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

Do I have a scientific temper if I do not acknowledge the limitations of my own thinking?



Dr. R. Gopichandran

I believe I am engaged in science and technology communication. I have to therefore introspect about my own credibility to communicate. I propose four facets of inclusiveness in communication and look for them in initiatives (in my own activities) that claim to be steeped in scientific temper and propagate it. (1) The first of these is already mentioned. It is about inclusiveness. (2) I need to also ask if I know enough about and limitations of my own understanding about aspects I wish to communicate. (3) Importantly, do I even attempt to get at-least a preliminary understanding of the spread and depth of wisdom in people I wish to engage with? Am I intelligent enough to recognise the wisdom they have? Answers to these questions are critical to determining the posture I adopt in communicating with fellow citizens. I cannot afford to adopt a condescending top – down model of engagement because I would have conveniently thrown out of the window such aspects as the inherent wisdom of the people I engage with and the circumstances that constrain them from transforming the intent of science culture to a reality. This statement in itself is condescending at best. You can see I am not sensitive to the fact that many of the people I engage with would have actually successfully adopted the best of practices despite the limitations they face. (4) Importantly, if I really practice the spirit of brotherhood amongst fellow citizens I should not condemn anyone as lacking in scientific temper. This self-aggrandisement is just the starting point towards concluding that the fellow citizens who I want to engage with have their own disruptive agendas and motives.

I realise I just cannot afford the kind of posturing stated above, because my fellow citizens too can suspect me of such motives that can be deemed incongruent. This predicament has to be overcome through a comprehensive mutually reinforcing communication strategy that ensures a bottom-up and top-down engagement. I will be happy to define the strategy as and when the opportunity arises. However, some of questions that have to be answered while defining the strategy could include: (i) Do we know enough about knowledge systems already prevalent in the stakeholders we wish to engage with? (ii) How do we showcase the pervasiveness of science and technology and method of science in daily lives and that they are already embedded in their walks of

life? This start-up advantage is critical to build a positive momentum. (iii) Am I not over emphasising such aspects as beliefs and practices by expecting a change in mindsets that will be aligned with my own limited thinking? (iv) What is the architecture of enabling circumstances that can help transform learnings into action? We cannot expect transformations just by delivering information and speaking hoarse about such intents. I may tend to actually trivialise the alignment of these two correlates? Popularisation too should not be oversimplified by too very often focussing only on changing mindsets. The various missions on science and technology in progress in our country provide excellent windows of opportunity to engage with citizens. The often-stated and almost rabid argument is about communication turfs/agendas of institutions. This reflects a mindset that is almost mediocre at best because it loses on opportunities to work with each other to serve the “unfinished agenda/reaching the unreached” in communication. (v) Can I expect fellow citizens to be receptive to all that I say when I stonewall myself to their values? The credibility of the communicator is central to the success of these interventions.

I remind myself of three goals of science and technology communication as defined by the Canadian Academy of Science through its publication on Science Culture: Where Canada Stands. It is about communication to (a) raise awareness, (b) build capacities to communicate, and (c) engage with fellow citizens so that they are able to transform learning to action. Obviously these are three stand-alone yet strongly intertwined means of working closely with fellow citizens. There is no place for one-upmanship in these approaches. Inclusiveness is about collateral benefits of expanded vision/thinking. My own credibility has to evolve and ensure inclusiveness. I cannot evolve incrementally based on my own whims and fancies. I should grow leaps and bounds. Charity begins at home. I should not throw stones at others when I myself live in my glass house that is opaque, antiquated by being unresponsive to the wisdom my citizens hold and stand for. I can at best be self-perpetuating with this limited vision. I will introspect.

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
 Tel : 011-26967532; Fax : 0120-2404437
 e-mail : info@vigyanprasar.gov.in
 website : <http://www.vigyanprasar.gov.in>

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Promoting Innovation in India

Innovation plays a key role in not only in economic development but overall development of a nation. Realising this the decade 2011-2020 has been declared as Decade of Innovation by the Indian government. Knowing that the innovation is the prime force which can accelerate national growth and development, the national policy for science and technology has been restructured and framed as Science, Technology & Innovation Policy in 2013. In line with the same, National Innovation Council (NInC) was formed at country level with the purpose of fostering innovations in the country.

NInC had already launched an India Innovation Portal with the purpose to bring the innovative community/people, their ideas, innovations and resources in one platform and to cater to their needs. Another initiative of the council involved formation of State Innovation Council to replicate the work of NInC at the state level i.e., to support and nurture innovations.

Where does India stand?

India is currently placed at 81st rank in the Global Innovation Index (GII) 2015. Switzerland tops the list followed by UK and Sweden while USA and China are at rank 5 and 29, respectively. India has moved down five positions over its previous ranking of 76 in 2014. The annual rankings are jointly published annually by Cornell University, European Institute of Business Administration (INSEAD) and World Intellectual Property Organisation (WIPO) featuring 143 countries and 81 indicators. Considering the region, India ranks no 1 in Central and Southern Asia (11 countries) but income-wise it is at No 7 in the Lower middle income group.

Nurturing innovations

There are numerous prospects available in India for those seeking mentoring or financial help to prove their innovation by realising them into a full-fledged enterprise or developing a prototype. Innovation or technological advancement is not restricted to researchers only, but can come from anyone like a student, housewife, scientist, farmer, even common man. Everyone may not have sufficient financial backing to translate their

ideas into reality. It is thus very essential that these innovative ideas, which may solve many local, national or international problems, should be supported either by hand-holding or providing them with an opportunity to develop and explore the utility of the ideas. Numerous organisations offer various schemes to provide mentoring and financial assistance. A glimpse of some schemes offered by Government of India is listed below.

(a) Department of Scientific and Industrial Research (DSIR)

Patent Acquisition & Collaborative Research & Technology Development – Started in 2013, it allows Indian industries to acquire patented technologies at early stage. A loan up to 50% may be availed for further developing the acquired technology.

Industrial R&D Promotion Programme – Under the scheme, recognition is granted that is in-house R&D units of various industries, universities, IITs, IISc, engineering colleges, etc., are certified and given recognition.

(b) Department of Science & Technology (DST)

Seed Support Fund – This fund has been instituted by Technology Development Board (TDB), constituted by DST, New Delhi where up to Rs. 1 crore is granted to Technology Business Incubators and Science and Technology Parks for a period of about three years. The grant is then used to support young entrepreneur under these Parks or Incubators in establishing their early-stage innovative technology-based enterprise. A maximum amount of up to Rs. 25 Lakh may be utilised for incubation or scaling up of technology.

(c) Technology Information, Forecasting and Assessment Council (TIFAC)

TIFAC-SIDBI Revolving Fund – TIFAC, New Delhi has placed about Rs. 30 crore with Small Industries Development Bank of India (SIDBI) to aid Micro Small and Medium Enterprises (MSME) undertaking establishing innovation based technology. They can approach either TIFAC or SIDBI with their proposals. Once the technical as



Pramila Majumdar

E-mail: pramila@niscair.res.in
E-mail: sanjeev@nrdc.in



Sanjeeva Kumar Majumdar

well as financial feasibility of the proposal is approved by TIFAC and SIDBI respectively, the fund will be provided.

Technology Refinement and Marketing Program – Since 2009, TIFAC is implementing this scheme through Technology Commercialisation Facilitator (TCF). TIFAC gives an annual grant of about Rs. 8.0 lakh to the TCF for identifying innovative technologies. The criterion for supporting an innovation is that at least a prototype has been developed having potential for patenting and up-scaling which will be commercially viable. It becomes the responsibility of the TCF to further commercialise the innovation and not the inventor.

(d) Biotechnology Industry Research Assistance Council (BIRAC)

Biotechnology Ignition Grant – This scheme offers individuals and companies grant of up to Rs. 50 lakh for a period of 18 months for research having commercial aspect. At present, the scheme is running in association with IKP Knowledge Park-Hyderabad, Centre for Cellular and Molecular Platforms-Bangalore, Foundation for Innovation and Technology Transfer-New Delhi, KIIT Technology Business Incubator-Bhubaneswar and Venture Centre-Pune.

BIRAC University Innovation Cluster – At present, BIRAC has opened innovation centres in five universities namely Anna University-Chennai, Panjab University-Chandigarh, Tamil Nadu Agricultural University-Coimbatore, University of Rajasthan-Jaipur, and University of Agricultural Sciences-Dharwad. The scheme offers students completing MSc or PhD, grant to realise their ideas.

BIRAC, a Public Sector Enterprise set up under Department of Biotechnology, Government of India offers a number of other schemes like Small Business Innovation Research Initiative, Biotechnology Industry Partnership Programme, Bio-Incubator support etc.

(e) Ministry of Micro Small and Medium Enterprises (MoMSME)

Credit-linked Capital Subsidy for Technology Upgradation – Launched in 2000, this GOI Scheme for Small Scale Industries (SSI) is executed by the Office of the Development Commissioner, MoMSME. Under the scheme 15% capital subsidy is given for incorporating established and approved technologies. An SSI can choose from more than 1,500 technologies under 51 different sectors to improve its technological input for better output. The subsidy is available from approved primary lending institutions like public and private banks, state financial corporation, etc.

Scheme for Promotion of Innovation of Innovation, Entrepreneurship and Agro-industry – the scheme allows for setting up of Livelihood Business Incubators and Technology Business Incubators (TBI). Under the TBI, there is provision of funds (i) to support existing and create new incubator; (ii) for developing of innovative ideas; and (iii) to create enterprise from the innovative ideas.

