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Sprinkling Colours or Hidden Poisons?

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

Some interesting thoughts on the "science of science communication"

Dr. R. Gopichandran

I am motivated to present this snapshot for the benefit of students researching on the form and function of science communication. Some interesting references in this field define approaches aligned with objectives and in some cases cite themes and outcomes they have been assessed on. Importantly, these papers reinforce my conviction that science communication cannot be trivialised or over-simplified and therefore has to be given its due respect.

Fischhoff (who is partly responsible for the inspiration behind the title of this editorial!) in 2013[1] referred to the 2012 Sackler Colloquium on "The Sciences of Science Communication". The paper discusses three important facets in this context including the relevance of channels for communication, four interrelated tasks, and some elements of behaviour of recipients of information. Van der Sanden and Meijman's[2] paper published a year earlier (2012) highlights the complexity and uncertainty in science communication processes. They argue it is therefore essential to design and manage communication processes through well aligned processes that integrate issues, experiences and data. A Design-Based Research (DBR) framework is also discussed to help define gaps between theory and practice in science communication. 'Balvert[3] in October 2015 made a presentation on communication embedded in 'Horizon' 2020. It will be useful to take note of the work programmes that converge on the goals of communication and the communication matrix cited therein. Inspiring Australia[4] presents a framework of principles for science communication initiatives. This is especially relevant for India because it is aims to help establish a "scientifically engaged" citizenry and in particular tests its responsiveness to "demands and needs" of citizens. One of the (relatively) early papers in this context was by Calhoun[5].

It will be useful for researchers to use the frameworks stated in the cited papers to design investigations, gather data, interpret and infer to strengthen science and technology communication in India. I remember citing some of these in editorials presented earlier. This is, however, an inspired re-statement.

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Charles Francis Richter
The Creator of the Earthquake Magnitude Scale

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"Nothing is less predictable than the development of an active scientific field."
Charles Francis Richter

"In 1935 he (Richter) devised the scale of earthquake strength which bears his name. Unlike earlier, qualitative scales, the Richter scale is an absolute scale based on the logarithm of the maximum amplitude of the earthquake waves observed on a seismograph, adjusted for the distance from the epicentre of the earthquake."
The Cambridge Dictionary of Scientists (2nd edition), 2002

Charles Francis Richter was one of the most recognisable figures in the field of seismology in the 20th century. He is best known for the development of the scale to quantify the relative strength of earthquakes that bears his name (Richter scale). In fact his name has become synonymous with earthquakes. Every time an earthquakes strikes we are reminded of him. To many it may be surprising to know that Richter never published in peer-reviewed journals. He published two books, namely *Seismicity of the Earth and Associated Phenomena* (1941, with Beno Gutenberg) and *Elementary Seismology* (1958). The *Seismicity of Earth and Associated Phenomena* is considered a classic in the field of seismology. The book, *Elementary Seismology* was based on his lectures given at Caltech (California Institute of Technology) and decades of his earthquake study. It contains description of major historical earthquakes, tables and charts and discussions on wide-ranging subjects—ranging from the nature of the earthquake motion to insurance and building construction. Both the books are still used as textbooks in several countries. Richter wrote an article on earthquakes for the 15th edition of the *Encyclopaedia Britannica* (first published in 1974).

Richter believed that it was impossible to predict an earthquake. He once said: "The idea of earthquake prediction appeals to the imagination, and attracts disproportionate attention from the public, the news media, and some officials. The immediate objective of reducing earthquake risk to lives and property would be served by the removal of old dangerous buildings."

Richter was instrumental in establishing the California Seismic Array, a network of instruments that helped scientists accurately track the origin and intensity of earthquakes and map their frequency. Richter and his colleagues utilised the Array to prepare the Southern California earthquake catalogue, which remains as one of largest and best catalogues of earthquakes available for any region of the world. He was involved in earthquake engineering by promoting good earthquake-resistant building and proper training for people living in earthquake-prone areas. Richter worked for saving human lives in major earthquakes. He is credited with saving many lives.

Charles F. Richter

He was fond of listening to classical music, reading science fiction and watching the television serial *Star Trek.* He frequently undertook solitary hikes in the southern California Mountains. Highlighting some of the personal attributes of Richter, Clarence Allen of Caltech in his tribute to Richter published in the *Bulletin of the Seismological Society of America* wrote: "Meeting Charles Richter was an experience never to be forgotten, for he was a very unusual person—a man of many contrasts. He could be charming or irascible; he could be outgoing or shy; he could be gentle and warm or abrupt and cold; and he was a man with truly remarkable memory, but at the same time, was renownedly absent-minded. In at least two areas, however, he never wavered in his consistency: he was absolutely dedicated to his science, almost to the exclusion of everything else, and he demonstrated utter intellectual honesty."

Richter was born on 26 April 1900 in a small farming community of Hamilton, Ohio, USA. His parents were Fred W. Kinsinger and Lillian Anna Kinsinger (nee Richter). Richter was born Charles Francis Kinsinger, but then he adopted his mother's maiden name in his childhood and later in 1926 he made it legal. On adoption of his mother's maiden name, Richter said: "…the name Richter is actually my mother's maiden name, which she resumed after a divorce, with court approval, and I have never been known by any other name. And it is the name, of course, of my maternal grandfather to whom I owe practically everything I am and have, in terms of support and education." Richter's parents divorced when he was nine years old. His maternal grandfather took him along with his mother to Los Angeles.

After completing his school education, Richter joined the University of Southern California where he spent his Freshman Year (1916-1917) – the first year in the university – before moving to Stanford University. It has been reported that at Stanford he first majored in chemistry but he broke so many beakers that his professor advised him to move into another field. He switched over to physics. In 1920 he earned an AB degree (an abbreviation of the Latin name for the Bachelor of Arts degree 'artium baccalaureus') in physics from the Stanford University. He planned to undertake graduate studies in physics. However, he had a nervous

breakdown and he had to leave the university. He was under the supervision of a psychiatrist for many years. He worked as a messenger boy at the Los Angeles County Museum and in a Warehouse for the California Hardware Company at Los Angeles.

