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APJ Abdul Kalam: The People's President

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

Some grassroots level engagement with students on biotechnology

Dr. R. Gopichandran

Sincere thanks to the Department of Biotechnology and the Department of Science and Technology for giving Vigyan Prasar the chance to assist in preparations for the Science Express. We could connect with some leading scientists across India to gather communication materials, edit, and get their okay to arrive at the launch-ready condition. It was truly inspiring to experience the zeal, clarity and tenacity of purpose of scientists who have contributed to the collection of materials. This activity also helped us know in greater detail than before about some important initiatives in progress in our country that connect with students in significantly large numbers about biotechnology.

It is important to take note of the humungous efforts of the stated departments through formal and non-formal systems to reach out to students across the country. The INSPIRE (Innovation in Science Pursuit for Inspired Research) programme of the DBT represents the intent and tangible outcomes of this initiative. The DBT seeks to strengthen undergraduate education in life sciences and with a special focus on the North Eastern region of our country. One of the most important interfaces of biotechnology with bio-resources is to understand qualitative and quantitative diversity and related ecological dynamics. Empirical evidences about their occurrence, distribution, ecological considerations and related responses at the individual and community level are expected to strengthen conservation measures. This is to help optimize on pubic engagement, through locally relevant knowledge systems to fulfil related goals.

The Vidyarthi Vigyan Manthan of Vigyan Bharti is another typical case in point[1]. Thousands of students get the opportunity to showcase their knowledge and applications abilities through competitions. They get to also interact with experts and experience the joy of learning through some hands-on activities at the national events. This is also a truly bottom-up approach that starts at the district/state level and culminates at the national level. The competition for the year 2015-1016 has been announced.

The Department of Biotechnology (DBT), Government of India runs and enables conduct of a large number of activities through its DNA clubs. Year-long activities through these clubs are aligned with formal learning systems through schools and regional resource agencies across the country[2]. The National Academy of Sciences India is a prominent facilitator in this process[3]. The ATREE's[4] education programmes aim to foster a conservation ethic and impart appropriate skills. Interestingly the State Biotech Hub[5] and the Bioinformatics Infrastructure Facility (BIF), funded by the DBT in Mizoram promotes education, research and transfer of knowledge for the benefit of students, farmers and citizens from all walks of life.

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Email: r.gopichandran@vigyanprasar.gov.in

Editor : R Gopichandran
Associate editor : Rintu Nath
Production : Manish Mohan Gore and Pradeep Kumar
Expert member : Biman Basu
Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016
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Dr. APJ Abdul Kalam: The People's President

Dr. Anup Kumar Das
E-mail: anupdas2072@gmail.com

The eleventh President of India Bharat Ratna Dr APJ Abdul Kalam (1931-2015) was the finest technocrat, who led many high technology missions in taking the country on the path of self-reliance with home-grown technologies. His approaches were simple that led to the development of frugal indigenous solutions, instead of high-technology acquisitions from the developed nations.

Dr Avul Pakir Jainulabdeen Abdul Kalam was born on 15 October 1931 in a Tamil Muslim family at Rameswaram in Tamil Nadu state (then the Madras Presidency). His father Jainulabudeen was a boat owner and part-time imam at a local mosque while his mother Ashiamma was a caring homemaker. His father had a good rapport with local Hindu and Christian priests that imbibed Kalam with spiritual values and principles. Kalam recalls the nature of his father: "My father Jainulabudeen was not formally educated but was a man of great wisdom and kindness" .

Kalam completed his school education from Ramanathapuram Schwartz High School, where he showed the distinction of a hardworking student with special interest in mathematics. He then studied graduation in physics at Saint Joseph's College at Tiruchirappalli in Tamil Nadu, which was then affiliated to the University of Madras, and he completed his first degree in 1954. After his BSc degree, he enrolled in a degree course in aeronautical engineering at Madras Institute of Technology in Tamil Nadu. He completed engineering education in 1958. His priority was to join Indian Air Force (IAF) as a fighter pilot soon after completion of his engineering education, but he narrowly missed it. Instead, he joined the Defence Research and Development Organisation (DRDO) as a junior scientist at the Aeronautical Development Establishment in Bangalore in 1958, where he was involved in research and development of fighter airplanes for the IAF.

In 1963, he was selected to join the Indian Committee for Space Research (INCOSPAR) in a position of a rocket engineer. INCOSPAR was the predecessor

President Dr APJ Abdul Kalam addressing the nation on the eve of 58th Republic Day in New Delhi on January 25, 2007 (Credit: Photodivision.gov.in)

to Indian Space Research Organisation (ISRO) led by Professor Vikram Sarabhai. Soon after joining at INCOSPAR, Kalam was nominated for a six-month training programme on sounding rocket launching techniques at the National Aeronautics and Space Administration (NASA) in the United States. He joined advanced training programme at NASA in 1963 and received practical training at various R&D centres of NASA such as the Langley Research Centre at Hampton, Virginia, and the Goddard Space Flight Centre at Greenbelt, Maryland. His training at NASA became very fruitful while he served as one of the chief architects of now flourishing Indian space programme. He took a leadership role in development and launching of India's first indigenous Satellite Launch Vehicle (SLV-3), which placed Rohini RS-1 satellite into Earth orbit in July 1980. SLV-3 was a historical achievement for India, as the country entered the elite space club. Kalam was fortunate to received affectionate mentorship during his scientific career from renowned Indian scientists such as Professor Vikram Sarabhai, Professor MGK Menon, Professor Satish Dhawan and Professor Raja Ramanna.

After his stint at the ISRO for about two decades, he moved back to DRDO in 1983 as its Chief Executive to lead the Integrated Guided Missiles Development Programme (IGMDP). Under his leadership, the IGMDP developed and operationalised the *Agni* and *Prithvi* missiles during the 1980s for building indigenous capability in critical technologies. After the success of IGMDP programme, Kalam was elevated to the position of the Chief Scientific Adviser to the Prime Minister and the Secretary of the DRDO and served te country between July 1992 and December 1999. Subsequently he also served as one of the Chief Project Coordinators in the Operation Shakti (Pokhran-II) nuclear tests in 1998, which received global attention as India became a full-fledged nuclear state in order to strike a balance to achieve regional stability and peace.

Kalam with young dancers in Singapore (Credit: Photodivision.gov.in)

Kalam served as Chairman of the Technology Information Forecasting and Assessment Council (TIFAC), an autonomous organisation under Ministry of Science and Technology while his co-author of many books Professor YS Rajan was its Executive Director. During 1990s, TIFAC was engaged in Technology Vision

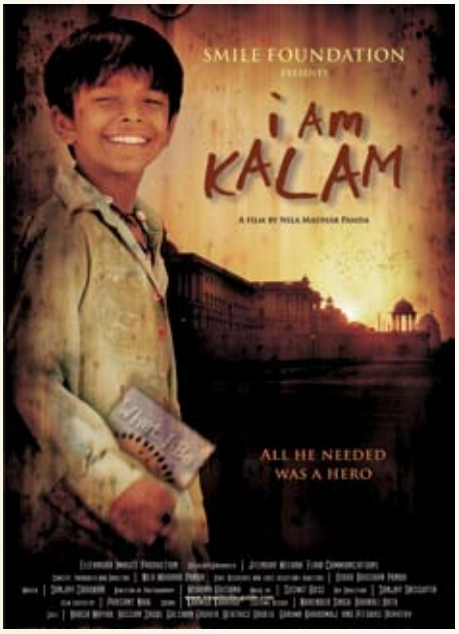
2020 exercise for India with an objective of "Transforming the nation into a developed country, with five areas in combination having been identified based on India's core competence, natural resources and talented manpower for integrated action to double the growth rate of GDP and realise the Vision of Developed India." The identified areas were namely:

- "Agriculture and food processing, with a target of doubling the present production of food and agricultural products by 2020. Agro food processing industry would lead to the prosperity of rural people, food security and speed up the economic growth;
- Infrastructure with reliable and quality electric power including solar farming for all parts of the country, providing urban amenities in rural areas and interlinking of rivers;
- Education and healthcare, to provide social security and eradication of illiteracy and health for all; and
- Information and communication technology: This is one of our core competencies and wealth generators. ICT can be used for tele-education, tele-medicine and e-governance to promote education in remote areas, healthcare and also transparency in the administration;
- Critical technologies and strategic industries witnessed the growth in nuclear technology, space technology and defence technology."

The book titled *India 2020: A Vision for the New Millennium* was a refinement of the series of "Technology Vision 2020" documents published by TIFAC. Kalam and Rajan wrote a touching dedication to the book:

After one of the talks delivered by Dr. Kalam, a ten-year-old girl came up to him for his autograph. 'What is your ambition,' he asked her. 'I want to live in a developed India,' she replied without hesitation. This book is dedicated to her and the millions of Indians who share her aspiration.

Kalam was popularly known as "the People's President" and "Missile Man of India" for divergent reasons. In an obituary, renowned journalist Mark Tully



A Poster of the Film "I Am Kalam" inspired by life of AJP Abdul Kalam

acknowledges: "He became known as the "People's President" because he welcomed the public into the palace in New Delhi (built for the last of the viceroys by the British architect Sir Edwin Lutyens) and made himself accessible whenever he travelled". Tully further described Kalam as one who played a crucial role in India's most successful technological programmes such as development and launching of the SLV-3, and indigenous guided missiles that earned him a coveted title "Missile Man of India". His leadership style was very unique and exemplary, as it was documented in a research paper titled "Visionary Leadership: A Survey of Literature and Case Study of Dr APJ Abdul Kalam at DRDL" by RS Dwivedi (*The Journal of Business Perspective*, 10(3), 11-21, 2006).