Protecting Innovations

In recent times, different laws have evolved to protect innovations throughout the world. But protecting innovations may involve continuous monetary obligations. For those who cannot afford to incur the huge amounts involved in protecting their innovations through patents, industrial design, geographical indication, etc., there are many avenues open for them to seek assistance.

1. Patent Facilitation Centres (PFC)

A number of PFCs have been set up in different states of India with the funds received from DST, Government of India coordinated by TIFAC. These PFCs assist in pre- and post-filing of patents of innovations resulting from DST-funded research projects free of cost to universities/govt institutions.

2. Intellectual Property Facilitation Centres (IPFC)

The IPFC is funded by Government of India and coordinated by Office of the Development Commissioner, MoMSME. These IPFCs are located in various parts of India and are formed with the aim to assist MSMEs with their IP needs like

IP protection, awareness and training, management, etc.

3. Innovation Facilitation Centre (IFC)

National Research Development Corporation (NRDC), a PSE under DSIR, New Delhi has opened up a couple of IFC outreach centre at AIIMS, New Delhi and Amity University, Noida. Purpose of the IFC is to promote and facilitate management of intellectual property among the academic fraternity.

Awarding Innovations

There are several competitions organised either regularly or as standalone event, which support the realisation of the winning innovative ideas. The competitions act as a dual booster to the innovators as they bring laurel and recognition to the innovator and also either suitably reward the winner in terms of monetary gains or may provide funding for prototype development or establishing an enterprise. A few of the regularly held competitions are the following:

(a) CSIR Award for S&T Innovation for Rural Development – This Award is given by CSIR, New Delhi to an Indian organisation or a company registered in India for implementation of S&T innovation that has led to improvement in quality of the lives of the rural community, generated rural employment. The award carries a cash of Rs. 10 lakh.

(b) NRDC Meritorius Innovation Award – NRDC, New Delhi offers awards in three categories namely NRDC Innovation Award of the Year, NRDC Societal Innovation Award of the Year, and NRDC Budding Innovators Award of the Year (for students).

(c) IGNITE – To foster the spirit of thinking creatively and to culture the habit of innovating to find solutions for local problems among the student fraternity, Ahmedabad-based National Innovation Foundation, under DST, GOI in association with other organisations conducts an annual national competition 'IGNITE' for student of up to 12th standard. Depending on the utility, NIF may further mentor and financially assist to protect and develop the technology.

(d) India Innovation Initiative (I³) – Awarded jointly by CII in collaboration with DST and other organisations to help and support innovators above 18 years of

age. The innovator should have developed a prototype which can cater to an industrial or societal problem. The entries are shortlisted and invited to national fair where they are further judged and awarded cash prize. Further incubation and financial support is provided to the selected participants.

(e) Initiative for Research & Innovation in Science (IRIS) – An initiative of CII, DST along with Intel Education awards innovations made by students of class 5 to 12. Submitted research-based projects are reviewed by a Scientific Review Committee and the selected ones are invited for participation in the National Fair. From there the selected students are further invited to represent India in Intel International Science and Engineering Fair.

(f) Grassroots Innovation and Outstanding Traditional Knowledge Award – Innovative ideas and traditional knowledge at grassroots level across wide subject areas are invited. Of these three of the best innovations are selected and given cash award. Another award for lifetime achievement is also given. Students are also invited to participate in the competition and the selected ones are given cash award.

(g) MSME Awards – To recognise and appreciate the innovation capacity of the micro, small and medium scale enterprises, MoMSME offers a number of awards. Some of them are (i) National Award for innovation in micro enterprises, (ii) National Award for innovation in small enterprises, (iii) National Award for innovation in medium enterprises, (iv) National Award for R&D in micro & small enterprises, (v) National Award for innovation in medium enterprises etc.

With the announcement of numerous schemes to promote innovation, there is scope for India to march ahead and feature among the top innovative nations in future. All we need to do is to make the people aware of the diverse opportunities available for them to take advantage of the same.

Pramila Majumdar is Scientist, Wealth of India & Associate Editor, IJNPR, CSIR-National Institute of Science Communication & Information Resources, Dr K S Krishnan Marg, New Delhi 110 060

Sanjeeva Kumar Majumdar is Deputy Manager, IPR Division, National Research Development Corporation, 20-22 Zamrudpur Community Centre, Kailash Colony Extension, New Delhi 110 048

Pepper – The Black Gold

Once considered as precious as gold and used as a form of commodity money, pepper is the world's most traded spice. Pepper or more specifically, black pepper is deemed to be the oldest used spices, discovered more than 4,000 years back along the Malabar Coast of South India, now known as Kerala. However, they came into cultivation around 1000 BC. Black pepper is native to India, and is extensively cultivated in South India. Currently Vietnam, India and Indonesia are the major producers of black pepper.

The spice was known in Greece in early 4th century BCE, but since it was highly expensive and rarely used; only the rich could afford it. Though it was grown in southern Thailand and Malaysia too, India was the most important source of pepper up to the end of Mediaeval Ages. The Romans, too, were aware of black pepper and opened ocean crossing the Arabian Sea, after the conquest of Egypt, to reach India's Malabar Coast. Later, black pepper was exported to Europe, the Middle East, and North Africa from India. But with the discovery of the New World and chili pepper, popularity of black pepper declined. With the Portuguese influence, black pepper was cultivated in Java, Sumatra, Malaysia and other parts of Southeast Asia. However, these areas traded mostly with China or used the spice locally. With the Indian black pepper gaining more popularity, the Portuguese managed to find a sea route to reach India.

Pepper – diversity and origin

The pepper fruit and its dried form 'peppercorn' have been used since antiquity for both its flavour and as a traditional medicine. It is one of the most common spices added to all kinds of cuisines in the world. Dried and ground pepper is omnipresent in the modern world as a seasoning and is often paired with common salt. Also two other derivatives such as pepper spirit and oil can be extracted from the fruits by crushing them. Pepper spirit is used in many medicinal and beauty products whereas pepper oil is used as an Ayurvedic massage oil and in certain beauty and herbal treatments. The spiciness of some other types of peppers like white, green, orange, and red pepper (see also Box 1) is also very familiar.

Several plants other than black pepper are used as pepper substitutes. The bark of canelo or winter's bark (*Drimys winteri*) is

Box 1: Other types of pepper and peppercorn

There are other types of pepper that are used in different culinary processes. Among them white pepper is the commonest, which are seeds of the black pepper drupes. Fully ripe pepper fruits are soaked in water for about a week, during which the pericarp of the pepper drupe softens, decomposes and ultimately the seed emerges. Then the naked seed is dried. White pepper has a slightly different flavour from black pepper and it is often used in cream sauces, salads and mashed potatoes. Green pepper, like black pepper, is made from the unripe pepper drupes. Dried green peppercorns are treated first with sulphur dioxide, followed by canning or freeze-drying to retain the green colour. Pickled green peppercorns are unripe drupes preserved in brine or vinegar. Orange pepper or red pepper usually consists of ripe red pepper drupes preserved in brine and vinegar.

used as a substitute for pepper in Chile and Argentina. Dried ripe fruits of the shrubs called Peruvian pepper (*Schinus molle*) and Brazilian pepper (*S. terebinthifolius*) are sold in the market as 'pink peppercorn'. In New Zealand the seeds of kawakawa (*Piper excelsum*) are sometimes used as pepper and the leaves of mountain horopito (*Pseudowintera colorata*) are another replacement for pepper. In North and Central America, the young fruits and seeds of field peppercorn (*Lepidium campestre*) and peppergrass (*L. virginicum*) are used as a spice, with a taste between black pepper and mustard.

Pepper plant

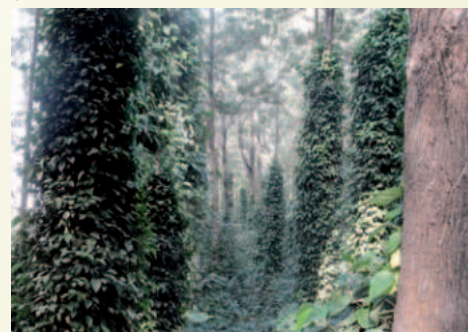
The pepper plant (*Piper nigrum*) is a perennial, scandent woody vine in the family Piperaceae. It grows on supporting trees (Figure 1), poles, or fences and attains up to 4 m in height. New root emerges readily where trailing branches touch the ground.



Dipanjan Ghosh Sreeparna Ghosh

E-mail: dpanjanghosh@gmail.com
E-mail: zeenaghosh@gmail.com

Flowers are densely arranged on pendulous spikes of about 7-15 cm long, produced at the leaf nodes. Each fruit is a single seeded globose drupe, approximately 5 mm in



Black pepper (*Piper nigrum*) cultivation at Anantagiri, Eastern Ghats, Andhra Pradesh (Photo: Parimal K Samanta).

diameter, unripe fruits are green in colour, and turn dark red when fully mature.

A single stem bears 20-30 fruiting spikes. The harvest begins as soon as one or two fruits at the base of the spikes begin to turn red, and while on the large scale, the fruits are still green, unripe and hard (Figure 2).



Unripe drupes of black pepper plant (Photo: Parimal K Samanta).

Unique peppercorns

Peppercorns are produced from green pepper drupes either by boiling in hot water followed by sun (or machine) drying for several days or by normal sun drying for several days without the boiling process. The heat ruptures cell walls in the pepper fruit. As a result, the fruit carp around the seed shrinks and darkens into a thin wrinkled black layer.