Beno Gutenberg

In 1924, he entered the California Institute of Technology (Caltech), Pasadena, California, as a graduate student. At the time of Richter's joining to Caltech, its President was Robert Andrews Millikan (1868-1953), a Nobel Prize winning physicist. Richter obtained his PhD degree in 1928. Even before he completed his PhD, he got an offer of an appointment from Millikan at the newly established Seismological Laboratory in Pasadena then managed by the Carnegie Institution of Washington. It was here he met Beno Gutenberg (1889-1960), a German-American seismologist, who was then the Director of the Laboratory. Richter had a decades-long collaboration with Gutenberg. In 1937, he joined the faculty of Caltech and he remained there till he retired from service in 1970 except for a visit to University of Tokyo from 1959-1960 as a Fulbright Scholar. At Caltech, he taught physics and seismology and worked at its Seismological Laboratory established in 1936.

In 1935, Richter published his scale for measuring intensity of earthquakes. Beno Gutenberg contributed towards the development of the scale. However, it came to be known as simply Richter's scale. Scales to measure earthquakes had been developed before by Michele Stefano de Rossi (1834-1898), an Italian seismologist, in the 1880s and by the Italian Catholic priest and volcanologist Giuseppe Marcalli (1850-1914) in 1902. However, the scales developed by de Rossi and Marcalli were descriptive ones, defined in terms of damage to buildings and behaviour and response of the population living in the affected areas. Thus the use of these scales was restricted to the measurements of earthquakes in populated areas. Contrary to these scales, Richter's scale is an absolute measure of an earthquake's intensity. It is not a physical scale but a mathematical construction. The magnitude point on the Richter scale is not a measure of the physical size of the earthquake fault, but of the vibration that it emits.

Robert Andrew Millikan

The Richter scale is the most widely used scale for measuring the magnitude of earthquake. The magnitude value is proportional to the logarithm of the amplitude of the strongest wave during an earthquake. Richter used a seismograph for recording the actual movement of the earth during an earthquake. It may be noted that an earthquake is a violent shaking of the ground that is usually caused by sudden motion on a geological fault. A seismograph is an instrument that usually consists of a constantly unwinding roll of paper attached to a fixed point and a pendulum or magnet suspended with a marking device above the roll. The seismograph need not be located close to the geological fault causing the earthquake. In fact a modern seismograph can record earthquakes of magnitude 5 and above occurring anywhere in the world.

Giuseppe Marcalli

It was Beno Gutenberg who had suggested that the scale be logarithmic. An earthquake of the magnitude of 6 on the Richter scale indicates disturbance with ground motion 10 times as that of earthquake of the magnitude of 5. The scale takes into account the instrument's distance from the epicenter or the point on the ground that is directly above an earthquake's origin.

Richter jointly with Gutenberg attempted to correlate the magnitude points on the scale with the amount of energy released during an earthquake. In 1956, they were able to demonstrate that the magnitude 0 corresponds to about 10^{11} ergs (10^4 joules), and magnitude 9 equals 10^{24} ergs (10^{17} joules). The energy release by an earthquake increases by a factor of 30 for every unit increase in the Richter scale.

Richter himself never referred to the scale for measuring earthquakes developed by him and Gutenberg as the Richter scale because he felt by doing so he would underrate Gutenberg's contribution. He simply called it 'the scale' or 'the magnitude scale'. On the role played by Gutenberg in developing the scale Richter said: "Incidentally, the usual designation of the magnitude scale to my name does less than justice to the great part that Dr. Gutenberg played in extending the scale to apply to earthquakes in all parts of the world."

It is believed that Richter chose the word 'magnitude' for his scale because he was so fascinated with astronomy. As we know that in astronomy a star's magnitude refers to its brightness seen from Earth. Richter himself acknowledged it. He wrote: "My amateur interest in astronomy brought out the term 'magnitude', which is used for brightness of a star". The term 'magnitude' was in fact used to distinguish the scale from the existing 'intensity' scales.

The scale developed by Richter was specific to California earthquakes. Other scales, based on wave amplitudes and total earthquake duration, were developed for use in other situations and these scales were designed to be consistent with Richter's scale. Commenting on the scale, Richter wrote: "The most remarkable feature about the scale was that it worked at all and that it could be extended on worldwide basis. It was originally envisaged on a rough-and-ready procedure by which we could grade earthquakes. We would have been happy if we could have assigned just three categories, large, medium, and small; the point is, we wanted to avoid personal judgments. It actually turned out to be a quite a finely tuned scale."

In theory, the scale has no upper limit. Thus Richter wrote: "Now there is no upper limit to the possible magnitude of an earthquake; that is, earthquake magnitudes are not measured on fixed scale of, say, 1 to 10. The highest magnitudes assigned so far to actual earthquakes are about 9, but that is not as observed fact, not a ceiling—a limitation in the Earth, not in the scale. The scale is, as we said, logarithmic, so a step up

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Sprinkling Colours or Hidden Poisons?

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Holi, the festival of colours, is celebrated at the advent of spring all over India. Holi breaks all the barriers of caste and religion. But colours used in present day holi are artificial dyes and have detrimental effects on our body and on the environment. Natural colours, on the other hand, are much safer because they neither harm us nor the environment.

Chemistry of holi colours

Holi comes alive with its vibrant colours. There are four categories of colours used such as gulal, dry powdered colour, pastes, and water colour available in the market. All these colours are usually industrial dyes mixed with various bases of inorganic origin.