Kalam helps students at the inauguration of speech applet 'Virtual Vision' software for visually challenged students (Credit: Photodivision.gov.in)

During his presidency (2002-2007), Kalam evolved many innovative ideas for sustainable development and peoples' empowerment, to be implemented by the national and local governments, including the Providing Urban Amenities in Rural Areas (PURA). PURA became a central scheme titled 'Provision of Urban Amenities in Rural Areas' in 2010 led by Ministry of Rural Development and implemented on pilot basis under a public-private partnership (PPP) framework during the 11th Five Year Plan.

He was bestowed Bharat Ratna, the highest civilian honour, in 1997 by Government of India for his leadership roles in attaining the country's scientific and technological competencies. He was earlier awarded two other coveted civilian honours the Padma Bhushan in 1981 and the Padma Vibhushan in 1990. He became an elected Fellow of the national academies such as the Indian National Academy of Engineering (INAE), the Indian Academy of Sciences Bangalore (IAS), the National Academy of Sciences of India (NASI), and an honorary fellow of the Institution of Electronics and Telecommunication Engineering (IETE). He also received honorary doctorates from many universities in India and abroad, such as, Aligarh Muslim University, India; Edinburgh University, UK; University of Wolver Hampton, UK; Simon Fraser University, USA; Oakland University, USA; Carnegie Mellon University, USA; University of Waterloo, Canada; and Nanyang Technological University, Singapore. He remained a bachelor throughout life.

Kalam had proved himself as an accomplished writer. He has written more than twenty books, although an official webpage of the former President (on Abdulkalam.nic.in/books.html) enlists thirteen books written by him. His works can be categorised in three genres, namely, autobiographical, futuristic or visionary, and inspirational. He wrote two autobiographical books, namely, *Wings of Fire: An Autobiography* jointly written with Arun Tiwari (1999) and *Turning Points: A Journey through Challenges* (2012). His inspirational book titles are similar to

the topics of his public lectures he loved to deliver in the assemblies of school, college and university students and youth citizens of India to ignite a dream for a developed nation in near future.

Many of his writings are highly rated or reviewed by the book readers. The top five books based on readers' choice at GoodReads.com website, which facilitates the readers and booklovers to rate and review a published book, are: *Wings of Fire: An Autobiography* (1999); *Ignited Minds: Unleashing the Power within India* (2002); *Turning Points: A Journey through Challenges* (2012); *India 2020: A Vision for the New Millennium* jointly with YS Rajan (1999); and *My Journey: Transforming Dreams into Actions* (2013).

The top five books, based on the number of citations each book received as reflected on Google Scholar search engine, are: *India 2020: A Vision for the New Millennium*; *Ignited Minds: Unleashing the Power within India*; *Wings of Fire: An Autobiography*; *Target 3 Billion: Innovative Solutions Towards Sustainable Development* jointly with SP Singh (2011); and *Envisioning an Empowered Nation: Technology for Societal Transformation* jointly with AS Pillai (2004).

In addition to the above-mentioned books, Kalam wrote a few more visionary and inspirational books for the Indian youth, namely, *Reignited: Scientific Pathways to a Brighter Future* jointly with SP Singh (2015); *Beyond 2020: A Vision for Tomorrow's India* jointly with YS Rajan (2014); *A Manifesto for Change: A Sequel to India 2020* jointly with V Ponraj (2014); *The Scientific Indian: A Twenty-first Century Guide to the World around Us* jointly with YS Rajan (2011); and *Mission India: A Vision for Indian Youth* jointly with YS Rajan (2005).

In a highly acclaimed feature film *I Am Kalam*, directed by Nila Madhab Panda and produced by Smile Foundation, a child labourer inspired by life of Abdul Kalam dreams to become an educated citizen overcoming all odds in his early life. The movie trailer further describes *I Am Kalam* as "an endeavour in championing the cause of empowering underprivileged children through education. Moreover, the heart-warming tale celebrates the survival of the human spirit against overwhelming odds" (Available at http://vimeo.com/120668088). Harsh Mayar, who acted the main character of Chhotu in the film, received the National Film Award for Best Child Artist in 2011.

Kalam will be remembered by Indian children, youth and knowledge workers, who aspire to live in a developed India and make India a self-reliant nation. He further ignited minds of many youths with his many famous quotes. An example is given here from the book *Ignited Minds: Unleashing the Power within India*:

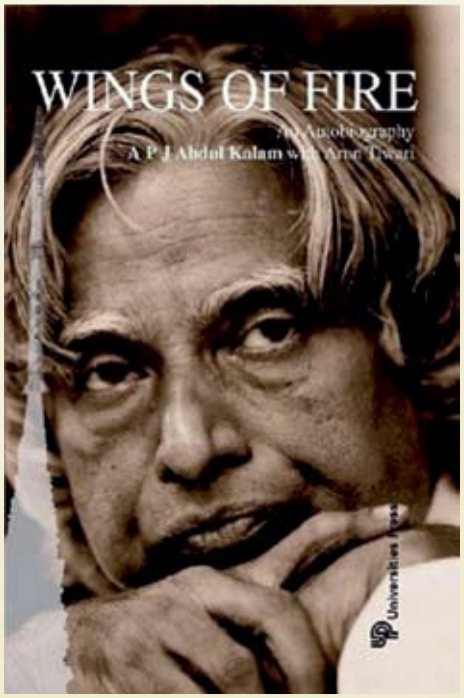
"Dream, Dream, Dream
Dreams transform into thoughts
And thoughts result in action."

Another of his oft-quoted quote is:

"Dream is not that which
you see while sleeping
It is something that does not let you sleep."

Timeline Dr APJ Abdul Kalam

1931	Born on 15 October at Rameswaram in Tamil Nadu, India. Mother: Ashiamma, Father: Jainulabudeen.
1954	Completed B.Sc. in Physics from Saint Joseph's College at Tiruchirappalli in Tamil Nadu, affiliated to University of Madras.
1958	Completed Engineering degree in aeronautical engineering from Madras Institute of Technology (MIT) in Tamil Nadu.
1958	Joined the Aeronautical Development Establishment of DRDO in Bangalore as junior scientist.
1963	Joined the Indian Committee for Space Research (INCOSPAR), predecessor of ISRO, as rocket engineer.
1963	Joined advanced training programme at NASA and received practical training at various R&D centres of NASA.
1980	Led launching of India's first Satellite Launch Vehicle (SLV-3), which placed Rohini RS-1 satellite into earth orbit on 18th July. India became a member of the elite space club.
1981	Conferred the Padma Bhushan.
1983	Joined as Chief Executive of the Integrated Guided Missile Development Programme (IGMDP) of DRDO, the Ministry of Defence.
1990	Conferred Padma Vibhushan.
1992	Became the Chief Scientific Adviser to the Prime Minister and the Secretary of DRDO and served till 1999.
1997	Conferred Bharat Ratna.
2002	Became President of India and served till 2007.
2015	Died on 27 July; Collapsed due to heart failure while delivering a speech at Indian Institute of Management Shillong in Meghalaya, India.



Cover Page of "Wings of Fire: An Autobiography"

Dr. Anup Kumar Das is attached with the Centre for Studies in Science Policy in Jawaharlal Nehru University (JNU), New Delhi, India.

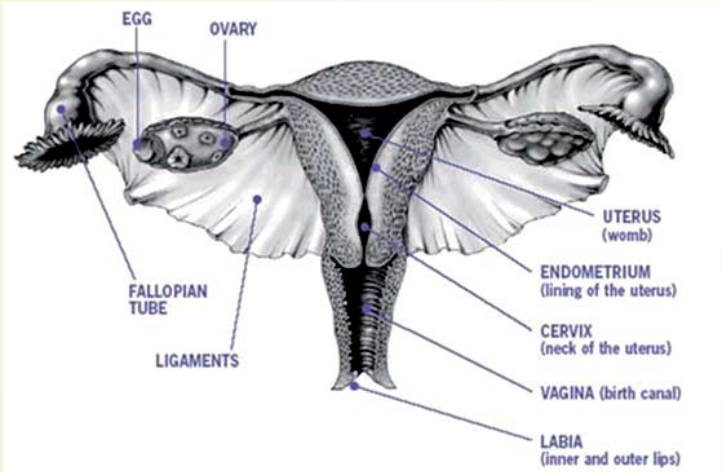
Surrogacy:
A New Dimension to Motherhood

Dr. M.S.S. Murthy
E-mail: mssmurthyb104@gmail.com

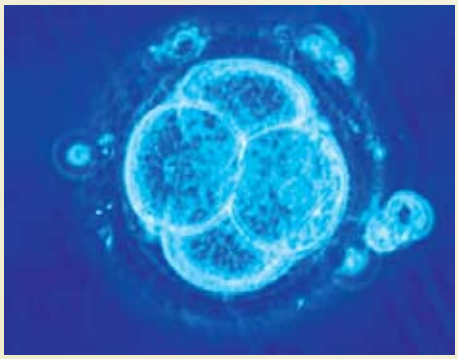
Recently a national daily carried an interesting news item, "61-year-old woman gives birth to her grandchild"! Age 61 is too late for a woman to get pregnant and how can one deliver her own grandchild? That is the magic of 'surrogacy'.

What is surrogacy?