Black pepper, or simply pepper, is known under different vernacular names in different Indian languages. In Bengali and Oriya it is known as 'golmarich', in Hindi, Urdu and Punjabi, it is called 'kalimirch'. In Gujarati it is known as 'kada mari'. In Kannada, pepper is known as 'kare menasu'. In Malayalam it is known as 'kurumulaku', in Tamil, as 'milagu' and in Telugu, it is called 'miriyalu'.

Peppercorns are often branded by their place of origin. For instance, 'Muntok' pepper comes from Indonesia and 'Kampot' pepper comes from Cambodia. 'Sarawak' pepper is native to Borneo whereas Vietnam produces both white and black pepper with a reckonable difference. India produces two types of black peppers known as 'Malabar' pepper and 'Tellicherry' pepper.

Black pepper is sold in ground, coarsely ground, cracked and whole peppercorn (Figure 3). Whole peppercorns are the best choice as they keep their freshness, flavour and essential oils intact for longer durations. Ground pepper tends to lose its texture and aroma with time through evaporation and takes on a bitter taste. Pepper can also lose



Dried pepper is the most widely traded spice in the world (Photo: Sreeparna Ghosh).

flavour when exposed to light, which can transform the chemical piperine into nearly tasteless isochavicine. Another alternative to obtain the full flavour is to use freshly

ground black pepper, as most culinary sources recommend.

Pepper gets its spicy taste mostly from a substance known as piperine derived both from the fruit carp and the seed. Black pepper contains between 5-9 per cent piperine by mass and white pepper slightly more than that. Piperine is known to irritate nostrils which results in sneezing. Pepper contains other chemicals, including amides, piperidines, pyrrolidines and trace amounts of saffrole. The aroma of the black peppercorn is attributed by a sesquiterpene compound rotundone and a few other terpenes, such as caryophyllene, limonene, linalool, pinene, and sabinene.

Ground black pepper contains a reasonable amount of vitamin E, K, and vitamin B (especially niacin, riboflavin and choline), minerals like calcium, magnesium, phosphorus, iron, and manganese, with a trace amount of other essential nutrients, protein and dietary fibres. The calorific value of black pepper is 257 calories per 100 gm of weight.

Traditional medicine

Like many other spices, pepper has been used as a medicine in both traditional and Ayurvedic treatments for ages. Amongst all the health benefits of black pepper, the most significant is its ability to improve digestion. By stimulating the taste buds, black pepper increases the secretion of hydrochloric acid, thereby enhancing the digestion process once food reaches the stomach. The antioxidant properties of black pepper help in preventing and repairing damage caused by free radicals, thereby avoiding the risk of cardiovascular diseases and liver problems. Besides, pepper also helps to reduce the damage caused by saturated fats, which is regarded as the primary cause of oxidative stress. Moreover, the outer layer of peppercorn is known to break fat cells and boost metabolism. Hence, all foods containing black pepper are an effective way of shedding those unwanted body fats.

Black pepper is good for curing toothache, tooth decay, earache, gangrene, hernia, hoarseness, sunburn and insect bites. Regular intake of black pepper is known to benefit people suffering from rheumatism and arthritis. Black pepper also improves circulation and provides relief to such patients. The spiciness of black pepper helps in clearing throat congestion and sinusitis.

Besides, it aids in relieving flatulence, sore throat, cough and cold.

In addition, pepper contains good anti-bacterial properties also. Bacterial infections of the mouth, colon, digestive system, urinary tract and others are successfully treated with black pepper. Pepper has been proved to be an effective remedy for curing vitiligo by stimulating the skin to produce pigments.

Piperine, found in black pepper, is effective in inhibiting the pro-inflammatory cytokines produced by tumour cells. This, in turn, holds back the signalling mechanisms between cancer cells and reduces the chances of tumour progression. Black pepper also acts as a protective agent against the risk of skin cancer that can occur due to excess ultraviolet radiation.

Black pepper oil helps in protecting the body from damage caused by oxidants and assists in the repairing process. Besides, it slows down the adverse effects of aging, such as vision loss, macular degeneration, wrinkling of skin, degeneration and loosening of muscles, loss in mobility of joints, nervous disorders and memory loss.

In India, black pepper is used as an ingredient of Ayurvedic medicines. Its use is quite well known to cure illness such as indigestion, diarrhoea, gonorrhoea, trouble in urination, waist, rib and shoulder pain and pulled muscles, insomnia, insect bites, and so on.

Conclusion

The unique aroma of black pepper has made it a valuable and most widely traded spice in the world. Presently Vietnam is the world's largest producer and exporter of black pepper followed by India, Brazil, Indonesia and Malaysia. India earns a good amount of foreign currency each year by exporting pepper. However, all peppers do not have the same taste. So the recent trend of industrial buyers is to mix peppers of different origins to maintain a balance between price, taste and other factors. Malabar (Indian) black peppers are used for weight and taste, Sumatra (Indonesian) for colour and Penang (Malaysian) for strength.

Dipanjana Ghosh is a popular science writer and one of the Editors of the journal 'Indian Science Cruiser' published from Kolkata.

Sreeparna Ghosh is a popular science writer and science communicator.

Taming Parasitic Diseases

Parasites are organisms that reside in or on another organism, where they feed on nutrients, multiply, and often cause chronic or life-threatening diseases. There are three main classes of parasites that can cause disease in humans: protozoa, helminths, and ectoparasites. Diseases caused by parasites, which affect the world's poorest populations have plagued humankind for thousands of years and constitute a major global health problem. These diseases, which include malaria, river blindness, and filariasis, represent a huge barrier to improving human health and wellbeing in the world's poorer countries. Many parasites also attack domestic animals and livestock, which add to the societal burden of the world's poorer societies.

The Nobel Prize in Physiology or Medicine for 2015 has been shared by three scientists for their discoveries concerning a novel therapy against infections caused by parasites. Youyou Tu, a pharmacologist at the China Academy of Chinese Medical Sciences in Beijing, received half of the prize for her work on the herbal anti-malarial drug artemisinin, while William C. Campbell, a microbiologist at Drew University in Madison, New Jersey, USA; Satoshi Omura, a microbiologist at Kitasato University in Japan shared the other half for their work on drugs against river blindness and lymphatic filariasis. Tu is the first China-based scientist to win a science Nobel.



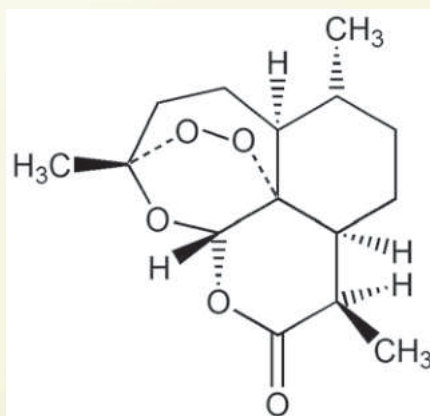
Artemisia annua



Youyou Tu (Credit: chine-informations.com)

Malaria is a mosquito-borne disease caused by parasitic protozoans that can cause fever and, in some cases, brain damage and even death. The disease has been a major global health problem for ages. According to the WHO World Malaria Report of 2014, about 3.4 billion people are at risk of being infected with malaria every year. In 2013 alone, 198 million cases of malaria were reported globally, leading to the death of 584,000 people. The largest number of cases was in Africa where almost 90% of all deaths occurred, mainly of children below 5 years of age.

The devastating impact of malaria spurred intense research efforts during the last centuries, leading to a series of Nobel



Structure of artemisinin

Prizes in Physiology or Medicine. Ronald Ross, a British army surgeon working in India, was awarded the Nobel Prize in 1902 after he discovered the transmission of malaria by mosquitoes. Charles Laveran, a French physician working in an Algerian hospital, received the Nobel Prize in 1907 after he discovered the existence of parasites inside the red blood cells of malaria-infected patients. He went on to show that quinine treatment eliminated the parasites from the blood. The Swiss chemist Paul Herman Müller was awarded the Nobel Prize in 1948 for his discovery of DDT that could be used to kill and control breeding of mosquitoes.



Biman Basu

E-mail: bimanbasu@gmail.com

Extensive use of DDT, together with the newly developed anti-malarial drug, chloroquine was initially very effective in reducing the incidence of malaria in many countries. However, after only a few decades, not only did the mosquitoes develop resistance towards DDT but the malaria-causing parasite *P. falciparum* also began to develop resistance to chloroquine. Both of these factors contributed to the widespread increase in mortality from malaria during the 1960's.

It was around this time that Youyou Tu, then working at the erstwhile China Academy of Traditional Chinese Medicine (now China Academy of Chinese Medical Sciences) in Beijing, consulted many traditional doctors from southern China and read through some 2,000 recipes of herbal remedies for fever. Finally, she narrowed her search to 380 extracts from 200 herbs, only one of which worked against the malaria parasite. It was an extract derived from a plant known as Qinghao in Chinese, with the botanical name *Artemisia annua* (common name, wormwood). Tu's research showed that the active ingredient she had isolated, called artemisinin, was effective against malarial parasites that had become resistant to chloroquine. It was a remarkable discovery. By 1972, chemically pure artemisinin had been isolated by her team. Since its introduction, artemisinin has saved millions of lives.