Gulal is considered as mildest and most harmless colour used to celebrate holi although practically it is not so (Figure 1). Gulals have two components – a colourant that is usually an oxidised heavy metal such as cadmium, chromium, iron, lead, mercury, nickel, zinc, etc., or toxic coal tar dyes or azo dyes such as auramine (yellow), malachite (green), rhodamine (orange), methylene (blue) and so on. The other part of gulal is a base which could either be asbestos or silica in which the colour is blended. Besides, gulals also contain sand, starch, salts and mica or powdered glass for extra lustre.

Fig. 1. Heading to holi, vendors store a variety of gulals and other colours beforehand.

Two types of dry holi colours in the form of fine powder and coarse granular colour are available in the market. These dry colours contain various inorganic compounds such as copper sulphate (green), lead oxide (black), mercury sulphite (red), chromium iodide (purple), aluminium bromide (silver), etc., most of which are highly toxic to human body (Figure 2).

Fig. 2. Most of the colours used in holi these days, contain toxic chemicals like black lead oxide.

Sometimes inorganic dry colours are mixed in a base of engine oil or other inferior quality oil to make a paste which is easy to apply. Adding oils in the colour increases the toxicity level and the permeability of the colours to human skin. Liquid colours as used in holi include inks, iodine solution, gentian violet, methylene blue, mercurochrome, potassium permanganate and so on.

In all the colours the colourant part either contains a heavy metal or some inorganic as well as organic dyes. All of these materials are not only toxic; most of them also have carcinogenic effects. The bases for dry colours such as asbestos, mica, silica, chalk powder or powdered glass, added for extra shine, have their own toxic effects.

Lead is the most dangerous heavy metal used for producing brilliant colours. It affects mainly the nervous system, kidneys and the reproductive system in humans. Exposure to lead or its deposition in the body gives rise to anaemia, headache, abdominal pain, joint discomfort and old-age osteoporosis. Moreover, lead poisoning affects severely on the physical and mental growth of children. Children become apathetic, irritable or lethargic. If a pregnant woman is exposed to lead, it may result miscarriage, abortion, premature birth, low birth-weight or nervous damage of the foetus.

Mercury is another toxic metal used mainly in the red colour (Figure 3). When applied on the face, fine colour particles containing mercury may get inhaled and cause severe cough, breathlessness, or even pneumonia. Mercury poisoning results in many health related problems including headache, increased heart rate, itching, tremors, fall in blood pressure, and forgetfulness. Besides, mercury is a possible carcinogen that causes cancer of skin and other organs. Pregnant mothers if exposed to mercury may give birth to small and growth retarded babies with mental retardation.

Fig. 3. During application on the face fine colour particles of mercury oxide (red) may get inhaled.

Green colour contains copper sulphate, which can cause itching, redness or swelling of the eye and even temporary or permanent blindness. Likewise, purple colour contains chromium iodide, which can cause severe allergy or may induce bronchial asthma in a

Fig. 4. Aluminium bromide present in silver colour is a human carcinogen.

hypersensitive person. Aluminium bromide present in silver colour (Figure 4) is a human carcinogen.

Some other dyes such as auramine, malachite, rhodamine, and methylene have several toxic effects to human. Auramine causes irritation to mouth, throat and stomach; eye irritation and blurred vision, skin itching and redness; mutagenesis and growth impairment; liver tumour, hepatic and renal disorders. Malachite is a genotoxic carcinogen, causes damage to bones, eyes and lungs. It may be responsible for tumour and cancer in testis, ovary, urinary bladder, kidney, liver, spleen and breast. Rhodamine on the other hand, causes cancer and genetic disorders as well as degenerative changes in liver, spleen, kidney and urinary bladder.

In addition, asbestos, silica and powdered glass, widely used as base in dry colours are harmful to humans. Asbestos is a known cancer causing material while silica and powdered glass may damage eyes and skin. Coloured pastes comprising inferior quality oils cause skin allergy, itching or even temporary blindness. Many water colours contain alkali as base. When such colours enter the eyes, they can create great problem to the vision. Gentian violet, the most widely used colour concentrate during holi, can cause skin discolouration, dermatitis, skin allergy or irritation of the mucous membrane.

Even the way people play holi is also dangerous. Some people make thick paste of a dry colour with little amount of water on their hands and then rub it on the faces of others. If fine particles like powdered glass in the dry colour get into the eyes of the victim, they can cause irritation, swelling or pain in the eye. Rubbing of cheap and inferior quality gulal on the face may lead to scratches and rashes on skin.

Apart from serious health problems, use of inorganic toxic colours also has various environmental impacts. All these colouring ingredients of holi are non-biodegradable. So when washed away, residues enter water sources and soil, causing pollution.

Natural colour options for holi

The only healthy alternative to avoid the toxic dyes bringing fatal consequences is to enjoy the holi with natural colours, prepared from different plant parts. Preparation of skin-friendly and eco-friendly colours from many herbs, shrubs and flowers even at home.

Efforts are already afoot, both by government concerns, institutions and laboratories as well as a large number of NGOs to produce safe and harmless organic colours for the festival of colours. In the year 2003, in association with the Malnad Home Garden and Seed Exchange Collective, the NGO 'Kalpavriksh' developed for the first time a range of four natural colours using organic ingredients such as haldi, maida and some flowers and leaves. Later the Chemical Engineering Department of the Jadavpur University, Kolkata in association with 'Moromi', an NGO, developed colours from waste flowers from the local flower markets. They used some common flowers like marigold, china rose, butterfly pea, flame of the forest, etc., for the extraction of colourful dyes. The National Botanical Research Institute (NBRI), Lucknow have made organic holi colours from vegetable dyes.

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Charles Francis Richter... (continued from page 33)

of one unit in magnitude implies a tenfold increase in ground motion."

Initially the Richter scale could be applied only to the records from instruments identical manufacture. However, today magnitude can be computed from the record of any calibrated seismograph as instruments are calibrated with respect to each other.

The original Richter scale has been replaced with other scales, like body-wave magnitude scale, which have no restriction regarding distance and type of seismograph used. However, the Richter scale is still commonly cited in news report of earthquake severity. After his retirement from Caltech in 1970, Richter started a seismic consulting firm that evaluated buildings and other structures from earthquake safety point of view.

