analysis of novel genes, small RNAs and their pathways in a local banana (*Musa acuminata* cv Berangan). Principal Investigator (PI). 2013-2016 UMRG (MOHE)

Sustainable and Inclusive Innovation in Agricultural Biotechnology: A Pilot Project to Determine the Potential for Reverse Engineering of Molecular Tools for Supporting Agriculture for the Orang Asli of Peninsular Malaysia Program Leader. 2012 – 2015. UMBIO – Flagship (MOHE).

Using an inducible Expression System to Investigate the Effect of Expressing the Bacterial Pezt Toxin of the Pezt- Peza Toxin-antitoxin System. Principal Investigator (PI). 2012 – 2014. ERGS (MOHE).

Development of Cell Ablation System for Restriction of Pollen Flow and Development of Male Sterile Line for Hybrid Rice Development. Principal Investigator (PI). 2012 – 2014. eScience (MOSTI).

Development of viral expression vector system for production of high-value peptides and proteins in banana biomass post fruit harvest. Principal Investigator (PI) 2012 – 2014. UMRG.

Establishment of a banana model for investigation of small RNA associated epigenetic modification during tissue culture. Principal Investigator (PI) 2011 – 2013. FRGS (MOHE).

Developing targets for shortening the juvenile period of oil palm through microRNA, Principal Investigator (PI), 2009-2011, Guthrie (Sime Darby)

Identification of microRNA related to stress and development in banana, Principal Investigator (PI), 2009-2012

Development of Novel Molecular targets for the control of Ganoderma through exploitation of omic data on Oil Palm-*G.Boninense* interactions, Co-Investigator, 2009-2010, Guthrie (Sime Darby)

An investigation of the roles of MYB transcription factors in flower development in orchid, Principal Investigator (PI), 2008-2010, FRGS (MOHE).

Biotechnology and Genetics for the Improvement for the Malaysian Giant Freshwater Prawns, *M.rosenbergii*, Co-Investigator, 2008-2011, MOSTI

Understanding of critical biomolecular pathways involved in the expression of single chain antibodies (ScFv) against Cucumber Mosaic Virus (CMV) in *E.coli*, using DNA microarray technology 02-02-05-SF0023, Co-Investigator, 2007-2008, MOSTI

Variation of bending capacity along the lamina length of rice 05-02-05-SF0022, Co-Investigator, 2007-2008, MOSTI

An investigation of the roles of MYB transcription factors in flower development in orchid (*Dendrobium* sp.), Principal Investigator (PI), 2007-2008, Geran Khas Universiti Malaya

ABI (P)-1 Molecular markers for quality control of clonal oil palm, Subproject 2.1; Global functional screening, Principal Investigator(PI), 2006-2009, MOSTI

Biomining for miRNA genes related to stress in banana roots (RMK9), Principal Investigator (PI), 2006-2008, MOSTI

Development and Deployment of A Wireless Sensor Network For Precision Agriculture 05-02-05-SF0011, Co-Investigator, 2006-2008, MOSTI

ABI (P)-8 Identification of Yield Related QTLs And Genes for Improvement of Malaysian Rice Cultivars, Sub-project 3 Transcriptomic analyses of rice grain filling, Coordinator, 2006-2009, MOSTI

Selected Awards

Gold Medal, University of Malaya Research, Invention & Innovation Expo 2010

Gold Medal, University of Malaya Research, Invention & Innovation Expo 2009

Gold Award, BioInno Awards, BioMalaysia 2008

Gold Award, Industrial Designs and Technology Exhibition (ITEX), 2008

Bronze Award, 33rd International Exhibition of modern inventions, Geneva, Switzerland, 2005

Bronze Award, Industrial Designs and Technology Exhibition (ITEX), 2004

Bronze Award, Pameran Reka Cipta & Penyelidikan, University Putra Malaysia, Selangor, Malaysia, 2003

The Lord Kings Norton Gold Medal, Cranfield University, 1990

Whitbread & Co. plc Ph.D. Scholarship, Whitbread & Co. plc (UK), 1985

Intellectual Property Rights

W.L.Miller, J.A.Harikrishna and S.M.Black (1996). Cholesterol disposal fusion enzymes. USA Patent, 5,547,868, 1991

W.L.Miller, J.A.Harikrishna and S.M.Black (1999). Cholesterol disposal fusion enzymes. USA Patent, 5,939,318, 1994

Rofina Yasmin Binti Othman, Chua Kek Heng, Norzulaani Binti Khalid, Jennifer Ann Harikrishna (2004) A method for constructing recombinant soluble flag tag single chain variable fragment (scFv) against cucumber mosaic virus (CMV), Malaysian Patent, PI20051184

Jennifer Ann Harikrishna &Rofina Yasmin Binti Othman (2009) Plant Virus Protection Solution, Malaysian Patent, PI 2009 3882