Human conception is a very complex process. The egg released from the ovary in the female reproductive system travels down the Fallopian tube. On its way, if it meets a sperm cell, it may get fertilised. The fertilised egg moves further down in the Fallopian tube to the uterus where it gets safely embedded. The foetus grows in the uterus and the baby is born after nine months. Any problem in the ovaries that release the eggs or in the Fallopian tubes, would make the female unable to conceive. In such a situation, a procedure known as *in vitro* fertilisation (IVF) comes to their aid. In this procedure the gynaecologist extracts the mature eggs from the ovary with the aid of a laparoscope under ultrasound, mixes them with sperm cells and keeps them in an incubator under controlled temperature and environment. In about 18 hours of incubation, a sperm cell penetrates the egg and deposits its genome. The egg, thus fertilised undergoes cell division in the next 48 hours, producing a mini embryo consisting of just eight cells, which can be easily recognised under a microscope. The gynaecologist picks it up and transfers it to the woman's uterus (womb). From then on the embryo develops into a baby in the normal course under natural surroundings.



The female reproductive system



A four-cell stage early embryo

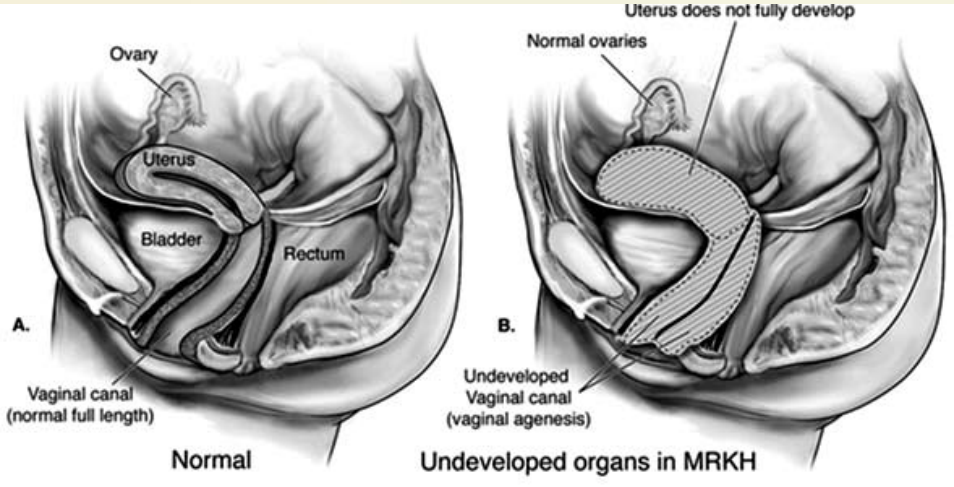
A second mother

So far so good. But if there are any defects in the uterus, which receives and nourishes the embryo over the next nine months, this procedure cannot produce the desired result. There is a condition called Mayer-Rokitansky- Kuster syndrome in which the female is born either with an underdeveloped uterus or no uterus at all, though the ovary is normal. The causes of this syndrome may be genetic, environmental factors during foetal development or some other unknown cause. It is estimated that about one in 5,000 girls are born with this defect. Then there are other conditions like cancer, heart diseases, etc., in which the patient may not be able to support pregnancy for nine months. In all such cases simple IVF will not be sufficient.

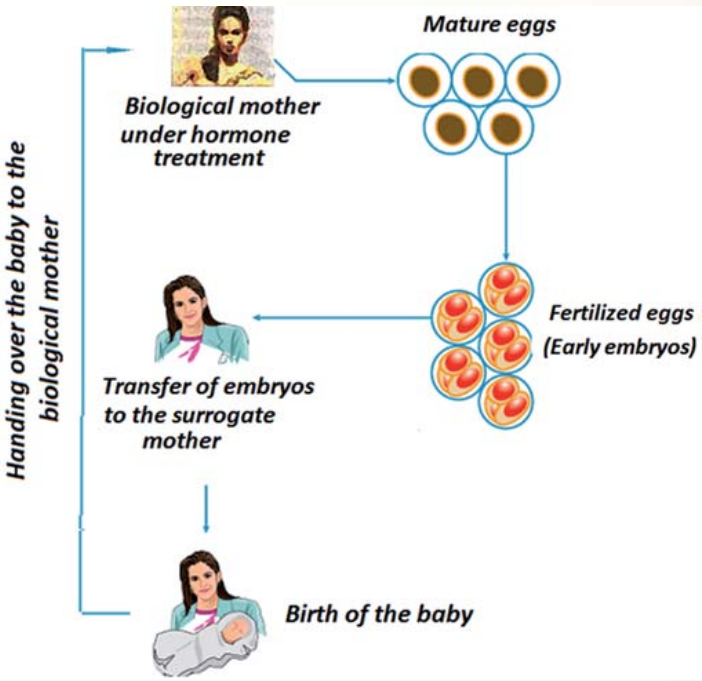
Until recently the only solution for such couple was adopting a baby. However, many couples may want to have a baby which is biologically their own. In such a situation an extension of the IVF, which involves a second woman – a surrogate mother – lending her womb, is practiced.

How is surrogacy practised?

If the biological mother has no problems in egg production, then surrogacy becomes simple and straight forward. Generally, a female releases one egg per period. However, in surrogacy the biological mother is put on a hormone treatment so that more than one egg matures. The gynaecologist recognises the mature eggs in an ultrasound procedure, picks them up using laparoscopy and mixes them with sperm cells from the husband in



Undeveloped uterus in Mayer-Rokitansky-Kuster syndrome patient



Various stages of surrogacy

a Petri dish for fertilisation and further cell division to an early embryo.

While the biological mother is undergoing a hormone treatment for the release of more eggs, the surrogate mother also undergoes a hormone treatment. This is to synchronise her period with that of the biological mother and to prepare her uterus to receive the embryo. At the end of this treatment the embryo is carefully picked up from the Petri dish and transferred to the uterus of the surrogate mother through her vagina. In order to ensure pregnancy, the gynaecologist generally transfers more than one embryo. By carrying out certain blood tests after 15 days, pregnancy can be confirmed. After that everything else is natural. When the baby is born, the surrogate mother has to give it away to the biological parents. She will have no rights on the baby. Names of the biological parents only will be recorded in the child's birth certificate. What is to be noted here is that there is no biological relationship between the surrogate mother and the baby. She is just a live incubator.

Some interesting cases

Surrogacy is becoming popular these days, leading to some interesting cases. In the case cited at the beginning, 27-year-old Seethalaksmi developed problems after her first failed pregnancy and had to undergo hysterectomy (removal of the uterus) to stay alive. This dashed her hopes of holding her own baby in her arms. Help came to her in the form of her 61-year-old mother who opted to be the surrogate. Seethalakshmi's eggs were fertilised with her husband's sperm and the embryo transferred to her mother's womb. Nine months later grandmother gave birth to her grandson!

Similar is the story of Shobhana Chawda (47) and her daughter Bhavika (26) of Surat. Bhavika was married to Sourabh. It was a love marriage. The couple knew that Bhavika cannot become a natural mother for she was born without a uterus. They thought of adopting a child, surrogacy was also on their mind. But it was very expensive. Then Bavika's mother offered herself to be the surrogate. "That is the greatest gift I can give to my daughter" says mother Shobhana. "What can I say? I have no words to describe what my mother has done to me" says Bhavika, overwhelmed with emotion.

Like these there are many interesting stories of surrogacy.

Renting the womb

One can recognise two types of surrogates: (i) involving relatives and close friends, and (ii) commercial surrogacy, wherein a woman rents out her womb. This is legal in many countries, including India. The surrogate mother is paid a fee running up to four lakh rupees for her service. Hence, women in distress like the ones deserted by their husbands, young widows, poor housewives, and the like often volunteer as surrogates to help financially manage their homes, children's education and so on.

India is known to have a reasonably inexpensive and good medical infrastructure. Hence, many foreign couples also come to India to have a baby through surrogacy. In addition to the metros like Delhi, Mumbai, Kolkata, Chennai, Bengaluru, even smaller cities like Ahmadabad, Bhopal, Anand, Surat have many IVF clinics which offer this service. According to an estimate there are about 3,000 IVF clinics in the country with a turnover of more than 30,000 crore rupees.

The reach of surrogacy is not limited to known individuals. Just as we have blood banks, there are sperm banks and egg banks across the country, where healthy sperm cells and egg cells are preserved under cryogenic conditions. If a woman has problems even in producing eggs, then eggs can be obtained from a bank, fertilised by the husband's sperms and the embryo transferred to the surrogate mother. Similarly, if the husband has problems in producing quality sperms, they can be obtained from sperm banks to fertilise the wife's eggs. In these cases the baby will be biologically related to at least one of the parents. But the biological parents will have no rights to know the name, address and other details of the donor. However, they can seek information from the bank about the donor's height, weight, skin colour, educational qualifications, family background, etc.

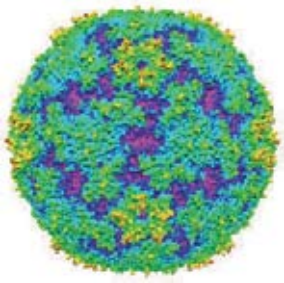
American couple with baby and the surrogate mother in a clinic at Anand, Gujarat

(Continued on page 27)

Polio-free India

Dr. Hemlata Pant
E-mail: pant_hemlata@yahoo.co.in

Poliomyelitis, commonly known as polio is a deadly disease. It is spread by a virus called poliovirus. Once afflicted by this disease it makes a person crippled for life. Polio mainly spreads through three serotypes of poliovirus, known as PV1, PV2 and PV3.