Richter was totally dedicated to the study of earthquakes. He would answer questions at all hours of the night. He even once installed a seismograph in his living room. He learnt Russian, French, Italian, Spanish, German and Japanese so that he could read scientific papers on earthquakes published in these languages. He was a member of the American Academy of Arts and Sciences. He served as the President of the Seismological Society of America.

Richter died on 30 September 1985 at Pasadena, California at the age of 85. Richter's work and life have been described in the book, *Richter's Scale: Measure of an Earthquake, Measure of a Man* by Susan Hough (Princeton University Press, Princeton, New Jersey, 2007).

Richter had to struggle to achieve his goal. Richter once said: "Do not wait for extraordinary circumstances to do good; try to use ordinary situations." He can be a great inspiration for young people.

(The article is a popular presentation of the points on the life and work of Charles Francis Richter in the existing literature. The idea is to inspire the younger generation to know more about Richter. The author has given the sources consulted for writing this article. However, the sources on the Internet are numerous and so they have not been individually listed. The author is grateful to all whose works have contributed to writing this article.)

Dr. Subodh Mahanti worked in Vigyan Prasar (1994-2014) and co-ordinated several science popularisation projects. He has written extensively. He writes both in Hindi and English.

Break Your Fast with a Good Breakfast

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Breakfast is the most important meal of the day and there is plenty of research to support it, yet many of us skip breakfast or do not have a proper breakfast on a regular basis. Let us see why it is important to eat breakfast and which foods should be included in an ideal breakfast in order to stay healthy and derive maximum nutrition from the first meal of the day.

It is usually seen that due to many reasons people avoid eating breakfast. Some people do not feel hungry early in the morning or feel nauseated at the thought of eating solid foods so early. Some are in a hurry to reach school, office, etc. Many women, especially housewives do not eat anything in the morning as they are too busy getting kids ready to send them off to school and preparing their lunchboxes and then sending off their husbands to office. Busy morning schedules leave little time for many to prepare a proper meal in the morning. Beside lack of motivation and time constraints, an inclination to spend some extra time in bed leaves no time for breakfast.

Adding milk and fruit to corn/wheat flakes makes it a balanced source of vitamins, minerals and fibre

People who skip breakfast often eat ravenously during lunch time. Also they tend to choose unhealthy foods later during the day to curb hunger pangs. For example, sugary foods or refined carbohydrates like biscuits, cakes, fizzy drinks, sherbets, jam, jellies, etc., may give you instant energy, but that won't last very long and the person may feel hungry again. Our body needs glucose as a source of energy. After 10-12 hours overnight without food, our energy reserves decline and our body, especially our brain, needs fuel in the form of glucose. Our brain requires glucose as a source of energy, which means if we do not eat sufficient carbohydrates our brain may get deprived of glucose, as carbohydrates are the main source of glucose in our body.

Since the gap between our dinner and the next meal is long, our body's energy reserves get depleted and need to be replenished through a good breakfast. After dinner, glucose released from the food is stored as glycogen in liver and muscles. Any glucose in excess is finally converted to fat and stored in fat cells. During the night, i.e., post-dinner, any glucose required to stabilise blood sugar levels is released from the glycogen stores which lasts for about 10-12 hours, after which body turns to proteins and fats for conversion to glucose because that is the primary source of energy for our body and especially the only fuel for our brain to function normally. This is why breakfast is important to replenish the body's energy reserves to prepare the individual for the day's activities.

A good breakfast not only revs up your metabolism but also helps in meeting your daily requirement for vitamins and minerals. Research has shown that regular breakfast-eaters not only feel more energetic throughout the day but are more relaxed and ready to face day's challenges as compared to breakfast-skippers who get stressed out and exhausted early during the day.

A healthy breakfast boosts your immunity, making you resist many infections. Research has shown that children who eat breakfast regularly have healthier weights, are less likely to fall ill and perform better in studies. As breakfast boosts your brain power, individuals who eat breakfast regularly have improved memory, problem-solving skills, greater retention power, are more alert and perform mental tasks with ease.

Dalia upma and vegetable sandwiches are good breakfast options as they are ri ch in complex carbohydrates

Since breakfast jumpstarts your metabolism which becomes sluggish during sleep, regular breakfast-eaters are more likely to maintain a healthy body weight and eat less during the latter part of the day. People who skip breakfast in an attempt to reduce weight eat more during the rest of the day and are more likely to make unhealthy food choices as they feel more hungry and have increased food cravings. Hence, a healthy fibre-rich breakfast helps to stabilise blood glucose levels, thereby reducing cravings and hunger pangs throughout the day.

People who consume starchy or sugary foods during breakfast with little or no fibre may get a quick energy boost in the morning, but this may not last very long and may lead to hunger soon. For example, a breakfast consisting of only refined carbohydrates like white bread with butter, bread and jam, rice dishes like *poha* without any vegetables, potato sandwiches, fruit juices with added sugar, *suji upma*, etc., provide carbohydrates in their most refined forms, totally lacking in fibre. Such refined carbohydrates are quickly broken down into glucose and released into bloodstream. This gives a sudden but a short burst of energy. As glucose enters the bloodstream quickly, insulin is released in relatively large amounts to stabilise blood sugar levels, which may cause the blood sugar to drop suddenly to lower than normal, leading to hunger pangs. This is known as sugar rush/ sugar crash syndrome, wherein sugary/starchy foods may give instant energy which may not last very long, leading to food cravings.

Oats Idli has more satiety value than traditional idlis as oats have a high beta glucan content making it rich in soluble fibre.