Two other parasitic diseases that cause widespread suffering and disability are river



A river blindness patient with inflamed cornea in Nigeria



Enlarged and disfigured legs of lymphatic filariasis patients.

blindness and lymphatic filariasis. Both are caused by parasitic worms (helminths), which are estimated to afflict one third of the world's population and are particularly prevalent in sub-Saharan Africa, South Asia and Central and South America. African river blindness is caused by the filarial worm *Onchocerca volvulus*. The disease is transmitted solely to humans by the bites of black flies, which breed in fast-flowing streams and rivers, hence the name of the disease. As the name implies, river blindness ultimately leads to permanent blindness, because of chronic inflammation in the cornea.

Lymphatic filariasis is an infection of the lymphatic system caused by infection with microscopic thread-like worms of the family *Filariodidea*. These are spread by infected mosquitoes. In an infected person, the worms occupy the lymphatic system, including the lymph nodes; in chronic cases, these worms lead to lymphatic filariasis,

commonly known as elephantiasis – a painful and extremely disfiguring disease in which a limb or other part of the body becomes grossly enlarged due to obstruction of the lymphatic vessels. More than 120 million people are infected with lymphatic filariasis and about 1.4 billion people are at risk of the disease in 73 countries. It is most common in Africa and Asia.

In 1974, Satoshi Omura, a microbiologist with expertise in isolating natural products and working at the Kitasato Institute in Japan, isolated strains of a group of soil bacteria called *Streptomyces*, which were known to produce a large number of agents with antibacterial activities (including the antibiotic Streptomycin). He successfully cultured them in the laboratory. From many thousand different cultures, he selected about 50 of the most promising, with the intent to get them further analysed for their activity against harmful microorganisms. He sent the cultures to William C. Campbell, an expert in parasite biology working at the Merck Shape and Dome Research Laboratories (MDRL) in New Jersey, USA for further study.



*Satoshi Omura
(Credit: abc.net.au)*



*William C. Campbell
(Credit: theguardian.com)*

against parasitic infection. It was subsequently tested in humans with parasitic infections and was found to effectively kill parasite larvae that caused river blindness and lymphatic filariasis. Over the years, the derivatives of ivermectin have radically reduced the incidence of river blindness and lymphatic filariasis. Ivermectin is considered a highly effective treatment that only needs to be taken once or twice a year. In this way, citizens of even the most remote parts of the world can be reached.

The discoveries of avermectin and artemisinin have fundamentally changed the treatment of parasitic diseases. Today, ivermectin is used around the world, especially in regions plagued by parasitic diseases. It is highly effective against a range of parasites, has limited side effects and is freely available across the globe. The impact of using ivermectin in improving the health and wellbeing of millions of individuals with river blindness and lymphatic filariasis, especially in the poorest regions of the world, has been immense.

Together, the unique contributions by Omura and Campbell have led to the identification of a new class of drugs with extraordinary efficiency against parasitic diseases. The treatment is so successful that these parasitic diseases are almost on the verge of eradication, which would be a major feat in the medical history of humankind. The elimination of river blindness and lymphatic filariasis are key targets for the WHO Regional Strategy to Eliminate Neglected Tropical Diseases.

Biman Basu is a former editor of the popular science monthly Science Reporter, published by CSIR. He is a winner of the 1994 'NCSTC National Award for Science Popularisation'. He is the author of more than 45 popular science books. ■

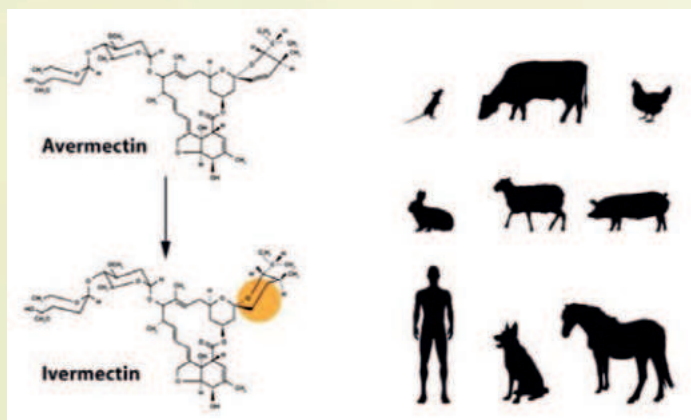


Diagram showing modification of avermectin to ivermectin, which turned out to be highly effective in both animals and humans against a variety of parasites, including those that cause river blindness and lymphatic filariasis in humans. (Credit: nobelprize.org)

Campbell's team showed that a component from one of the cultures was remarkably efficient against parasites in domestic and farm animals. The bioactive agent was purified and named avermectin. Campbell, together with colleagues at MDRL, subsequently chemically modified avermectin to a new version called ivermectin, which turned out to be even more effective

Emmy Noether: The Neglected Genius

Many a time it has happened in the history of science that although two individuals made outstanding discoveries of equal significance, one of them was rated so high that the other got overshadowed. A glaring example is that of Albert Einstein and Emmy Noether both of whom made outstanding contributions to physics and mathematics, respectively, in 1915. The former presented his famous general theory

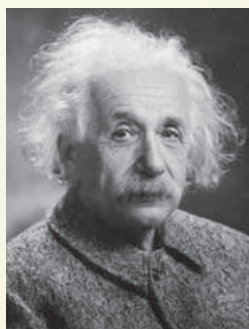
of relativity, while the latter came out with her brilliant mathematical theorem. Due to the tremendous impact of Einstein's general relativity, perhaps Noether's theorem got overshadowed, but it was no less in stature.

An interesting similarity

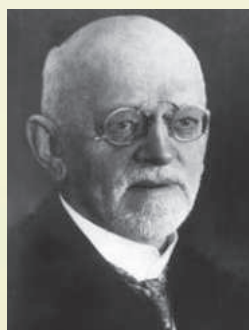
Einstein and Noether were both born in same calendar month and had their last breaths again in the same calendar month (though calendar years were different). Keeping up with the erstwhile society's acceptable trends regarding female education, Emmy Noether started out with studying English, French, and piano. But her interests soon turned to mathematics. At that time German universities did not admit female students. She was barred from matriculating formally at the University of Erlangen. In pursuit of her learning, she had to ask each individual professor for permission to attend the class and at the end she did so well in her exams that the University was forced to award her the equivalent of a bachelor's degree.



Emmy Noether (23 March 1882 – 14 April 1935)



Albert Einstein (1879 – 1955)



David Hilbert

brilliance was noted by her colleagues and they all, especially males, tried to help her find a teaching position, that too a paid position.

Hilbert tried extremely hard to reason with the administration of the University of Gottingen for her to be appointed as the equivalent of an associate professor. Other male faculty members blocked the recommendation with arguments like: "What will our soldiers think when they return to the university and find that they are required to learn at the feet of a woman?" She did not get a full-time position until 1919.

At Gottingen, Noether carried on her research on mathematical invariance. Mathematical invariance means the study of numbers that can be manipulated in various ways and still remain constant. Invariance exists in nature. The distance of the Sun from a planet in its orbit may change at every moment, but the area swept out by the line joining the Sun and the

Noether came from a mathematics oriented family. Her father was a distinguished professor of mathematics at the Universities of Heidelberg and Erlangen. Her brother was also a renowned mathematician. She went on to a graduate school at the University of Gottingen before returning to the University of Erlangen. She met many of the leading mathematicians of the day including David Hilbert and Felix Klein. Her early work focussed on invariants in algebra. Her extraordinary



Dr. C.K. Ghosh



Sumit Budhiraja

E-mail: ckghosh@ignou.ac.in

planet per unit time always remains the same (Kepler's second law). If we study the bird flying data we find that a bird body axis is an invariant dimension during flight. There are many such examples of invariance in nature that attracted Emmy Noether. Noether's theorem is an outcome of that.

Noether's theorem

In 1915, when Einstein published his general theory of relativity, Noether began applying her work of invariance to some issues of the theory. She simplified the complex geometry of the universe and behaviour of mass and energy that exist in the universe. She discovered that every symmetry found in nature has with it a corresponding law of conservation, which explains why energy can neither be created nor destroyed. Noether's theorem guided physicists to get conserved quantities from symmetries of the laws of nature. For example, time symmetry gives conservation of energy; rotation symmetry gives conservation of angular momentum; symmetry in space gives conservation of linear momentum; etc.

To illustrate symmetry of time – if we move in our house from one room to another, then irrespective of time, there will be no change in our movement trajectory. Using Noether's theorem one can arrive at the principle of conservation of energy by taking into consideration the symmetry of time.

Noether's theorem can be related to Newton's first law of motion. The empty three-dimensional space looks the same in whichever direction one looks. This space-time symmetry applied to Noether's theorem is what derives the principle of conservation of linear momentum. We refer to this space-time symmetry as the homogeneity of space. If we look in any direction from any point in space, statistically they would appear very nearly the same. It amounts to saying that



Symmetries in various objects. Some of them are natural, some artificial.

the universe is very nearly homogeneous. This indicates that the universe is nearly isotropic.

As a matter of fact, isotropicity ensures homogeneity but the reverse is not always true. For example, if we consider an infinitely long cylinder and look down through it, every point would look like any other, as the corresponding space extends to infinity. But along the other two mutually perpendicular directions it extends only up to the length of the circumference of the circle, which is the cross-section of the cylinder. So, the infinitely long cylinder is homogenous, but not isotropic. Noether applied the concept of isotropicity of space to her theorem to establish the principle of conservation of angular momentum, which incidentally forms the basis of Kepler's second law referred to earlier.

Noether's theorem has been applied in many branches of physics. For example, in quantum physics the phase of the wave function attached to a system can be incremented without affecting any other measurable parameters, which is termed as 'gauge symmetry'. It corresponds to the conservation of electric charge.