The poliovirus thrives and multiplies within human intestine. Under favourable conditions it reaches the nervous system either directly or through blood. Once the virus reaches the nervous system the various body parts suffer paralysis; even the breathing muscles may be affected in some cases.

The poliovirus infects through the faecal-oral route. Initial symptoms of polio include fever, fatigue, headache, vomiting, stiffness in the neck and pain in the limbs and various body parts. One in 200 infections leads to paralysis that usually affects the limbs. On an average one out of 10 persons crippled by the disease face death. The disease mainly spreads in hot weather or at the onset of the autumn season. It spreads rampantly in extremely hot regions and affects children in the age group of 4-5 years.

Spread of polio

The poliovirus is excreted through stool even after six to eight weeks of an individual getting infected by the virus. The virus is often carried from faeces to food items by flies due to lack of hygiene thus spreading the disease. The main carriers of the disease are humans. Sometimes, these viruses contaminate drinking water also. The incubation period (time from exposure to virus to onset of symptoms) of these viruses is 3-21 days, but on an average, it has been found to be 7-12 days. With longer incubation period, the severity of the infection is also more. In the initial stages of the disease the patient feels highly restless. Pregnant women are found to be highly susceptible to the poliovirus and need to be careful.

Complete prevention from polio disease is possible. As the poliovirus is found only in the human body, its complete eradication is possible. In the first phase of treatment, it is essential that the 'soldiers' (antibodies) that fight against polio must be abundantly present in the body. For this polio vaccine is available. Both injectable and oral polio vaccines are available, but oral polio vaccine is more widely used. The doses of the vaccine are administered orally and two drops are given with every dose. The first dose is to be given to the child at the time of birth. After this, in the first year, three more doses are given to the child at the age of one-and-a-half months, two-and-a-half months and three-and-a-half months (i.e., after 45, 75 and 105 days). Two more doses administered after one-and-a-half years and four-and-a-half years may trigger the formation of sufficient number of antibodies against the poliovirus. In this way, prevention from the disease becomes possible.

Pulse polio campaign

In 1988, the United Nations first started its campaign for a polio-free world. Before declaring a country polio-free, cognizance is taken of the fact that there had been no polio cases in that country for the previous three years. After the polio eradication initiative started in 1988, five lakh people (especially from developing countries) who could have fallen prey to paralysis due to polio were saved from the clutches of the disease.

The pulse polio campaign to free India from the clutches of polio started in 1995. When the global initiative of eradication of polio following World Health Assembly resolution started in 1988, its outreach extended to merely 40 percent of children. At that time, every year almost one-and-a-half lakh children were getting affected by paralysis due to polio. Even when the pulse polio campaign was started in India in 1995, the number of children getting affected by polio was no less. Around seven thousand children were getting paralysed every year due to polio. However, as of the current year 2015, not a single polio case has been reported in the span of last four years. About 24 lakh vaccinators were involved in this programme. Around 1.5 lakh supervisors made door-to-door visits, examining each individual case. Thanks to this programme, about 17.2 crore children got immunization from polio. The information about cases of polio infection was collected from 35,325 centres.

The last polio patient in India was reported on 13 January 2011. This case, pertaining to wild polio type-1 (WPV1), was from Howrah district of West Bengal. Five-year-old girl Rukhsa Shah belonging to Shubharara village in Panchala Block of Howrah got infected by polio.

Although we have won the battle against polio, the danger of its striking back has not been totally eliminated. Even now infection due to the wild polio virus can revisit India anytime from across the border. Around 102 locations situated in the countries like Pakistan, Nepal, Bangladesh, Myanmar, Bhutan, Afghanistan, Nigeria and China have been identified from where the danger of this deadly disease can reach India. Therefore, it is the need of the hour that children (up to the age of 5 years) crossing the international borders be administered polio vaccine by setting up polio immunization posts along the international borders (with Pakistan, Nepal, Bangladesh, Burma and Bhutan). Moreover, children up to the age of 5 years may, as before, be continued to be given oral polio vaccine.

Dr. Hemlata Pant is working as Secretary (in-charge) in Society of Biological Sciences & Rural Development, Jhusi, Allahabad, Uttar Pradesh. She is Editor of Journal of Natural Resource & Development and Grameen Vikas Sandesh Magzine.

(Translation: Abhas Mukherjee) ■

Microbes:
The Tiny Friends of Farmers

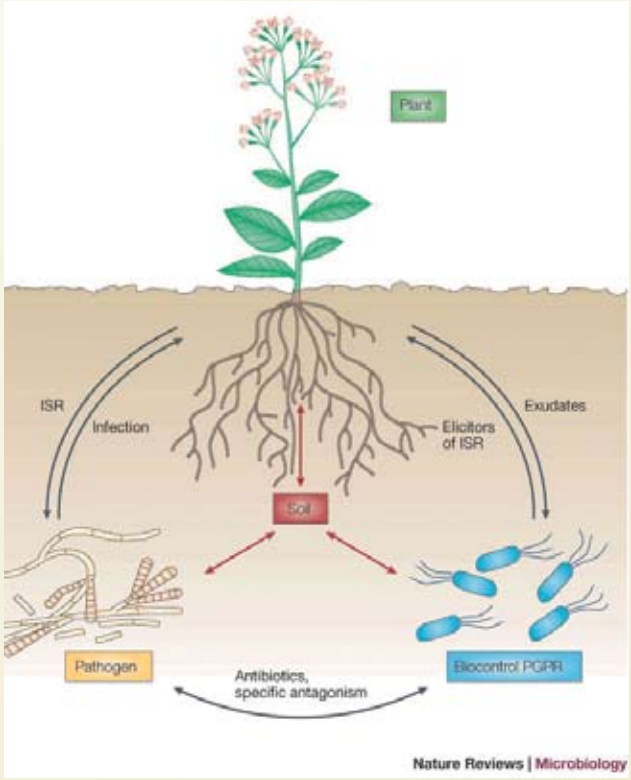
Balaram Mohapatra
E-mail: balarammohapatra09@gmail.com

The Earth's biosphere is crowded with organisms that have made this planet worthy of living. They include bacteria, fungi, algae, protozoa, etc. Apart from a relatively small number of disease-causing agents, the importance of microbes cannot be over emphasised; they contribute to the functioning of our biosphere with cycling of elements and materials essential for life. It is estimated that microorganisms contain 50% of the biological carbon and 90% of the biological nitrogen on Earth, exceeding rest of the organisms present. Pioneers like Antony Van Leuwenhoek, Louis Pasteur and Robert Koch made tremendous contribution to make the field of microbiology for a key factor in human welfare. The recent trend in the use of microorganisms in food, feed, cosmetics, medicines, industries, agriculture, and other sectors has made life more comfortable, safe and sustainable. Use of microorganisms has led to tremendous success in increasing agricultural production in a safe and sustainable way which has had a positive impact on famers. From agricultural viewpoint, soil microorganisms play a crucial role for plant growth and development which has significant impact on food production. Microbial diversity in soil is much higher than in any other environment and portions of soil (microhabitat) around the plant root (rhizosphere) are the crucial sites for microbial growth. They reside in the pores of the soil particles and remain associated with plants. Plants generally produce certain secreting substances (called root exudates, mostly phenolics and sugar in nature) in the soil. Microorganisms (mostly bacteria) sense these molecules, get attracted towards them, use it for their growth and reproduction and in return produce certain substances which help in plant growth and development. So, it is a mutual interaction between plants and microbes that sustain the plant growth. Hence these microbes are called plant growth promoting (PGP) bacteria.

It is estimated that microbial diversity within a typical forest soil is of the order of 5×10^9 cells/cm^3 and that microorganisms rather than the plants account for most primary production (i.e., vegetation produced directly from sunlight available for trophic levels) in terrestrial ecosystem.

What are PGP microbes?

PGP microbes can be defined as the most essential part of plant-root microbial community, which grows in association with the host plant and can stimulate the growth of the plant due to their high adaptability in a wide variety of environments, faster growth rate and production of plant growth factors, ability to metabolise a wide range of natural and xenobiotic compounds to non-toxic level. The important bacterial members of PGP groups are: *Agrobacterium*, *Arthrobacter*, *Azotobacter*, *Azospirillum*, *Bacillus*, *Pseudomonas*, *Burkholderia*, *Allorhizobium*, *Azorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, *Rhizobium*, *Streptomyces*, *Streptosporangium*, etc. These bacteria perform various actions responsible for plant growth like: fix nitrogen, lower production of stress-related hormone ethylene, synthesise auxin, cytokinins, siderophore for iron metabolism by plant, induce pathogen resistance, solubilise phosphorus, potassium, sodium and other trace minerals, decrease toxic level of heavy metals and other foreign substances, produce of antibiotic compounds, reduce water and other physiological stresses, etc.



Interactions between biocontrol plant growth-promoting rhizobacteria (PGPR), plants, pathogens and soil. Source: Haas, D. & Defago, G. (2005)

Farmer's friends

As we all know that our population is growing rapidly and we have to produce enough food for the growing population. The increasing use of chemical fertilisers, pesticides and harmful chemicals for achieving higher food production is threatening our environment and soil health. The only way to keep our environment safe is to go for better, safer, organic and eco-friendly way of agriculture with limited use of chemical fertilisers and more use of green chemicals (natural agro-based chemicals and microorganism-based formulations). In this context, PGP microbe-based "biofertilisers" are the best alternative for the farmers as replacement to chemical fertilisers. They are prepared from living microorganisms which, when applied to seeds or any plant parts adjacent to soil can colonise the whole area and thereby promote plant growth. Green manure and compost can be used along with biofertilisers for better yield of crops. The microorganisms used for this purpose are known as "biocontrol agents" due to their ability of killing harmful disease-causing insect pests and pathogens

(biopesticides) and have been an important part of integrated pest management.