People who eat breakfast regularly tend to have higher rate of metabolism as compared to those who starve in the morning. It is often recommended to have small frequent meals than to rely on three large meals for weight management. The reason being that excess calories obtained after a large meal gets converted to fats, which slows our metabolism. Eating small regular meals ensures a steady supply of energy from glucose. People who eat at regular intervals without skipping any meals are less likely to gorge on unhealthy snacks and are more satiated and full as compared to skippers who have hunger pangs and more food cravings. Avoiding breakfast reduces mental performance in both children and adults since glucose, the only fuel for your brain, is not replenished after an overnight fast of 10-12 hours. Moreover glycogen stores diminish in the morning as glucose is released from these stores throughout the night to keep blood sugar levels stable while asleep. So, people who do not have a proper breakfast in the morning, feel lethargic and turn to high-energy foods and drinks to get them through the day. In such a case, if a person skips breakfast, he must have a nutritious fibre-rich snack like a vegetable sandwich, a fruit or yoghurt in mid-morning to prevent hunger pangs later in the day.

In Indian households, people often believe that having a "heavy" breakfast means loaded with fats like *puris*, *paranthas* with potato dish, which is the traditional breakfast in northern India. On the contrary, a "heavy breakfast" means fibre-rich foods which delay digestion and keep you full for a long time. Since our emphasis is on replenishing energy reserves after a period of fast, glucose is the primary source of energy which comes mostly from carbohydrates that we eat. Complex carbohydrates are a better option than refined carbohydrates as they are more nutrient-dense and release glucose slowly into the bloodstream besides adding more satiety value to food. Processing of cereal grains strips away vital nutrients like fibre, vitamins and minerals. Hence, processed cereals like *suji/rava*, maida (white flour), white bread, white polished rice used for preparing dishes like lemon rice etc., as it is consumed as a breakfast item in the south should be avoided. Whole grain cereals like *dalia* or broken wheat porridge, oat bran, breakfast cereals containing bran and whole wheat bread sandwiches are good breakfast options as they are not only filling but healthier too.

If processed cereals like white bread, white rice or *suji* are the only available options, then add some vegetables to make them healthy and fibre-rich. For example, adding onions, peas, carrots and curry leaves in good amounts can make *suji upma* fibre-rich. Instead of just having plain bread and butter in the morning, slice a cucumber and tomato to make healthy sandwiches. Besides carbohydrates, some amount of proteins in the form of low-fat milk, cottage cheese (paneer), eggs, curd or buttermilk must be included to make your breakfast well-balanced. Having a fruit as a part of your breakfast not only increases the satiety value of a meal (gives a feeling of fullness), but also makes your breakfast, a balanced source of vital nutrients viz., vitamins and minerals. Your breakfast need not be elaborate and time consuming. It can be as simple as whole wheat toast with a cup of low-fat curd/milk and a fruit or wheat flakes with bran and milk along with a fruit like apple, strawberries or mango etc., that doesn't need much preparation!

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Innovative Ways of Fire-fighting

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Any fire – whether accidental or caused due to natural factors and gone out of control – can only lead to sheer destruction of life and property. It is also generally known that whenever a fire breaks out traditional sprinkler systems and fire extinguishers are pressed into service to put it off. But in instances of wild fires it is generally seen that despite massive fire-fighting efforts, the fire refuses to die down easily and humans are left mere spectators watching their homes and properties getting reduced to ashes. Moreover, many of the current methods of fire-fighting often put the very life of fire fighters at stake and gobble up thousands of litres of water. Use of fire extinguishers also releases harmful chemicals in the environment. Keeping these factors in mind, there is a need for smart eco-friendly innovations for fighting fire.

According to the Defence Advanced Research Projects Agency (DARPA) of the United States, there has been a dearth in innovation in fire extinguishing methods in the last fifty years or so. But things have been beginning to look up on this front since past five years or so. The current year promises to be really exciting from the viewpoint of fighting fire with innovative methods. So let's take a look at some of the interesting innovations made in this front in 2015.

Sonic fire extinguisher

Ideas lead to innovation. This holds true for Seth Robertson and Viet Tran, both engineering majors from George Mason University, US. Taking a cue from the novel concept developed by DARPA scientists of using sounds to extinguish flames, the engineering students worked on the idea to come up with a practical hand-held device which merely emits a low hum to fight fire. The scientists from DARPA in 2011 had succeeded in putting out fire with sound. They used two large speakers which played a specific low-frequency sound to successfully extinguish flames. The scientists had explained that the specific low-frequency sound led to higher fuel vaporisation, which spread the flame and also dropped the overall flame temperature. Combustion was disrupted as the same amount of heat was spread over a larger area.

Seth Robertson and Viet Tran with their sonic fire extinguisher (Credit: Evan Cantwell)

Robertson and Tran had to work relentlessly to figure out the correct frequency of sound which could snuff out fire. After many trials conducted in an eight-month period they at last succeeded in finding the correct low-frequency sounds in the 30 to 60 hertz range that could extinguish fire. In the beginning of their experiments they were successful in putting out a cigarette lighter. Later they were successful in snuffing out a frying pan fire in a matter of seconds.

The inventors believe that the new fire-fighting device will not only have numerous everyday uses it could also be attached to drones to fight fires from buildings or forests thereby keeping the fire fighters safe. In 2014 alone the US reported 87 fire fighter fatalities. The dynamic young inventors are already on their way of securing a provisional patent of their product they have also formed a company named Force SV for further research and development as well for commercialisation of their product. This innovative device has a dual advantage over sprinkler system and fire extinguishers from the view point that is eco-friendly. It neither leaves behind harmful chemicals or powder and also that it completely eliminates the need of water. (see also *Dream 2047*, June *2015*)

Fire fighter Robot

In spite of technological advances, fire still remains one of the greatest threats to shipboard life. Now researchers have come up with an innovative idea of fighting fires on ships by developing a humanoid robot and assigning the major and complex fire-fighting job to it. Engineering students from the Terrestrial Robotics Engineering and Control Labs and the Extreme Environments, Robotics & Materials Laboratory at Virginia Tech in USA have created this special robot. This special fire fighter robot was unveiled to the world in February 2015.