Noether's theorem guides an approach to identifying symmetries with conserved quantities which form the basis of the Standard Model of particle physics. Rather the symmetries of system of particles have led to the discovery of many subatomic particles.

In 1954, Chen Ning Yang and Robert Mills showed that other types of symmetries could describe the behaviour of a vast array of particles and forces. In 1962, Murray Gell-Mann was able to predict the existence of a new particle after simply studying symmetries written on a blackboard. Noether's theorem inspired the search of

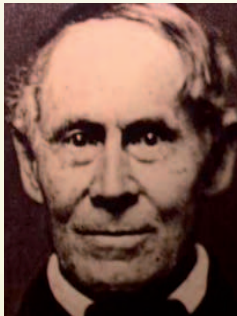
Higgs Boson – a particle that was found in 2012 at the Large Hadron Collider.

Noether's first theorem connects symmetries with conservation laws. The theorem was proved by Noether in 1915, the same year in which the famous general theory of relativity of Einstein was proposed, but it got published in 1918. Einstein himself praised Noether's work as a piece of 'penetrating mathematical thinking'. He called her the most significant and creative female mathematician of all times.

Noether's theorem was as important



Chen Ning Yang



Robert Mills



Murray Gell-Mann

as Einstein's theory of relativity. Rather her theorem was in response to analysing some complexities related to generally covariant equations of Einstein's theory of general relativity. Her theorem established relationship between two parallel distinct concepts of symmetry in nature and the universal law of conservation. Einstein's equations are solvable with the aid of symmetry proposed by Noether's theorem. In other words, Noether's theorem allows us to find the space-time symmetry related to a quantity that is believed to be conserved.

Noether's work also deserves celebration in the centenary year (2015) as she was an outstanding researcher whose determination and unshakable commitment towards work helped her overcome severe handicaps, first being a Jew in the era of Nazis power, and second, she being a female scholar at a time when most German universities did

not accept female students or hire female faculty. She was younger to Albert Einstein. She worked unpaid in Erlangen as a student supervisor, and sometimes giving lectures for her ailing father. Later with the help of mathematical giants, David Hilbert and Felix Klein, Noether became the first woman lecturer at the University of Göttingen. Initially Noether worked for no pay and her lectures were advertised under Hilbert. It was only after the German's liberalisation after World War I, she was allowed to give lectures officially.

She published great papers, sometimes under a man's name. Ransom Stephens, a physicist and a novelist said, "You can make a strong case that her theorem is the backbone on which all of modern physics is built."

Her unselfish, highly significant work was disregarded by the Nazis when they came to power and she was dismissed. Her life became harsh due to paucity of means of her life maintenance and her passion for research which lacked the desired support.

However, her highly acclaimed work also gave her friends who helped her in getting employment at Bryn Mawr College, and at Princeton in America. Noether was very happy after taking charge. She told her friends that women were finally gaining acceptance in the field.

Shortly after Noether's death in 1935, Albert Einstein wrote a letter in her praise to the *New York Times* about her genius. He wrote: "*In the judgement of the most competent living mathematician, Fraulein Noether was the most significant creative mathematical genius thus far produced since higher education of women began. In the realm of algebra, in which the most gifted mathematicians have been busy for centuries, she discovered methods which have proved of enormous importance in the development of the present day younger generation of mathematicians.*"

Dr. C.K. Ghosh is Regional Director, IGNOU Regional Centre Delhi-3, who takes keen interest in mathematics.

Mr. Sumit Budhiraja is Coordinator of an IGNOU Study Centre, and Director of School of Professional Development, New Delhi. He has 17 years of teaching experience of Management and IT subjects. ■

Mother Nature's Own Pharmacy

R. Vathsala E-mail: vathsalarangachari@gmail.com

Unlike domestic pets, animals in the wild don't have access to the range of treatments provided by owners of pet animals or vets. So what do wild animals do when they fall sick? Do wild animals know how to cure themselves?

Sometimes we notice our dog or cat eating a certain plant in the garden or else in



the nearby fields. This phenomenon is called zoopharmacognosy. It is a behaviour in which non-human animals apparently self-medicate by ingesting or topically applying plants, seeds, routes, soils, etc., to treat or prevent disease. The term, zoopharmacognosy was coined by Dr. Eloy Rodriguez, a biochemist and professor at Cornell University in USA, to describe the process by which wild animals select and use specific plants with medicinal properties for the treatment and prevention of disease.

Recent scientific evidence indicates that animals indeed have knowledge of natural medicines. In fact, they have access to the world's largest pharmacy, Mother Nature herself.

Self-medicating behaviour is a topic of rapidly growing interest to biologists, pharmacologists and conservationists. Scientists are currently exploring the possibility that many species use plants, soils, insects, and fungi as 'medicines', in ways that guard against future illness (preventive medicine) and/or relieve unpleasant symptoms (curative or therapeutic medicine). It is important to note that the scientific study of animal self-medication is not based on an assumption that animals

possess an innate 'wisdom', by which they flawlessly know what is good for them.

Self-medication strategies are survival skills evolved through natural selection. In most cases self-medication could be motivated by a desire to immediately reduce unpleasant sensations. Some species, particularly great apes, show an intention of purpose in their medication.

A very common and well-known example of zoopharmacognosy is dogs eating grass to induce vomiting. Observers have noted that some species ingest non-foods such as clay, charcoal, and even toxic plants, apparently to ward off parasitic infestation or poisoning.

Golden retriever dogs are often seen eating the echinacea plant (*Echinacea angustifolia* and *E. purpurea*), which contains a number of constituents that stimulate the immune system to deal with both bacterial and viral infections. Horses often consume the yarrow (*Achillea millefolium*). One of the constituents of yarrow is chamazulene, which is a strong anti-inflammatory drug. Horses



also consume mullein (*Verbascum thapsus*) while out on the trail. Here too, mullein is a known to be an effective herb for coughs and congestion.

Indigenous traditions and cultures had knowledge of animal self-medication for centuries; many folk remedies have been developed by noticing which plants animals eat when they are sick. But it has been only in the last 30 years that zoopharmacognosy has been scientifically studied. Biologists watching animals eating things not part of their usual diet realised that the animals were

self-medicating with natural remedies.

Self-medication in wild animals remains a controversial subject, because evidence is mostly circumstantial, but there are many fool-proof examples. The methods by which animals self-medicate vary, but functionally, self-medication can be classified as prophylactic (preventative, before infection) and therapeutic (after infection, to get rid of the pathogen).

There is good evidence that some animals have evolved adaptive behaviours which include selecting certain stuff preferentially when they have a certain medical problem. However, there is considerably less evidence that animals consistently make accurate choice about ingesting specific substances to treat or prevent specific medical conditions.

Let us go a little deeper into specific examples in the animal kingdom.

Insects

When gypsy moth caterpillars consume foliage high in certain toxic compounds, transmission of viruses between the caterpillars is reduced, facilitating moth outbreaks.

According to scientists, less attention has been given to the many cases in which animals medicate their offspring. Wood ants incorporate an antimicrobial resin from conifer trees into their nests, preventing microbial growth in the colony.

Parasite-infected monarch butterflies protect their offspring against high levels of parasite growth by laying their eggs on anti-parasitic milkweed.

In addition, biologists are of the opinion that animal medication should alter



the evolution of animal immune systems. Honeybees are known to incorporate antimicrobial resins into their nests. Analysis of the honeybee genome suggests that they lack many of the immune-system genes of other insects, raising the possibility that honeybees' use of medicine has been partly responsible – or has compensated – for a loss of other immune mechanisms.

Birds

Native doctors like Shamans and even qualified doctors have used clay for a thousand years. More than 200 species of song birds swipe ants through their plumage in a behaviour often called 'anting'. Birds grasp ants in their bill and wipe them vigorously along the spine of each feather down to the base. Sometimes, they roll in ant hills twisting and turning so the ants crawl through their feathers.

Birds most commonly use ants that spray formic acid. Laboratory tests have indicated that this acid is harmful to feather lice. The vapours of formic acid can kill the parasites on the feathers.

Some birds select nesting material rich in anti-microbial agents that may protect them and their young from harmful infections. European starlings line their nests with wild carrot and house sparrows with materials from the neem tree (*Azadirachta indica*).

Some species of South American parrot and macaw are known to eat soil with high kaolin content. The parrots' diet contains toxins because of the fruit



seeds they eat. (Even apple seeds contain cyanide.) The kaolin clay absorbs the toxins and carries them out of the birds' digestive system, leaving the parrots unharmed by the poisons. Kaolin has been used for centuries in many cultures as a remedy for human gastrointestinal upset.

Clay absorbs heavy metals, trace elements, organic substances, and other minerals. When bird ingests one of the wholesome clays, the colloidal substance goes to work cleansing the living thing from impurities, as well as, re-mineralising the body at the same time. Unwanted deposits of heavy metals are removed from the body while required elements are replenished.

Toxins and pathogens are absorbed and removed, hence inflammation diminishes. As the body re-acquires the essential building blocks from the clay and rids itself of undesirable matter, the whole metabolism benefits.

Benign bacteria can actually flourish in an environment where clay has been administered. This means that neither we, nor the animals, have to eat as much to acquire the nutrition we seek because the trace elements in the clay induce and speed up vital reactions leading to better assimilation of nutrients.

Geophagy, or the phenomenon of eating mineral-bound clay is not exclusive to macaws. While six species of macaws are known to frequent exposed Amazonian clay deposits in cliffs bounding rivers and waterways, nearly a dozen parrots, and lorikeets are also known to be clay-eaters.