The PGP microbes are usually formulated with solid substances (called carrier materials) like chalk, peat, charcoal powder, etc., in which microorganism are mixed in a proper ratio with desired water activity and sold in market under different trade names. The US Department of Agriculture as well as Indian Council of Agricultural Research (ICAR) have set the recommended dose of using these biofertilisers with minimum amount of chemical fertilisers for better yield. USA has made tremendous progress in this field with thousands of commercial biofertiliser products, but India is still at a low pace due to lack of production technology and commercialisation skill which relates scientific organisation and industries.

World market of microbial biofertilisers is very demanding and there are many potential products in the market like: Diegall, Azo-Green, Rhizo-Plus, Blue Circle, Victus, Bio-Save 10, Mycostop, etc. Indian market is still in deficit of these biofertilisers mainly due to technological constraints, although there are some products related to *Azotobacter*, *Azospirillum*, *Rhizobium* and *Bacillus* biofertilisers which are good. Good commercialisation of these biofertilisers requires market demand, consistent and broad-spectrum action, safety, stability, low capital costs and easy availability of carrier materials. Considering all the parameters, it is now essential to explore new and unique ecosystems where these potent microbial species can be found. Now-a-days scientists are focussing more on specific

potential bacterial and fungal species that can work best with all soil conditions and crops. So, genetic manipulation of these microorganisms through genetic, use of genetically modified PGP bacteria for higher efficiency is still in progress.

Future prospects and challenges

PGP microbes can fulfil diverse beneficial interactions in plants leading to promising solutions for sustainable and environment-friendly agriculture. Their applications in agricultural crops with desirable bacterial populations have established considerable promise in greenhouse and pot-trial experiments. Improved understanding of their way of action can lead to reducing the potential negative environmental effects associated with the food production. Recent progress in this field of research has led to interesting finding that these microbes can reduce the toxic level of heavy metals and other foreign substances and understanding their mechanism of tackling the toxicity could encourage suitable area of research for the coming young scientific minds of the country. Higher studies in this field (research or engineering) are the most challenging and promising task to develop proper strains to make agriculture more productive. Many agricultural universities and research institutions (IARI, CRRI, CRIDA, NIPGR, etc.) funded by ICAR, DBT, DST and CSIR are focussing on development of suitable biofertilisers and their upstream as well as downstream processing pathways.

Balaram Mohapatra, Ph.D scholar (INSPIRE fellow), Environmental Microbiology and Genomics Laboratory (EMGL), IIT-Kharagpur, India.

Surrogacy: A New Dimension to Motherhood *(Continued from page 30)*

Selection of a surrogate mother is not an easy task. She has to be of suitable age (21-35 years), must possess proper mental and physical health to carry and deliver the baby. She should not have any heritable diseases in her family. It is not necessary that she should be unmarried, or not have her own children.

Generally, women who opt to become surrogate mothers are in economic distress. Hence, in order to ensure that they are not exploited, the Medical Council of India has developed certain guidelines. The Government of India has brought out legislation on those lines to safeguard their interests. It aims at clearly defining the responsibilities of the biological parents, of the surrogate mother, her fee, her health insurance during pregnancy and child birth and ownership of the baby. If the biological parents are of foreign nationality, questions about the citizenship of the baby are also considered. It becomes mandatory on the part of the biological parents to accept the child irrespective of its gender, even if they are twins or handicapped. It becomes essential that even before the treatment starts an agreement between the biological parents and the surrogate mother (and her family) detailing all these features be signed so that the interests of both the parties are met.

Recently, Dr. Mats Brannstrom of Sweden reported successful uterus transplant in a woman who was born without it. Later she conceived and gave birth to a healthy baby on 4 September 2014. This procedure will undoubtedly become more popular in the coming years and may reduce the demand on surrogate mothers. However, patients with uterus problems are not the only ones who look for surrogacy. Even normal, career-minded females and women in show business are now postponing motherhood as much as possible and some of them may even opt for surrogacy. Hence, the real game change will occur when scientists could invent an artificial womb which supports the growth of the foetus during the entire period, and biological parents can simply take home the baby on the appointed date – a totally mechanised process of human reproduction!

Dr. M.S.S. Murthy retired as a senior scientist from the Bhabha Atomic Research Center, Mumbai in 1997. He is a popular science writer and authored a number of books.

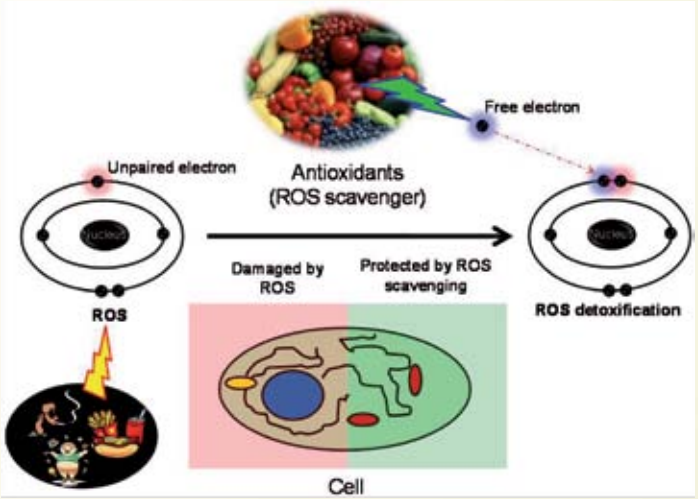
Organic Cultivation of Rice


T. B. Bagchi S. Ray
E-mail: torit.crijaf09@gmail.com

Agriculture has enabled human beings to produce food for sustaining life. Once the means of subsistence, agriculture have now emerged as the largest industry in the world. To cope with the expected population pressure of the upcoming decades, agricultural production has to be increased many folds. But, in an attempt to obtain higher production, people have traditionally used several agrochemicals such as fertilisers and pesticides – many a times, indiscriminately. This indiscriminate application of agrochemicals has now started posing threat of environmental pollution and health hazard for humans as well as livestock. In this perspective organic farming has started gaining worldwide appreciation as an alternative eco-friendly agricultural practice. A whole set of policy instruments exists both at European and at national level to support the development of organic farming. As a consequence, the organic sector has experienced a boom in many countries during the nineties. But the progress of organic agriculture in India has been very slow. Currently, only about 5.41million hectares are under organic farming (APEDA, India). Demand for organic rice is growing day by day in most parts of India and exporters are increasingly adding organic rice to their product range.

Concept of organic farming

The concept of organic farming is based on integrated approach of sustainable agriculture with resource conservation, maintenance of biodiversity and health benefits of human beings. To meet the demand for food for the entire population, crop yield has to be increased, which is thought to be possible only through the use ofchemical fertilisers, plant protection and growth promoting chemicals, and adoption of proper management practices. From this point of view, organic cultivation is a fashionable concept, but in the long term, it is the only way to save the world without compromising productivity and it is indeed possible.



Schematic diagram of scavenging mechanism for free-radicals like ROS (reactive oxygen species) by antioxidants.

Natural resources can be used efficiently for increasing productivity. Botanicals can also be used for plant protection and above all, high-yielding varieties with multiple biotic and abiotic stress tolerance capacity need to be cultivated to fulfill the challenge of productivity.

Why organic products are beneficial for human health

There are fundamental differences in organic and conventional production practices, but limited information is available regarding how the procedural differences influence the nutritional qualities; especially in terms of antioxidant content. It is not yet established if the difference in cultivation practice can bring about any significant modification in nutritional content of the produce. Epidemiological studies consistently indicate an inverse correlation between the consumption of

Some components of organic cultivation of rice

Fertilisers and manures	Nutrient source	Method of use	Botanicals and others	Use
1. Sunnhemp (*Crotalaria juncea*)	Good source of nitrogen	Soil incorporation at the time of land preparation	1. Neem oil	Spraying for pest attack
2. Cowpea	Fixes nitrogen from air.	Soil incorporation	2.Pyrethrum	Spraying for pest attack
3. *Sesbania sp.*	Good source of nitrogen	Soil incorporation of tender plants at the time of puddling	3.Nicotine: extract from tobacco	Spraying for pest attack
4. Organic manure (cow dung, poultry, etc.)	Good source of nitrogen	Soil incorporation at the time of tillage operation.	4. *Tricoderma sp.* (microbial insecticide)	Pest and diseases management
5. Fly ash, ash from burning of stables, straw, etc.	Good source of potassium	Soil incorporation	5. Uncontaminated irrigation water	Irrigation for crops
6. Rock phos-phate	Good source of phosphorus	Soil incorporation	6. Jute bags	Packaging and storage

Black, Red and brown rice, full of antioxidative compounds.

fruits and vegetables and the risk of human cancers, cardiovascular disease, diabetes and age-related declines in cognition. These chronic diseases are linked to the oxidation of critical cellular macromolecules (e.g., proteins, lipids, and DNA) by reactive oxygen species (ROS). Phenolic antioxidants are thought to neutralise ROS before they can cause damage and lead to disease development. Additionally, reports by the World Health Organization (WHO) and the Food and Agriculture Organisation (FAO) of the United Nations emphasise the role of foods and nutrition in the prevention of non-communicable diseases and also point out the roles of plant-derived phytochemicals in the prevention of heart disease and cancer. In general, this theory states that high nutrient availability leads to an increase in plant growth and development, and a decreased allocation of resources towards the production of secondary metabolites such as the phenolic antioxidants. Actually, there is always a trade-off between primary metabolism, which favours growth and development, and secondary metabolism, which favours defence to several stresses, as there goes on a tug-of-war for substrates between these two pathways, which they derive from a common pool of photosynthates. Every time a plant tends to strike out the right balance between these two pathways depending on the environment surrounding it. Since organic farming, as opposed to conventional farming, do not use chemical fertiliser and pesticides, the plants in this case are actually subjected to continuous nutritional as well as biotic stress, which ultimately favours the synthesis of secondary metabolites. (Secondary plant metabolites are defined as those compounds which are not essential to sustain the life of the plant such as DNA, RNA, chlorophyll, amino acids and starch.) The term phenolic antioxidant refers to both simple phenolic acids and flavonoids. They are products of secondary plant metabolism and are ubiquitous natural components of plants. They include phytochemicals such as caffeine, isoflavonoids and phenolic antioxidants, etc.