The humanoid robot has been named Shipboard Autonomous fire-fighting Robot or 'SAFFiR'. The fire fighter robot stands 1.8 metres and weighs 64 kilograms. It is equipped with a suite of sensors that include a camera, a gas sensor and a stereo infrared camera that allows it to find its way through choking black smoke. Its upper body has been designed in such a fashion as to manipulate fire suppressing equipment and to even throw propelled extinguishing agent grenades. The robot can use fire-fighting gears used by humans such

Fire fighter Robot "SAFFiR" (Credit: CNN)

as protective coats, and hand-held sensors and can handle a fire hose on its own. With enough battery power to last for half an hour of fire–fighting, 'SAFFiR' is capable of walking in all directions, balancing in rough seas and stepping around obstacles.

Other new fire Fighting Innovations

Tackling fires with explosives

In 2014, an Australian researcher and professor at Sydney's University of New South Wales Graham Doig came up with an idea of using conventional explosives to snuff out wild fires. As part of his research Prof. Doig conducted large-scale experiments at a remote bomb testing site in New Mexico, US called the Energetic Materials Research Testing Centre and successfully snuffed out a 9cm-high flame shooting out of a propane burner by using explosives.

Professor Doig conducting his experiment to extinguish fire with explosives (Credit: UNSW)

Professor Doig explained that it was like blowing a candle except that here you get a much stronger blast of air. Due to the explosion there is a sudden change in the pressure across the shock wave and then the impulse of the airflow behind it pushes the flame straight of the fuel source. As soon as the flame doesn't have access to fuel anymore, it stops burning.

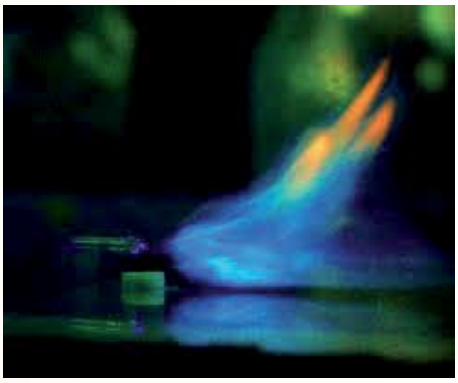
Professor Doig believes that in case of wildfires an explosion could knock the fire out of intensely burning trees and on the ground, where fire fighters could more easily reach it. This unconventional method of fighting fire is being considered to have a potential to stop a fast uncontrolled fire in its track and give fire fighters a much needed time to get things in control or getting civilians evacuated that are downwind of the blaze.

Fighting fire with Electricity

In 2011, a team of researchers from Harvard University's Whitesides Research Group demonstrated that electric field too have the potential to snuff out fire. The scientists connected a thin wire to a 600-watt amplifier capable of generating an electric field with the strength of million volts per metre, approximately the field necessary to generate a spark in dry air. Whenever the researchers brought the electric wire close to a burner emitting thin jets of fire up to 50 centimetres tall, the flames almost instantly went out.

According to Ludovico Cademartiri, a post-doctoral fellow at Harvard, electrons, ions and soot inside a flame can all respond to electric fields. Based on this principle the electrified fire uses electricity to push the flame away from the burner, detaching it from the fuel source, so it goes out.

This technique of fighting fire is said to be safe and the researchers had concluded that its electric frequency, voltage and current are not sufficient to create health issues in humans. This unique method of fighting fires is not intended for forest fires or other widespread fire because scientists consider it a challenge to create large electric fields over large areas.



Extinguishing fire with electric fields (Credit: Jabulani Barber/Ludovico Martiri)

The recent fierce wildfire in California in the US has once again brought man's helplessness against fire to the fore. Wildfires in advanced countries like Japan, Australia and the United States are still untamed. More innovative means of fighting fire will be a welcome step. Innovative means of fighting fire without harming the environment as well as protecting the precious life of fire fighters is the need of the hour.

Shakunt Pandey is a science writer and journalist based in Kolkata.

Hundred Years of Zoological Survey of India

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The study of zoology grew out of the study of natural history. India had its own age-old tradition of studying nature. The Vedas mention of names of nearly 250 kinds of birds including the knowledge of brood parasitism in the Indian koel. Ustad Mansur, a 17th-century court artist of Emperor Jehangir, was the first man to accurately paint the Siberian crane. The dodo was brought to Jehangir's court via Portuguese controlled Goa.

Natural history research in early times included the broad fields of paleontology, zoology, botany, anthropology, and geology. Zoology in its modern form was a late starter in British India. These studies as of now fall under the ambit of ecology, but in earlier times, such researches were undertaken mainly by amateurs, often physicians, civil servants and army officers. Plants then being a commercial item, the modern form of systemic study of botany started much before zoology. The inception of modern-day zoology in India happened in the hands of botanists like Dr. Nathaniel Wallich.

Annandale Nelson (1876-1924)

Edward Blyth (1810-1873)

The Indian Civil Services brought many British naturalists to India. India was much sought after by explorers and travellers in the region and many collectors from different countries travelled through India. Even Winston Churchill had made a small collection of 65 butterfly species during his brief stint in Bangalore (now Bengaluru). Some people even collected species on behalf of the British and other European naturalists and museums. The birth of museums thus traces to colonialism.

The massive collections and their documentation led to the production of numerous works. The earliest effort came from Thomas Hardwicke (1755–1835), a military officer serving in India. He hired local artists to produce a huge collection of illustrations of Indian animals. It was subsequently studied by John Edward Gray (1800–1875) giving rise to the publication of *Illustrations of Indian zoology* consisting of 202 colour plates.