Australian cockatoos have been observed to seek out clay for medicinal and remedial purposes. It is suspected that cockatiels (a member of the cockatoo), budgerigars (parakeets), toucans and other

tropical birds may also benefit from a wide assortment of trace minerals found in certain kinds of clays.

Mammals

A female capuchin monkey in captivity was observed using tools covered in a sugar based syrup to groom her wounds and those of her infant. Many animals eat minerals like clay or charcoal for their curative properties. Colobus monkeys on the island of Zanzibar have been observed stealing and eating charcoal from human bonfires. The charcoal counteracts toxic phenols produced by the mango and almond leaves which make up their diet.



Not only do many animals know which plant they require, they also know exactly which part of the plant they should use, and how they should ingest it. Chimpanzees in Tanzania have been observed using plants in different ways. The *Aspilia* shrub produces bristly leaves, which the chimps carefully fold up then roll around their mouths before swallowing whole. The prickly leaves 'scour' parasitical worms from the chimp's intestinal lining.

The same chimps also peel the stems and eat the pith of the *Vernonia* plant (also known as bitter leaf). In biochemical research, *Vernonia* was found to have anti-parasitic and anti-microbial properties. Both *Vernonia* and *Aspilia* have long been used in

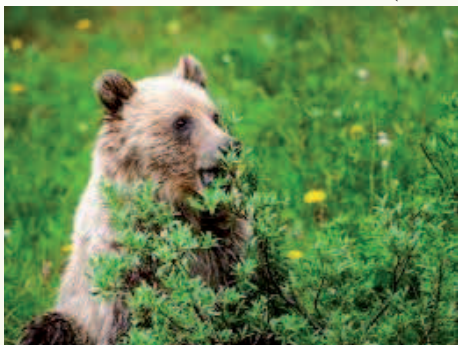


Tanzanian folk medicine for stomach upsets and fevers.

It is only the sick chimpanzees that eat the plants. The chimps often grimace as they chew the *Vernonia* pith, indicating that they are not doing this for fun; healthy animals would find the bitter taste unpalatable.

Wild animals won't seek out a remedy unless they need it. Scientists studying baboons at the Awash Falls in Ethiopia noted that although the tree *Balanites aegyptiaca* (Desert date) grew all around the falls, only the baboons living below the falls ate the tree's fruit. These baboons were exposed to a parasitic worm found in water-snails. *Balanites* fruit is known to repel the snails. Baboons living above the falls were not in contact with the water-snails and therefore had no need of the medicinal fruit.

North American brown bears (*Ursos*



arctos) make a paste of Osha (*Ligusticum porteri*) roots and saliva and rub it through their fur to repel insects or soothe bites. This plant, locally known as bear root, contains 105 active compounds, such as coumarins that may repel insects when externally applied. Navajo Indians are said to have learned to use this root medicinally from the bear for treating stomach aches and infections

Osha is a plant native to the western United States and Mexico. Another name for Osha root is bear medicine. The story is that Native Americans had noticed bears rolling around in this plant, eating the roots and applying a root mash to any injuries they may have had. They also noticed bears would seek this plant out when they awoke from their hibernation. The reasons for this action may be for the plant's respiratory cleansing properties and to clean out their digestive systems.

Osha root is known for its powerful antiviral and antibacterial action, used for bronchial infections and sore throats. There are many stories about indigenous cultures



discovering their medicines by observing animals self-medicating themselves.

When a pregnant African elephant was observed for over a year, a discovery was made. The elephant kept regular dietary habits throughout her long pregnancy, but the routine changed abruptly towards the end of her term. Heavily pregnant, the elephant set off in search of a shrub that grew almost 30 kilometres from her usual food source. The elephant chewed and ate the leaves and bark of the bush, then gave birth a few days later. The elephant, it seemed, had sought out this plant specifically to induce her labour. The same plant also happens to be brewed by Kenyan women to make a labour-inducing tea.

Cat

Catnip is another name for the herb *Nepeta cataria*, a relative of oregano and spearmint. *N. cataria* is a pretty common plant, often found along highways and railroads. The active molecule in *N. cataria* is nepetalactone, which is believed to mimic a cat pheromone. Nepetalactone binds to a cat's olfactory receptors to produce catnip's unique response.



Animals use medications to treat various ailments through both learned and innate behaviours. Moths, ants and fruit flies are now known to self-medicate and choose food for their offspring that minimises the impact of disease in the next generation. This information has profound implications for the ecology and evolution of animal hosts and their parasites.

How do wild animals know about the medicinal plants? While animals in the wild instinctively know how to heal themselves, humans have all but forgotten this knowledge because we have lost connection with nature. Since wild animals have begun to be observed actively taking care of their own wellbeing, it raises questions of how we approach healthcare with natural remedies, not just for ourselves but for our companions and farm animals too.

Because plants remain the most promising source of future pharmaceuticals, studies of animal medication may lead the way in discovering new drugs to relieve human suffering.

Today, wildlife biologists still observe animals in their natural habitat and find many new medicinal qualities in plants through these observations.

Why should we study Zoopharmacognosy?

Maybe even more important than the medicinal potential, the understanding of animal self-medication can help us safeguard our food supply. Food, for the most part, is no longer farmed, but mass-produced. But, nature does not function as such. Nature functions as a web of diverse interlinking, overlapping and complex relationships, which do not run on a linear plane as found on a factory floor.

Zoopharmacognosy principles could save the farming industry billions of dollars. When animals are given the option to self-medicate, farmers will no longer have to give antibiotics to all their animals, including the healthy ones, as they do now.

Swine flu has become endemic all over the world and we understand now how unhealthy animals can all too quickly translate into unhealthy humans. There are many zoonotic diseases that may have been prevented, had we understood more fully the implications of animal self-medication.

(Continued on page 19)

Coeliac disease: When a food protein turns villain



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

Coeliac disease is a peculiar digestive disorder that occurs in reaction to gluten, a protein found in wheat, rye, barley, oats and hundreds of foods made with these grains. The body's immune system reacts to the gluten and causes damage to the intestine.

More common among the people of West Bengal, Punjab and northwest India and widely prevalent in several parts of the world, the disease is caused by loss of intestinal villi—the tiny, finger-like protrusions which project into the bowel cavity and serve to absorb nutrients.

Coeliac disease is a lifelong disorder. However, its treatment is fairly straightforward; it simply requires doing away with all gluten-containing foods. This requires a shift to rice, corn, sorghum (*jowar*), and millet (*bajra*) as the staples in the diet. In the initial phase of treatment, people with coeliac sprue require supplemental therapy to help fix the nutritional deficiencies. The disease carries an excellent prognosis if it is diagnosed early and the person adheres to a life-long gluten-free diet. Growth and development in children proceed normally if care is taken to withdraw gluten. Even in adults, once the diet is gluten-free, the intestinal absorptive function returns to normal, and almost all ill effects of the disease disappear.

What causes the intestinal damage?

In people with coeliac disease, the body's immune system is triggered by gluten in food. Antibodies attack the intestinal lining, damaging, flattening, or destroying the tiny hair-like projections (villi) in the small bowel. Damaged villi cannot effectively absorb nutrients through the intestinal wall. As a result, fats, proteins, vitamins, and minerals get passed through the stool. Over time, this can lead to malnutrition.

Symptoms and signs

Age

Coeliac disease may occur at any age, be it children, the young, adults or even elderly. While people must have a genetic predisposition to it, researchers don't know why some people develop an immune reaction after years of tolerance to gluten. But the average length of time it takes a person with symptoms to be diagnosed with coeliac disease is four years.



Gastro-intestinal symptoms

Symptoms of coeliac disease can vary from mild to severe. Some people have no symptoms, although they still are developing intestinal damage. Coeliac disease is sometimes misdiagnosed as irritable bowel syndrome, Crohn's Disease, or gastric ulcers. Digestive symptoms may include:

- Abdominal bloating and pain
- Diarrhoea

- Vomiting
- Constipation
- Pale, foul-smelling stool

General symptoms

Many people with coeliac disease don't have digestive symptoms at all. But the failure to absorb nutrients may lead to a host of other problems, including weight loss and malnutrition. Signs and symptoms related to weight loss or malnutrition can include:

- Anaemia
- Fatigue
- Osteoporosis
- Infertility or miscarriage
- Mouth ulcers
- Tingling, numbness in the hands and feet
- Unhealthy swings in blood glucose levels or low blood sugar

Autoimmune and skin symptoms

Some people with coeliac disease may suffer with other autoimmune disorders, including thyroid disease and rheumatoid arthritis. Some may develop an itchy, blistering rash known as dermatitis herpetiformis. This rash may begin with an intense burning sensation around the elbows, knees, scalp, buttocks, and back. Clusters of red, itchy bumps form and then scab over. It often first occurs in the teenage years and is more common among men than women. The rash usually clears with a gluten-free diet.

Mood and memory symptoms

Some people with coeliac disease experience depression, irritability, poor memory, and face trouble in concentrating. The strain of having a chronic disease can contribute to problems with mood and memory, particularly when there is chronic pain or fatigue related to anaemia.

Warning signs in children

Coeliac symptoms may start in childhood, even in infants when parents introduce foods that contain gluten. Symptoms can include vomiting, bloating, pain, diarrhoea, and irritability.

The disease can lead to slowed growth or even failure to thrive. Children with coeliac disease may have teeth that are pitted, grooved, discoloured, or poorly formed. Children with a parent or sibling with coeliac disease should be screened.