As mentioned earlier, plants produce secondary metabolites as a defence mechanism against photo-oxidation, herbivory (insect and animal predation), and for protection against pathogen attack. Additionally, they are critical components in the health of the plant, and many are pigments that help to attract pollinating insects. The composition of secondary plant metabolites differs between plants and within plant tissues. Scientists have recently begun to question whether the levels of phenolic antioxidants are lower in foods grown using conventional agricultural practices, since these practices utilise high levels of pesticides and fertilisers that can result in a disruption of the natural production of plant-defence related metabolites. The observed differences between the content of phenolic metabolites in organically and conventionally produced fruits and vegetables hint about the possibility that organic produce might be more beneficial than its conventionally grown counterpart. But a critical review of existing literature demonstrates these differences to be often inconsistent in case of conventionally and organically produced vegetables with the exception of potentially higher levels of certain minerals, ascorbic acid and less nitrates in organic foods. However, these are difficult to interpret, since cultivar selection and growing conditions varied widely and different methods of sampling and analysis were used by the investigators. Additionally, the majority of these studies have not assessed levels of phenolic antioxidants, as their role in human health was not much appreciated until recently. However, there is a general consensus regarding the fact that, the level of secondary metabolites can differ to a great extent in response to these two agricultural practices, since the amount of stress exerted on the crops certainly differ between organic and conventional farming. Several studies demonstrated that there was a decrease in the concentration of phenolic antioxidants in plants with increasing nutrient availability. Some researchers also reported consistently higher levels of total phenolics and ascorbic acid in organic strawberries, marionberries and sweet corn. Some red rice varieties (*Mamihunger*, *Chakha*, *Nalbora*, *Asambiroin*, *Gandhi biroin*, *Saathi*, etc.) of north east India possess higher anti-oxidative compounds like phenolics, flavoniods, and anthocyanins as compared to white rice varieties. Their processing with traditional *dheki* provides maximum nutrition than milling machine and this *dheki* product is very helpful for minimising cardiovascular diseases.

Organic rice cultivation in CRRI, Cuttack.

Panicle (19-cm long) of rice variety Annapurna, grown under organic management at CRRI, Cuttack.

Continued on page 19

Lactose Intolerance:
When your body fails to digest milk

Dr. Yatish Agarwal
E-mail: dryatish@yahoo.com

Many children and some 50–65 per cent of the adult people in the world suffer from an inability to digest the milk sugar. As a result, they experience diarrhoea, gas and bloating after eating or drinking dairy products. The disorder goes by the name of lactose intolerance, and needs to be dealt with dietary discretion and a bit of help from your doctor.

What causes milk sugar intolerance?

A deficiency of *lactase* — an enzyme produced in your small intestine — is usually responsible for lactose intolerance. Normally, lactase turns milk sugar into two simple sugars — glucose and galactose — which are absorbed into the bloodstream through the intestinal lining.

If you're lactase deficient, lactose in your food moves into the large bowel (colon) instead of being processed and absorbed. In the colon, normal bacteria interact with undigested lactose, causing the signs and symptoms of lactose intolerance.

Many people have low levels of lactase but are able to digest milk products without problems. If you're actually lactose intolerant, though, your lactase deficiency leads to symptoms after you eat dairy foods.

Types of milk sugar intolerance

There are three types of lactose intolerance. Different factors are responsible for exciting the deficiency of lactase in each.

Genetic defect

It is possible, but rare, for babies to be born with lactose intolerance caused by a complete absence of lactase activity. This disorder is passed from generation to generation in a pattern of inheritance called autosomal recessive, meaning that both the mother and the father must pass on the same gene variant for a child to be affected.

Premature infants may also have lactose intolerance because of an insufficient lactase level.

Primary lactose intolerance

This is the most common type of lactose intolerance. People who develop primary lactose intolerance start life producing plenty of lactase — a necessity for infants, who get all their nutrition from milk. As children replace milk with other foods, their lactase production normally decreases, but remains high enough to digest the amount of dairy in a typical adult diet.

In primary lactose intolerance, lactase production falls off sharply, making milk products difficult to digest by adulthood. Primary lactose intolerance is genetically determined, occurring in a large proportion of people with Asian ancestry.

Secondary lactose intolerance

This form of lactose intolerance occurs when lactase production your small intestine decreases after an illness, injury or surgery involving your small intestine. Among the diseases associated with secondary lactose intolerance are celiac disease, bacterial overgrowth and Crohn's disease. Treatment of the underlying disorder may restore lactase levels and improve signs and symptoms, though it can take time.

Factors which increase the risk

Factors that can make you or your child more prone to lactose intolerance include:

Increasing age

Lactose intolerance usually appears in adulthood. The condition is uncommon in babies and young children.

Ethnicity

Lactose intolerance is most common in people of certain descent, and despite the legendary stories about Krishna and milk products in Indian mythology; the disorder is fairly common in people born in the country.

Premature birth

Infants born prematurely may have reduced levels of lactase because the small intestine doesn't develop lactase-producing cells until late in the third trimester.

Following viral or bacterial diarrhoea

Many infants and children typically develop lactase deficiency following viral or bacterial diarrhoea.

Diseases affecting the small intestine

Small intestine problems that can cause lactose intolerance include bacterial overgrowth, celiac disease and Crohn's disease.

Certain cancer treatments

If you have received radiation therapy for cancer in your abdomen or have intestinal complications from chemotherapy, you have an increased risk of lactose intolerance.

Symptoms

The signs and symptoms of lactose intolerance usually begin 30 minutes to two hours after eating or drinking foods that contain lactose. Common signs and symptoms include:

- Diarrhoea
- Nausea, and sometimes, vomiting
- Abdominal cramps
- Bloating
- Flatulence

When to see a doctor

If you frequently experience worrisome symptoms after eating dairy foods, it indicates that you may have lactose intolerance. See your family doctor or a gastroenterologist, who can help come to the diagnosis and advise you appropriately.

What you can do in the meantime

Maintain a record

Keep track of your daily servings of different dairy foods, including milk, ice cream, yogurt and cottage cheese, along with when you have them and what you eat with them. Let your doctor know which dairy foods, in what amounts, give you symptoms. This information can be most helpful for your doctor in making a diagnosis.

Try cutting dairy products

If you think you may have lactose intolerance, try cutting dairy products from your diet for a few days to see if your symptoms ease. Let your doctor know if your symptoms got better on the days you didn't have dairy products.

Your doctor may suspect lactose intolerance based on your symptoms and your response toreducing the amount of dairy foods in your diet.

Making the diagnosis

Your doctor can confirm the diagnosis by conducting one or more of the following tests:

Hydrogen breath test

This test also requires you to drink a liquid that contains high levels of lactose. Subsequently, your doctor shall measure the amount of hydrogen in your breath at regular intervals. Normally, very little hydrogen is detectable. However, if your body doesn't digest the lactose, it will ferment in the colon, releasing hydrogen and other gases, which are absorbed by your intestines and eventually exhaled. Larger than normal amounts of exhaled hydrogen measured during a breath test indicate that you aren't fully digesting and absorbing lactose.

Lactose tolerance test

The lactose tolerance test gauges your body's reaction to a liquid that contains high levels of lactose. Two hours after drinking the liquid, you'll undergo blood tests to measure the amount of glucose in your bloodstream. If your glucose level doesn't rise, it means your body isn't properly digesting and absorbing the lactose-filled drink.

Stool acidity test

For infants and children who can't undergo other tests, a stool acidity test may be used. The fermenting of undigested lactose creates lactic acid and other acids that can be detected in a stool sample.

What you can do

Practice dietary discretion

Currently, there is no remedy to boost your body's production of lactase, but you can usually avoid the discomfort of lactose intolerance by:

- Avoiding large servings of milk and other dairy products
- Eating and drinking lactose-reduced ice cream and milk
- Including small servings of dairy products in your regular meals

With some trial and error, you may be able to predict your body's response to different foods containing lactose and figure out how much you can eat or drink without discomfort. Few people have such severe lactose intolerance that they have to cut out all milk products and be wary of non-dairy foods or medications that contain lactose.

Limit dairy products

Most people with lactose intolerance can enjoy some milk products without symptoms. You may be able to tolerate low-fat milk products, such as skim milk, better than whole-milk products. It also may be possible to increase your tolerance to dairy products by gradually introducing them into your diet.

Ways to change your diet to minimise symptoms of lactose intolerance include:

Choosing smaller servings of dairy

Sip small servings of milk — up to 120 mL at a time. The smaller the serving, the less likely it is to cause gastrointestinal problems.