The legacy

In 1796, the Asiatic Society of Bengal in Calcutta (now Kolkata) planned establishing a natural history museum. It was, however, only in 1814 that contributions of animals, plants, minerals, etc., were solicited and arrangement made to house them and thus the Oriental Museum of the Asiatic Society was born. Dr. Nathaniel Wallich, a Danish botanist became the first founder and curator of the Oriental Museum of the Asiatic Society. William Blanford among others contributed to the collections of the museum and also played critical role in bringing out a compendium, *Fauna of British India*.

In 1865, John Anderson, a field naturalist took over as the first curator of the upcoming Imperial Museum (now called the Indian Museum). The Imperial Museum at Calcutta came up in 1875 using mostly the collections from the Oriental Museum of the Asiatic Society of Bengal.

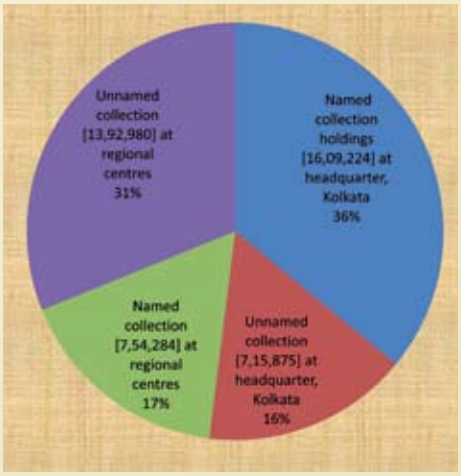
A hundred years ago, on 1 July, 1915, the Zoological Survey of India was formed to promote survey, exploration and research of faunal distribution of the country. The Asiatic Society of Bengal stood as the cornerstone of the Geological Survey of India, the Botanical Survey of India, the Zoological Survey of India as well as the Anthropological Survey of India. In 1891, the Botanical Survey of India was constituted long before the Zoological Survey of India was formed in 1915.

It was on 1 June 1915, the anthropological and zoological sections of the Indian Museum, Calcutta were made into the Zoological Survey of India, spearheaded by Dr. Thomas Nelson Annandale. In the beginning, the Zoological Survey of India acquired collections from the former Indian Museum that included the collections it had inherited from the Asiatic Society of Bengal of the period between 1814 and 1875. Dr TN Annandale went on to describe more than 300 new species from different groups and also researched upon island and aquatic fauna.

Faunal repository

With the increasing interest in life sciences and with the advent of country´s Five Year Plans after independence, the expansion programme of the Survey surged ahead. The Survey has so far established 16 regional and field stations. The Zoological Survey of India is the designated repository for the National Zoological Collection (NZC) in India as per section 39 of the National Biodiversity Act, 2002. Over 4.4 million zoological specimens including 17,000 Type Specimens are maintained in the NZC repository. Altogether 4,755 animal species have been described by scientists of ZSI since its inception. About 1.7 million living species have been described and named

Zoological Survey of India National Designated Repository of Fauna



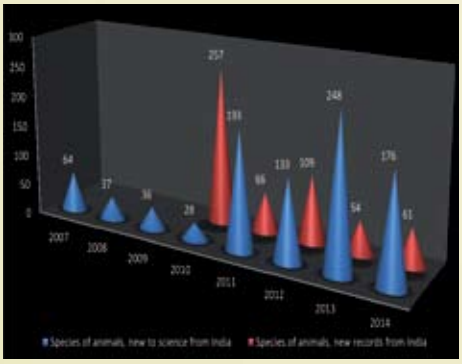
from all over the world, and another 5 to 15 million species are expected to be discovered. In India till date, nearly 96,891 species of animals have been described, but a large number of species are yet to be discovered, especially from the lower invertebrate groups occurring in various ecosystems.

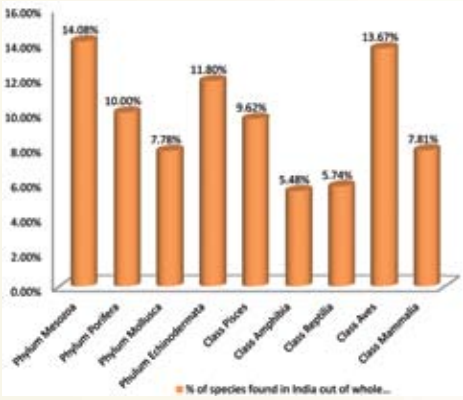
ZSI has been enriching its zoological collections by accepting the 'types' and other identified faunal materials from animal taxonomists and biodiversity researchers of various zoological institutions and universities in the country and abroad. The Central Entomological Laboratory receives thousands of zoological specimens from various sources. The confirmation of identification up to species level is also undertaken.

Confiscated faunal materials are regularly being received by ZSI from various government agencies, such as departments of Police, Forest and Customs for their identification and reports to be submitted to the Judiciary for the sake of implementation of different conservation laws including the Indian Wildlife (Protection) Act, 1972. The experts of the department even receive samples of skin, hair, feathers, and other items of animal origin, proposed to be exported from India by different private firms, are sent from the Custom Authorities for authentic identification to ensure that the threatened and endangered species according to CITES (Convention of International Trade on Endangered Species) are not exported.

Indian biodiversity

India is located at the confluence of Oriental, Palearctic and Ethiopian biogeographical realms and Indian mammals are the



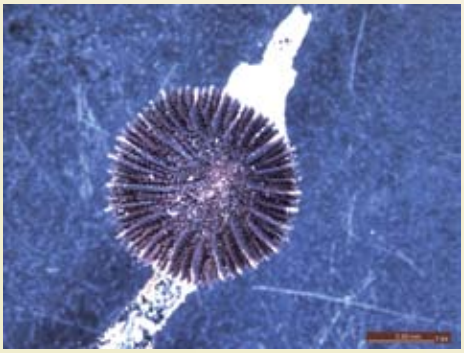


admixture of these three realms. Since the inception of ZSI in 1916, twenty-three new taxa of animals have been described as new to science. The scientists of ZSI have conducted 30 expeditions that include expeditions to Silent Valley, Chilka Lagoon, Namdapha, Subansiri, Neora Valley, and Antarctica among others.