Foods which trigger coeliac disease

Wheat is a staple in Indian culture. Many foods contain gluten in variable amounts and can aggravate coeliac disease (Table 1). A wide variety of processed foods also contain gluten. Wheat flour is also used widely in the food industry as a thickener and inexpensive filler in pre-cooked meals, convenience foods, and commercial products (Table 2) and also as an ingredient in lipstick, pills and other products (Table 3).

Table 1: Gluten-containing foods

Gluten-rich grains and flours

1. Wheat
 - Wheat flour, white flour, wheat bran, wheat germ
 - Farina (prepared from cereal grain and various other plant products and often used as a cooked cereal or in puddings)
 - Wheat starch
 - Graham (whole wheat) flour
 - Semolina (*sooji, rava*)
 - Durum (hardy wheat used chiefly in making pasta)
 - *Dalia, maida*
2. Barley
3. Rye
4. Oats (oat flour, oat bran, oatmeal)

Common foods with gluten-rich ingredients

1. Breads and cereals
 - *Roti, poori, kulcha, naan, bhatura, naratha*
 - Bakery breads: pao-bread, bun, croissant, pizza and other forms of bakery breads
 - Cereals, wheat flakes, *upma, dalia*
 - Noodles, *sewaiyan*, macaroni
2. Beverages and dairy products
 - Instant tea and coffee, non-dairy creamer, commercial milk shakes
 - Ice cream
 - Custard powder
 - Hot chocolates
 - Horlicks, Bournvita, Boost
3. Restaurant foods, sauces and soups
 - Gravies
 - Soup mixes, bread crumbs
 - Soy sauce or soy sauce solids
 - Sauces and ketchup
4. Spreads, dressings and mixes
 - Cheese spreads
 - Mixed seasonings
 - Salad dressings
 - Chip and dip mixes
5. Snacks
 - Bread *pakora, samosa*
 - *Matthi, sankhein*
 - Bread roll, patties
 - Burger, sandwiches
6. Bakery products and confectionary
 - Biscuits, rusk and cookies
 - Cakes, pastries and pies
 - Chewing gum
 - Crackers and cream rolls
 - Toffees
 - Chocolates
7. Meats
 - Luncheon meats
 - Meat sauces
 - Salami
 - Smoked sausages
 - *Seekh kabab*
 - Processed canned meats and poultry
8. Desserts and *mithai*
 - Milk cake, *burfi, khoya* sweets
 - *Jalebi, gulab jamun, balushahi, shakarparre*
 - Atta *laddoos, sooji ka halwa*
 - Karachi *halwa*
9. Alcoholic beverages
 - Beers
 - Lagers, ales, and home brews



Table 2: Foods which may contain gluten unless certified as free

- Natural flavourings
- Vinegar or distilled vinegar
- Vegetable gum
- Brown rice syrup
- Food additives and emulsifiers
- Malt or malt flavouring
- Condiments containing distilled vinegar
- Alcohol-based flavouring extracts (e.g., vanilla)
- Caramel colouring
- Vegetable protein
- Oat gum
- Stabilisers

Table 3: Non-food products that may contain gluten

- Lipstick
- Postage stamps
- Medications that use gluten as a binding agent in a pill or tablet

Gluten contamination can also occur in many extraordinary ways. For example, a gluten-free food may come in contact with foods containing gluten, and this may produce a cross contamination. This is likely if a person uses a butter-knife with a few breadcrumbs left on its surface, or uses a toaster which has been used for toasting regular bread, or eats food preparations which have been deep-fried in a cooking medium previously used for frying gluten-containing food items.



(Next month: Coeliac Disease: Diagnosis and Care)

Prof Yatish Agarwal is a physician and teacher at New Delhi's Safdarjung Hospital. He has authored 47 popular health-books. ■

Dream 2047

Articles invited

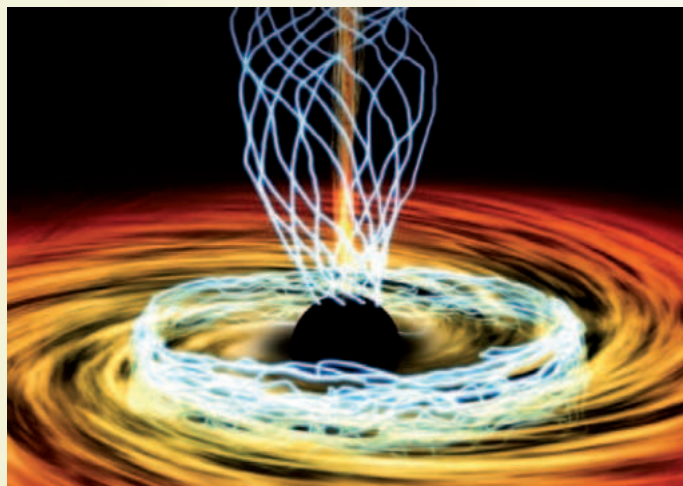
Vigyan Prasar invites original popular science articles for publication in its monthly science magazine *Dream 2047*. At present the magazine has 50,000 subscribers. The article may be limited to 3,000 words and can be written in English or Hindi. Regular columns on i) Health ii) Recent developments in science and technology are also welcome. Honorarium, as per Vigyan Prasar norm, is paid to the author(s) if the article is accepted for publication. For details please log-on to www.vigyanprasar.gov.in or e-mail to dream@vigyanprasar.gov.in

Recent Developments in Science and Technology

Biman Basu E-mail: bimanbasu@gmail.com

Magnetic fields detected near Milky Way's black hole

For the first time, an international team of astronomers have detected magnetic fields just outside the event horizon of the black



In this artist's conception, the black hole at the centre of our galaxy is surrounded by a hot disk of accreting material. Blue lines trace magnetic fields. The Event Horizon Telescope has measured those magnetic fields for the first time. (Credit: M. Weiss/CfA)

hole at the centre of our Milky Way galaxy using the Event Horizon Telescope (EHT) – a global network of radio telescopes that are linked together to function as one giant telescope the size of Earth. These magnetic fields have been predicted to exist, but no one has seen them before. The EHT data puts decades of theoretical work on solid observational ground,

Since larger telescopes can provide greater detail, the EHT ultimately will resolve features as small as 15 micro-arcseconds. (An arcsecond is 1/3600 of a degree). Such resolution is needed because a black hole is the most compact object in the universe. The Milky Way's central black hole, Sgr A* (Sagittarius A-star), weighs about 4 million times as much as our Sun, yet its event horizon (the point at which the gravitational pull becomes so great as to make escape impossible) spans only 13 million kilometres – smaller than the orbit of Mercury.

The goals of the EHT are to test Einstein's theory of general relativity,

understand how black holes eat and generate relativistic outflows, and to prove the existence of the event horizon, or 'edge,' of a black hole. The discovery of magnetic fields near a black hole can explain what power the huge relativistic jets that emerge from many accreting black holes and blast across thousands of light-years – shaping entire galaxies along the way. Relativistic jets are extremely powerful jets of plasma with speeds close to the speed of light that are emitted near the central massive objects of some active galaxies, notably radio galaxies and quasars.

Using the EHT, the team detected what is called synchrotron radiation. Synchrotron radiation is polarised.

The team measured how that light is linearly polarised. On Earth, sunlight becomes linearly polarised by reflections, which is why sunglasses are polarised to block light and reduce glare. In the case of Sgr A*, polarised light is emitted by electrons spiralling around magnetic field lines. As a result, this light directly traces the structure of the magnetic field, which the researchers did.

The team found that magnetic fields in some regions near the black hole are disorderly, with jumbled loops and whorls resembling intertwined spaghetti. In contrast, other regions showed a much more organised pattern, possibly in the region where jets would be generated. They also found that the magnetic fields fluctuated on short time scales of only 15 minutes or so.

These observations used astronomical facilities in three geographic locations: the Submillimetre Array and the James Clerk

Maxwell Telescope (both on Mauna Kea in Hawaii), the Submillimetre Telescope on Mt. Graham in Arizona, USA, and the Combined Array for Research in Millimetre-wave Astronomy (CARMA) near Bishop, California, USA. As the EHT adds more radio dishes around the world and gathers more data, it will achieve greater resolution with the goal of directly imaging a black hole's event horizon for the first time.



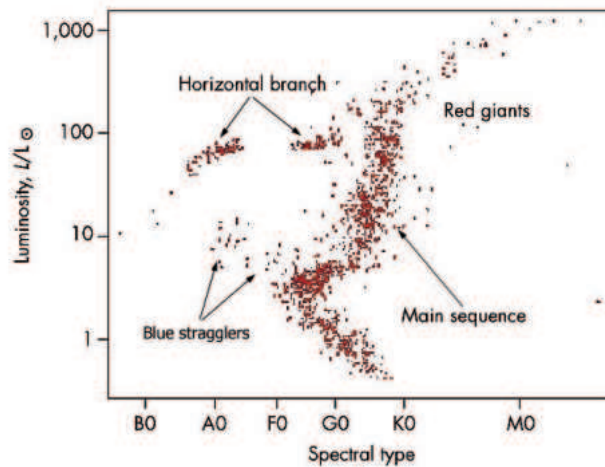
The 13 radio telescopes involved in the Event Horizon Telescope. 1. Submillimetre Array (SMT), James Clarke Maxwell Telescope (JCMT), Caltech Submillimetre Observatory (CSO) in USA. 2. Combined Array for Research in Microwave Astronomy (CARMA), USA. 3. Submillimetre Telescope (SMT), USA. 4. Large Millimetre Telescope (LMT), Mexico. 5. Atacama Pathfinder Experiment (APEX), Atacama Submillimetre Telescope Experiment (ASTE), Atacama Large Millimetresubmillimetre Array (ALMA), Chile. 6. South Pole Telescope (STP). 7. (Greenland Telescope (GLT) (under construction). 8. IRAM 30-metre telescope, Spain. 9. Plateau de Bure interferometer, France. (Credit: Dan Marrone/University of Arizona)

New light on “blue straggler” stars

Stars come in many varieties. We are familiar with names like red giants, white dwarfs, etc., which are older stages of stars. There is also a mysterious group of stars known as “blue stragglers”, which are old stars that appear younger than they should be: they appear hot and blue. Blue stragglers were first discovered by American astronomer Allan Sandage in 1953 while studying stars in the globular cluster M3. Several theories have attempted to explain why they don't show their age, but, until now, scientists have lacked the crucial observations with which to test each hypothesis. Recent studies with the Hubble Space Telescope may provide an explanation of why these unusual stars look hotter and bluer than they should for their advanced age.