Saving milk for mealtimes

Drink milk with other foods. This slows the digestive process and may lessen symptoms of lactose intolerance.

Experimenting with an assortment of dairy products

Not all dairy products have the same amount of lactose (Table 1). For example, hard cheeses, such as Swiss or cheddar, have small amounts of lactose and generally cause no symptoms.

You may also be able to tolerate cultured milk products, such as yogurt, because thebacteria used in the culturing process naturally produce the enzyme β-galactosidase that breaks down lactose.

However, tolerance for yoghurt varies between people. Due to its low lactose content, home-made yoghurt is best. Commercially available yoghurt and buttermilk are sometimes sweetened by adding cream or milk and are not necessarily low in lactose.

Table 1: Opting for foods with low lactose

Content of lactose in dairy products		
Dairy product	**Qty**	**Lactose content**
Whole milk	250 mL	11 g
2% milk	250 mL	9–13 g
Skim milk	250 mL	11–14 g
Sweetened condensed milk (250 mL)	250 mL	35 g
Buttermilk	250 mL	9–11 g
Low-fat commercial yoghurt	250 mL	11–15 g
Light cream	1 tbs or 15 mL	0.6 g
Whipped cream topping	1 tbs	0.4 g
Butter	1 tbs	0.15 g

Cottage cheese		5–6 g
Reconstituted dry whole milk	250 mL	48 g
Prepared foods which contain large amounts of lactose		
• Sweets • Caramels and coated candies • Cakes and sweet rolls • Cheese spreads, party dips, sour cream, white sauces • Puddings and fudge • Infant formulas • All food products with milk, cream, milk powder, milk solids, milk sugar and galactose		
Foods with small amounts of lactose (<1 g/100 g)		
• Dried soups • French fries • Corn cereals • Canned or frozen fruits and vegetables • Cookies and cookie sandwich fillings • Instant coffee • Ready-to-serve instant meals, instant potatoes • Salad dressings • Meat products prepared with fillings • Pie crusts and fillings • Liquid antibiotics, vitamin, and mineral mixtures • Cordials and liqueurs		

Try out Probiotics

Probiotics are living organisms present in your intestines that help maintain a healthy digestive system.

Probiotics are also available as active or "live" cultures in some yogurts and as supplements in capsule form. They are sometimes used for gastrointestinal conditions, such as diarrhoea and irritable bowel syndrome. They may also help your body digest lactose. Probiotics are worth a try if other methods don't help.

Maintain good nutrition

Get enough calcium

Reducing the dairy products doesn't mean you can't get enough calcium. Calcium is found in many other foods, such as:

- Milk substitutes, such as soy milk and rice milk
- Calcium-fortified products, such as breads and juices
- Spinach
- Broccoli
- Oranges
- Rhubarb
- Custard apple
- Canned salmon

Get enough Vitamin D

Make sure you get enough vitamin D, since you are likely to miss out its typical source, viz., fortified milk.

Eggs, liver and yogurt also contain vitamin D, and your body makes vitamin D when you spend time in the sun.

Recent Developments in Science and Technology

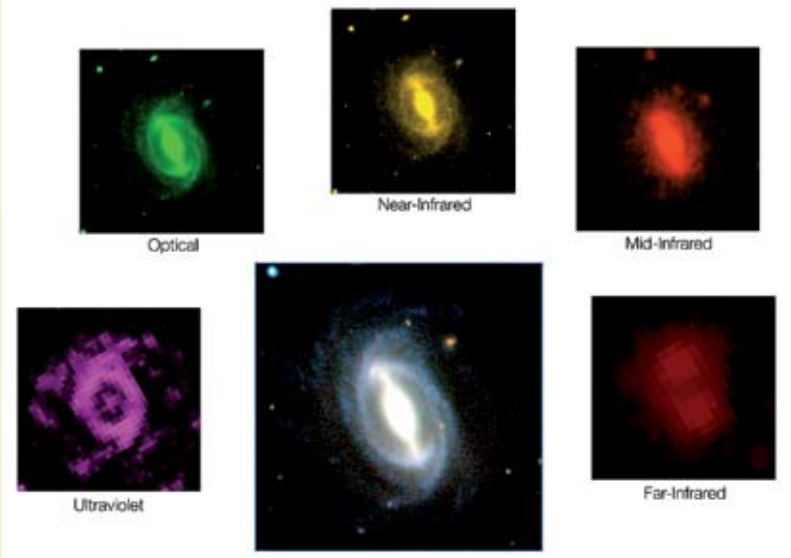
Biman Basu
E-mail: bimanbasu@gmail.com

Is the Universe dying?

Ever since it was born 13.8 billion years ago after what is known as the Big Bang, the Universe has been expanding. When it was born, some portion of the energy of the Universe was locked up as mass. While most of the energy in the universe arose in the aftermath of the Big Bang, additional energy is constantly being generated by stars as they fuse elements like hydrogen and helium together. When stars shine, they are converting the locked-up mass back into energy, according to Albert Einstein's famous equation $E = mc^2$. The Universe has been sustained by this energy created by the trillions of stars in billions of galaxies that make it up.

However, a recent study by an international team of astronomers, who measured the energy generated in more than 200,000 galaxies, has shown that rate of energy production is slowly decreasing. According to the astronomers, the Universe is only churning out half as much energy as it did two billion years ago, and is gradually approaching an equilibrium state. The study confirmed something researchers have suspected for decades; that is, the stars that populate countless galaxies are slowly burning themselves out.

The study involved many of the world's most powerful telescopes, including European Southern Observatory's VISTA and VST survey telescopes at the Paranal Observatory in Chile. Supporting observations were made by two orbiting space telescopes operated by NASA (GALEX and WISE) and another belonging to the European Space Agency (Herschel). The team observed the energy output in over 21 different wavelengths and found that the energy output is dropping over all the wavelengths, making their results the most comprehensive assessment to date of the energy output of the nearby Universe. The study was part of the Galaxy And Mass Assembly (GAMA) project, the largest multi-wavelength survey ever put together. The team presented this work at the International Astronomical Union XXIX General Assembly in Honolulu, Hawaii, on 10 August 2015.



This composite picture shows how a typical galaxy appears at different wavelengths in the GAMA survey. (Credit: ICRAR/GAMA and ESO)

Some experts are, however, of the opinion that the observation only indicates that the Universe is fading out but that does not mean it is dying. According to them, even if the Universe is dying, the endgame is too far into the future for humans to worry about. In fact, one scientist contends it could be 100 billion years out before the universe fizzles out, and it has so far been in existence for only 13.8 billion years. It is worth remembering that in 5 billion years, the Sun will expand and swallow the Earth, and in 10 billion years, our galaxy will merge with Andromeda galaxy.

ISS astronauts eat first space-grown food

Three astronauts on-board the International Space Station have for the first time tasted space-food, becoming the first humans ever to eat food grown in space! They munched the freshly harvested crop of a variety of blood-red-coloured lettuce called 'Red Romaine' lettuce salad during a live webcast from ISS in August from its 400-km-high orbit (http://www.nasa.gov). One of the astronauts, Scott Kelly, is now in the 5th month of his planned 1-Year-mission aboard the ISS. The joyful trio saved some for the produce for their three Russian station colleagues to try later. Another portion was set aside "to be packaged and frozen on the station until it can be returned to Earth for scientific analysis. Two of the Russian cosmonauts also conducted a spacewalk simultaneously as the lettuce tasting was going on.

The vegetable were grown in the microgravity environment of space in an innovative and ground-breaking "Veggie" plant growth system, housed inside the European Space Agency's Columbus laboratory located at the end of the US section of the ISS, without soil. The goal was to test hardware for growing vegetables and other plants to be harvested and eaten by astronauts in space. According to NASA, the collapsible and expandable Veggie unit uses red, blue and green LEDs, which "waste almost no energy on heat, but its variable light output allows it to be adapted to specific plant species at specific growth stages. Overall, it uses about 60% less energy than traditional plant lighting systems."

The plants were grown for 33 days before being harvested. The seeds had been stored dormant on the station for some 15 months since Veggie, along with two sets of bags containing the romaine seeds and one set of zinnias, was delivered to the station on the third cargo resupply mission by SpaceX in April 2014. One of the astronauts carefully

Red Romaine lettuce leaves grown entirely in the weightless condition of space. (Credit: NASA)

and methodically snipped away about half of the lettuce crop, which had grown to quite a size under the carefully maintained conditions inside Veggie, on live NASA TV.

However, it is not the first time food was grown on a space station. For decades, NASA and other agencies have experimented with plants in space, but the results were always sent to Earth for examination, rather than eaten. This was the first time that any astronauts were "officially" granted "permission" to eat the fruits of their labour. Growing edible space food marks a significant new milestone towards enabling deep space human exploration. "Plants will be an integral part of any life-support system for extended missions, providing food and oxygen and processing waste," NASA says. "Significant further advances will be necessary, and each of them promises to bring new innovations to agriculture here on Earth." Experiments like these are critical for NASA's plans to send humans on a "Journey to Mars" in the 2030s. The "Journey to Mars" and back is likely to take well over two years and resupply is not possible.

As NASA moves toward long-duration exploration missions farther into the solar system, Veggie will be a resource for crew food growth and consumption. Crews will have to grow at least a portion of their own food and the ISS experiment in a way helps pave the human path to the Red Planet. It also could be used by astronauts for recreational gardening activities during deep space missions.