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2015) CEBAR Plant Biotech Facility Standard Operation Procedure 13: Operation of Bleach Sterilizer (training video) copyright registration FM2015002695

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2015) CEBAR Plant Biotech Facility Standard Operation Procedure 14: Spill Management (training video) copyright registration FM2015002696

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2015) CEBAR Plant Biotech Facility Standard Operation Procedure 15: Emergency Management (training video) copyright registration FM2015002697

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2015) CEBAR Plant Biotech Facility Fire Drill Video (training video) copyright registration FM2015002698

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2016) CEBAR Plant Biotech Facility Standard Operation Procedure 6: Gowning and De-gowning (training video) copyright registration DV2014002340

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2016) CEBAR Plant Biotech Facility Standard Operation Procedure 7: Transfer of Genetic Modified Organism (GMO) (training video) copyright registration DV2014002341

University of Malaya

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2016) CEBAR Plant Biotech Facility Standard Procedure 11: Operation of Autoclave. Copyright registration DV2014002343

Jennifer Ann Harikrishna, Lau Su Ee, Zarina Binti Md Ali (2016) CEBAR Plant Biotech Facility Standard Operation Procedure 12: Waste Management.Copyright registration DV2014002344

Jennifer Ann Harikrishna, Rofina Yasmin Othman &Lau Su Ee, (2016) dsRNA silencing of an R2R3-MYB transcription factor affects flower cell shape in a Dendrobium hybrid. Copyright registration LY2015002726

Postgraduate student supervision

PhD (Completed):

Md. Rezaul Karim, University of Malaya (2017)
Mohtaram Mahmoudieh Koravieh University of Malaya (2017)
Fauziah Binti Abu Bakar, University of Malaya (2017)
Wong Sher Ming, University of Malaya (2016)
Lee Wan Sin, University of Malaya (2015)
Chan Wai Ting, University of Malaya (2011)
Nguyen Phuoc Dang, UPM, (2005)
Chua Kek Heng, University of Malaya (2003)

MSc (Completed):

Ng Shet Lee, University of Malaya (2017)
Lau Su Ee, University of Malaya (2013)
Adriya Dzulkkurnain, University of Malaya (2013)
Tan Tian Tian, University of Malaya (2012)
Yeap Hui Yin, University of Malaya (2012)
Alireza Saeidi, Molecular Analysis of Transgenic Rice. University of Malaya (2011)
Syed Hossein Beheshti, University of Malaya (2011)
Law Yee Song, University of Malaya (2010)
(Sahar) Fatemeh Mehrpooyan, University of Malaya (2010)
Faiza Binti Omar, University of Malaya (2009)
Hee Teng Wei, University of Malaya (2008)
Wong Yeen Yee, UPM (2005)
Tan Pui Ling, UKM (2005)
John Keen Chubo, UKM(2004)

M. Bioinformatics (Completed)

Sri Devi Ramaroa, University of Malaya (2012)

University of Malaya

M. Biotechnology (Completed)

Nor Kamila Kamaruzaman. University of Malaya (2011)

Tan Yew Seong, University of Malaya (2010)

Janice Khor Sheau Sean, (2009)

Pui Han Pin, (2009)

Jennifer Vincent, University of Malaya (2008)

M.Sc (Biotech) from Malaysia University of Science & Technology (completed):

Adeline Song Ai Lian, (MUST, 2006)

Siong Jong Hang, (MUST, 2006)

Teoh Yeam Chuan, (MUST, 2006)

Ho Hui Li, (MUST, 2006)

Yap Gaik Chin, (MUST, 2006)

Diana Ooi Jia Miin, (MUST, 2005)

Lim Choon Ping, (MUST, 2005)

Nital Lalitkumar Patel, (MUST, 2005)

Mori Tetsushi, (MUST, 2004)

Wong Poi See, (MUST, 2004)

Chong Sun Li, (MUST, 2004)

Wong Sie Chuong, (MUST, 2004)

Tan Yong Leh, (MUST, 2004)

PhD (on-going at University of Malaya):

Ho Hui Li, (Submitted)

Gudimela Ranganth

Gan Khai Swan

Arinaitwe Ivan Kabiita

Jasdeep Kaur A/P Darsan Singh

Joel Low Zi-Bin

Kwong Qi Bin

Narendren A/L Rengasamy

Tan Yew Seong

PhD (on-going, under co-supervision, registered in other Universities:

Khew Choy Yuen, PhD candidate registered at Swinburne University, Sarawak

Mohana Eswari Ragu, PhD candidate registered at Monash University, Malaysia

MSc (on-going at University of Malaya):

Theresa Ng Lee Mei (thesis submitted)

Wong Gwo Rong

University of Malaya