The Hertzsprung-Russell (H-R) diagram is a graph showing the absolute magnitude plotted against the surface temperature for a group of stars. Blue straggler stars are stars in open or globular clusters that are hotter and bluer than other cluster stars having the same luminosity. Thus, they are separate from other stars on the cluster's H-R diagram. Blue straggler stars appear to violate standard theories of stellar evolution, in which all stars born at the same time should lie on a clearly defined curve in the H-R diagram, with their positions on that curve determined solely by their initial mass. In a cluster, it can be taken that the stars comprising the cluster all formed at approximately the same time, and thus in an H-R diagram for a cluster, all stars should lie along a clearly defined curve set by the age of the cluster. With masses two to three times that of the rest of the main-sequence cluster stars, blue stragglers seem to be exceptions to this rule.

Although blue stragglers were first identified 62 years ago, astronomers were yet to converge on a solution for their odd appearance. The most popular explanation among several competing theories was that an aging star spills material onto a smaller companion star. The small star bulks up on mass to become hotter and bluer while the aging companion burns out and collapses to a white dwarf – the burned out core of the collapsed star. To test this theory, University



The Hertzsprung–Russell diagram is a scatter graph of stars showing the relationship between the stars' absolute magnitudes or luminosities versus their spectral classifications or effective temperatures.

of Texas astronomer Natalie Gosnell used the Hubble Space Telescope to conduct a survey of the open star cluster NGC 188 in the constellation of Cepheus in the northern sky that has 21 blue stragglers. It is known that hot white dwarfs with temperatures above 12,000 kelvins give out ultraviolet radiation. By identifying the ultraviolet glow that is detectable by Hubble, she found that seven of the 21 had white dwarf companions. Of the remaining 14, a further seven show evidence of so-called mass transfer between stars in other ways. According to Gosnell, this discovery sheds light on the physical processes responsible for changing the appearance of 25 percent of evolved stars (*Astrophysical Journal*, 1 December 2015). The presence of the hot white dwarfs probably makes blue stragglers appear younger than their contemporaries.

However, Gosnell's method is limited by the fact that it will not detect white dwarfs that have cooled down enough so that they don't emit UV radiation detectable by Hubble. That means that only those white dwarfs formed in the last 250 million years (youngsters, astronomically speaking) are detectable. Nevertheless, such models are important because distant galaxies figure into many different types of cosmological studies. Right now, Gosnell

said, “the models have a lot of room for improvement.”

Deep-sea bacteria may help cut greenhouse gas

A probable solution to the looming threat of global warming may come in the form of minute, deep-sea bacteria that could neutralise large amounts of industrial carbon dioxide being emitted into the Earth's atmosphere. Carbon dioxide, a major contributor to the build-up of atmospheric greenhouse gases, can be captured and neutralised in a process known as sequestration. A group of University of Florida researchers led by Robert McKenna, who carried out the research, found that the bacterium, *Thiomicrospira*

crunigena, produces an enzyme that helps convert carbon dioxide into a harmless compound. The bacterium produces carbonic anhydrase, an enzyme that helps remove carbon dioxide in organisms by turning it into harmless bicarbonate (*Acta Crystallographica D*, August 2015 | doi:10.1107/S1399004715012183). Carbonic anhydrases form a family of enzymes that catalyse the rapid interconversion of carbon dioxide and water to bicarbonate and protons (or vice versa).

According to the researchers, since the deep-sea bacterium thrives near hydrothermal vents (undersea cracks from which geothermally heated water at high temperature comes out), it is accustomed to high temperatures. That makes it suitable for use in industrial environment to trap



Graduate research assistants Brian Mahon and Avni Bhatt (right) inspect the bacterium *Thiomicrospira crunigena* (inset) that is used to produce carbonic anhydrase. (Credit: Mindy Miller, University of Florida Health)

carbon dioxide and turn it into harmless products like bicarbonate thus sequestering it. Bicarbonate is a harmless compound that can then be further processed into products such as baking soda and chalk.

Neutralising carbon dioxide in industrial quantities could require large amounts of the carbon anhydrase enzyme which would need harvesting of large quantities of the bacteria from ocean floor and could be impractical. To avoid that, the researchers have devised a way to produce this enzyme in the lab by using a genetically engineering version of the common bacterium *E. coli*. Most atmospheric carbon dioxide is produced from fossil fuel combustion, a waste known as flue gas. For using the enzyme on industrial scale, it would be immobilised with solvent inside a reactor vessel that would serve as a large purification column. Flue gas would be passed through the solvent, with the carbonic anhydrase converting the carbon dioxide into bicarbonate, releasing carbon dioxide-free flue gas into the air.

According to Avni Bhatt, a researcher associated with the discovery, their team is working hard to find ways to increase the enzyme's stability and longevity. They are also trying to produce a variant of the enzyme that is both heat-tolerant and fast-acting enough to be used in industrial settings. There are many challenges to be overcome before the enzyme could be put to use against carbon dioxide in real-world settings. For example, so far, the researchers have produced several milligrams of the carbonic anhydrase, though Bhatt says much larger quantities would be needed to neutralise carbon dioxide on an industrial scale.

Ideally, the researchers are trying to produce a variant of the enzyme that is both heat-tolerant and fast-acting enough that it can be used in industrial settings. Next, the researchers want to study ways to increase the enzyme's stability and longevity, which are important factors to be sorted out before the enzyme could be put into widespread industrial use.

Method to produce cleaner diesel developed

Diesel vehicles are the worst polluters of air mainly because they emit fine particulate matter of 2.5 micron size or less, known as PM 2.5, which not only reduces visibility and causes the air to appear hazy when

levels are high, but is also a serious threat to health as they can travel deep into the respiratory tract, reaching the lungs. To reduce air pollution there is even move to restrict or ban diesel vehicles in some cities. Recently, researchers from KU Leuven and Utrecht University in Belgium have discovered a new approach to make cleaner diesel that emits less carbon dioxide and particulate matter. According to the researchers, the process can be quickly scaled up for industrial use and the first cars driven by this new clean diesel may be on roads in 5 to 10 years (*Nature*, 10 December 2015 | doi:10.1038/nature16173).

The usual process of producing diesel from crude oil is by fractional distillation and then subjecting some fractions to catalytic reforming to produce liquid fuels like diesel. A catalyst triggers the chemical reactions that convert raw material into fuel. In the case of diesel, small catalyst granules are added to the raw material to sufficiently change the molecules of the raw material to produce usable fuel. In most catalytic reforming processes, platinum is used as the active catalyst; it is distributed on the surface of an aluminium oxide carrier. Small amounts of rhenium, chlorine, and fluorine act as catalyst promoters. In spite of the high cost of platinum, the process is economical because of the long life of the catalyst and the high quality and yield of the products obtained.

The catalyst used by the KU Leuven and Utrecht University researchers for this particular study was a bifunctional catalyst made up of two different materials: a metal (platinum) and a solid-state acid (zeolite). The researchers modified the catalyst – comprising an intimate mixture of zeolite Y and alumina binder, with platinum metal controllably deposited on either the zeolite or the binder – and found that if the active centres within a catalyst are nanometres apart, the process yields better molecules for cleaner fuel. According to the researchers, the new method can optimise quite a few molecules in diesel, making it cleaner. During the production process for diesel, the molecules bounce to and fro between



Diesel vehicles are the main source of fine particulate matter (PM 2.5) that causes air pollution.

the metal and the acid. Each time a molecule comes into contact with one of the materials, it changes a little bit. The final product at the end of the process is clean diesel fuel that emits far less particulates and CO₂. The new technique can be applied not only to petroleum-based fuels, but also to renewable carbon from biomass. ■

Mother Nature's Own Pharmacy

(Continued from page 24)

Understanding animal self-medication behaviour and ensuring that both domestic and wild animals have access to the natural remedies they need might be able to prevent endemics such as Mad Cow disease, Bird Flu and Swine Flu in the future. Provided zoopharmacognosy is studied further with the collaboration of ecologists, animal behaviour experts, pharmacists, veterinarians, and human health care professionals, humans might be able to avert dangerous zoonotic disease transmissions or at least find medicines to cure them.

Zoopharmacognosy researchers can work together with conservationists to help preserve the habitat of biodiversity in the tropics. Through studying animal self-medication and plant metabolites, they can help maintain healthy ecosystems and also share their knowledge with the local forest-dwelling and farming communities.

Ms. R. Vathsala is a retired Vice Principal from a CBSE School in Chennai. She has served for more than 30 years in the field of education and at present is engaged in preparing educational software for school children. ■