Skin gets thinner in space

Recent studies have shown that astronauts' skin gets thinner in space, by as much as 20 percent. It has been known earlier that prolonged stay in the microgravity environment (zero-gravity) leads to several physiological changes in human body. For example, muscles atrophy as they don't have to support the weight of the body against Earth's pull, even with daily exercise in zero-gravity. In zero-gravity, fluid in the head is not pulled down as it happens on Earth and this can create pressure on the eyeballs, causing vision problems. And bones lose density – about one to two percent per month. After five months in space, former ISS astronauts needed several months to recover. But the effect of zero-gravity on human skin was not known before.

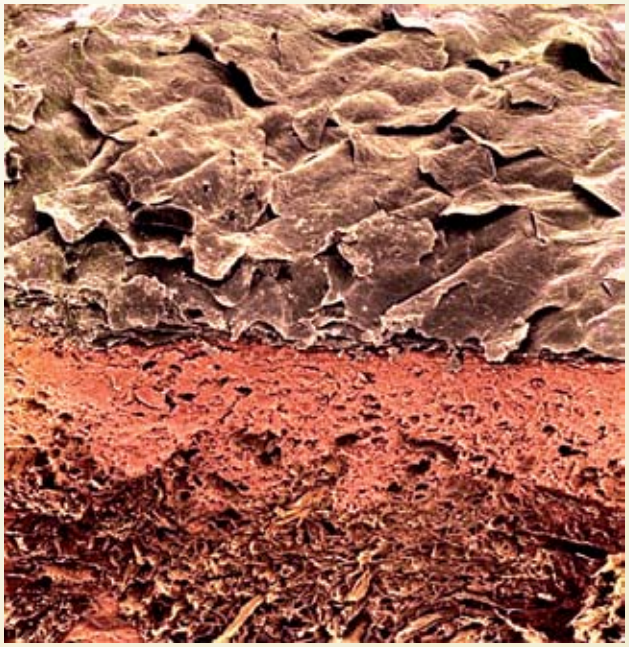


Image of a cross-section of human skin, showing dermis (bottom), epidermis (top), and collagen connective tissue.

In the past, many astronauts returning from long stay in space had skin problems such as skin dryness and itching – making them more vulnerable to scratches and irritation. To find the answer, NASA and the European Space Agency approached Professor Karsten Koenig of Saarland University in Germany, to see if he would be able to assist with their "Skin-B" project, aimed at improving our understanding of skin aging, which is slow on Earth but very much accelerated in space.

The technology, developed by Koenig's team for the study, uses a femtosecond laser pulses (1 femtosecond = 1 quadrillionth; i.e., 10^{-15} second) to image sections of the skin in high resolution using a technique known as tomography. The signals are then used to build up images and get a precise look into the skin with a high resolution. The laser technique looks at the way light is absorbed and reflected from the skin, and makes it possible to study beneath the epidermis into the dermis and subcutaneous tissue without surgical intervention.

The team studied three astronauts – two Italian and one German – who had spent up to 199 days in space. Each astronaut had their skin scanned just before going into space, and again on their return. The finding of the study was quite interesting. On the one hand, it was found that there was increased production of collagen; so suddenly these astronauts had more collagen in the dermis (lower layer of the skin), which can be termed as an 'anti-aging' effect. On the other hand, cells in the epidermis (outermost layer of the skin) were found to be shrinking, which is a common sign of aging and makes the skin look dull and thin, causing the skin to lose its elasticity, resulting in wrinkles and ageing lines. These two changes in the skin of the astronauts appear to counteract each other, in terms of the typical ageing process, but the researchers do not yet know what this will mean as the astronauts get older (http://nasaresearch.nasa.gov). According to Koenig, "So far we have no explanation yet, and we are waiting for the other astronauts to figure out what's going on and maybe to try to figure out how we can protect, how we can help so that this epidermis does not shrink".

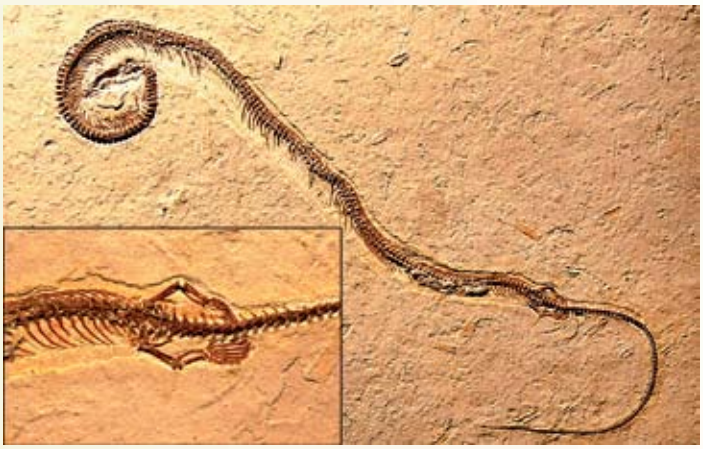
NASA scientists are of the opinion that the findings will provide insights into the aging process in other (similar) bodily tissues in general. This could help in determining impact on astronauts on future missions to

the Moon and Mars, for example, where environmental conditions are more challenging.

Four-legged snake fossil discovered

Snakes are a remarkably diverse and successful group today, but their evolutionary origins have been obscure. The discovery of snakes with two legs had shed light on the transition from lizards to snakes, but no snake has been described till now with four limbs. The first four-legged fossil snake ever found is forcing scientists to rethink how snakes evolved from lizards. Discovered in Brazil and estimated to be 113 million years old, it is the oldest snake fossil on record and looks almost like a modern snake, except for one glaring difference; it has four limbs, each with five digits, a new study finds. The fossil snake has been dubbed *Tetrapodophis amplectus* (literally, four-legged snake). According to David M. Martill, a professor of palaeobiology at the University of Portsmouth in UK, who led the research, although it has four legs, *T. amplectus* has other features that clearly mark it as a snake. At 4-mm and 7-mm long respectively, its limbs are very small indeed. The animal probably did not use them for walking, but rather for grasping prey or for burrowing. According to the scientists, *T. amplectus* may be the missing link between snakes and lizards (*Science* 24 July 2015 | DOI: 10.1126/science.aaa9208).

Scientists have long argued over whether snakes evolved from land or marine animals. *Tetrapodophis* lacks adaptations for marine life, such as a tail useful for swimming. But its skull and body proportions are consistent with adaptations for burrowing. Nicholas R. Longrich of University of Bath in UK, who was member of the research team, says that the finding unequivocally shows that snakes originated in the Southern Hemisphere and strongly supports a terrestrial origin. Another striking feature of the 20-cm-long fossil is the relative lengths of its skeleton. *T. amplectus* has 272 vertebrae, 160 of which are in its main body, not its tail. This number is more than twice the limit that researchers thought elongated bodies could reach before starting to lose their limbs.



Tetrapodophis amplectus, the 'four-legged hugging snake'. (Inset) Close-up of the five-fingered limbs. (Credit: Dave Martill/University of Portsmouth)

The researchers found several indications that the fossil is, in fact, a trransitional snake. Unlike lizards and crocodiles, *Tetrapodophis* has faint impressions of a single row of belly scales, a signature still seen on snakes today. (Belly scales are large and oblong scales on the underside, which are used by snakes for movement and even to grip branches to climb trees.) The fossil had other classic snake features, including a short snout, long braincase, elongated and flexible spine capable of constricting prey, fanged teeth and a flexible jaw that could swallow large prey; the researchers even found impression of snake-like scales. According to Martill, two-legged snake fossils had been known to exist, but this is the first known snake ancestor to sport four legs. He said, it probably evolved from terrestrial-burrowing creatures, and was a transitional animal that lived during the shift from ancient lizards to modern-day snakes.

In order to try to pinpoint the *Tetrapodophis*' place in history, the team constructed a family tree using known information about the physical and genetic make-up of living and ancient snakes, plus some related reptiles. That analysis positioned *T. amplectus* as a branch – the earliest branch – on the very same tree that gave rise to modern snakes. The findings suggest that the ancestor of all snakes was a terrestrial animal, which lived partially underground. ■

Organic Cultivation of Rice *(Continued from page 25)*

Conclusion

If we critically analyse agriculture from a technology perspective, it is actually the way of taming the nature and modifying it at will. Manipulating nature and harnessing desired output from it is the unique capability of mankind, which made them the unprecedented master of the world and agriculture has certainly played the biggest role in this direction. But, like any other technology, agriculture has also invited some hidden demons. Agriculture not only started encroaching natural forest cover, thus creating an imbalance in nature, but indiscriminate use of agrochemicals also stated polluting the environment and invited many previously unforeseen health hazards. But it is not actually the technology itself, rather human greed and lack of understanding the consequences are responsible for turning a technology evil. But, though late, good sense has started prevailing and people are beginning to understand the importance of a sustainable way of agriculture, which can meet human needs as well as restore and protect environmental stability. Organic farming is coming up as an attractive option in this regard. It is not only beneficial for sustainability of soil health, environment and overall biosphere; but also seems to be good for human health; especially in terms of negating the escalating risk of cardiovascular diseases and diabetes in recent decades. The production from organic farming may be a bit less as compared to conventional agricultural methods, but it can be treated as a value added product and therefore, farmers might be benefited economically by practising organic farming as the products have the potential to fetch a higher price in the market. It is still the early days of organic farming – principles and practices are still developing. Certainly it has shown some initial promise, but it might take some more time to understand and harness the complete potential of this technology.

T.B. Bagchi is a scientist in the Department of Crop Physiology and Biochemistry, and S. Ray is a scientist in the Division of Crop Improvement at Central Rice Research Institute, Cuttack. ■