Grappling with recording location

The Zoological Survey of India is designated for the collection of zoological specimens as per Section 39 of the National Biodiversity Act, 2002. With reference to Articles 5, 6, 7, 8, 10, 13, 14, 17 and 18 of the Biodiversity Convention, the role of ZSI has been broadened. As per Article 7, for identification and monitoring, ZSI has made extensive surveys in different parts of the country and large numbers of specimens have been collected. Of these collections, only about 65% have been taxonomically studied. These include the major groups of vertebrates, while the lower groups of invertebrates need more attention in identification as well as in surveys and explorations. As per Article 14, ZSI undertakes Environmental Impact Assessment with special reference to ecology and wildlife.

According to the past Director of ZSI, Dr. Venkatraman, "We have a strong affinity towards marine organisms, especially the corals. A very few institutes in India concentrate on marine organisms and our Regional Centres in Port Blair and Chennai work on Andaman and Nicobar region and East Coast of India including the Gulf of Mannar region. Due to climate change and recent tsunami, many coral dominant regions in both Andaman and Gulf of Mannar get affected. In 2012, we had reported 42 species of hard and soft corals from Andaman and Nicobar chain of islands. Such reporting of a considerable higher number of 42 corals in just one year shows how important the whole region is in terms of marine biodiversity."



Species name: Paracyathus caeruleus
Indian presence first recorded in 2014
by Tamal Mondal, C. Raghunathan
and K. Venkataraman

Species name: Lobophyllia dentatus
Indian presence first recorded in 2014
by Tamal Mondal, C. Raghunathan
and K. Venkataraman

Redeeming finds

- The 2003 report of the living fossil frog *Nasikabatrachus sahyadrensis* by S.D. Biju and Franky Bossuyt from Western Ghats is considered as once in a century find due to its relationship with Gondwanan relics.
- Dr. Biswamoy Biswas, one of the eminent ornithologists of the country while working at ZSI has described the blossom-headed parakeet, *Psittacula roseate* besides undertaking taxonomic revisions of many bird groups. Dr. Biswas also happened to be a part of the *Daily Mail* expedition sent to look for the Yeti around Mount Everest in 1954.
- Recently the scientists posted at the ZSI's Andaman and Nicobar Island Centre have discovered an apparently new species of Rallina crake (a wading bird with short bills) from the Great Nicobar Island with the help of Dr. Pamela Rasmussen. It is a rather elusive species.
- Discovery of Namdapha Flying squirrel *Biswamoyopterus biswasi* Saha in1981 is remarkable as this arboreal, nocturnal flying squirrel was described based on a single specimen from Arunachal Pradesh and till now there is no information on its population. Exact number of species described by Zoological Survey of India is yet to be ascertained.

What more to find?

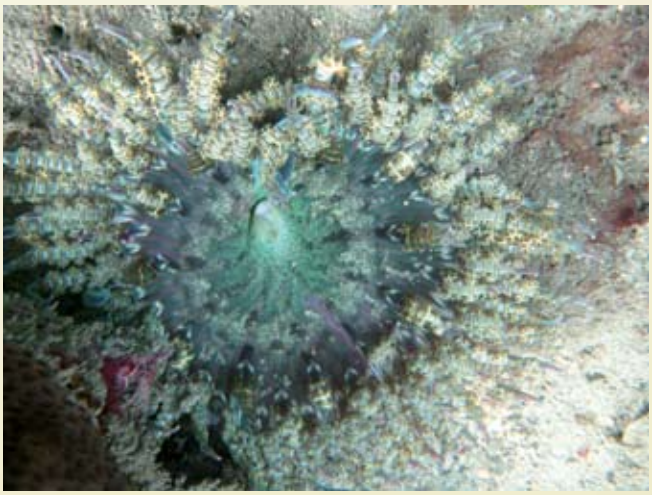
No, it's not the end of journey. India is recognised as one of the twelve mega diversity countries of the world with two biodiversity hot spots – the Eastern Himalaya and the Western Ghats. There are about 1.7 million living species described from all over the world and an estimated 15 million species are waiting to be discovered.

The Western Ghats, Eastern Himalaya, and the Andaman and Nicobar Islands have several unique and endemic reptilian fauna. Many new bird species hitherto not known to science may emerge from the chain of islands within Andaman and Nicobar region, northeast India and northeast Himalayas. Majority of the world's primitive burrowing snakes that constitute the family, Uropeltidae, are restricted to the mountain ranges of south India.

Publications of the Survey

The publication called, *Records of the Zoological Survey of India* (formerly *Records of the Indian Museum*) was started in the year 1907 and so far 107 volumes have been published. Keeping in view the mandate of the department to take up the status survey of endangered species, a series of publications called, *Status Survey of Endangered Species*, totalling 11 of them so far have been brought out.

Species name: Calliactis miriam
Indian presence first recorded in 2014 by C. Raghunathan, R. Raghuraman, Smitanjali Choudhury and K. Venkataraman



Species name: Phymanthus buitendijki
Indian presence first recorded in 2014 by C. Raghunathan, R. Raghuraman, Smitanjali Choudhury and K. Venkataraman

Zoological Survey of India has published its Red Data Book, *An Identification Manual for Scheduled Mammals of India*, containing a consolidated documentation and listing of all the scheduled or protected species of mammals found in India. It provides detailed information on scheduled mammals, their status as per IUCN (International Union for Conservation of Nature) Red List of Threatened Species. The book also lists the mammals that fall in the "Critically Endangered" category of the IUCN.

India is home to 428 species of mammals out of which more than 60 per cent; that is, about 251 species are under protected or scheduled categories of the Indian Wildlife (Protection) Act, 1972. Of these 428 species of mammals in India that constitute to about 8 per cent of the total mammal species found in the world, about 50 per cent of mammalian fauna of India have shrunk in their distributional range due to various anthropogenic pressures. Already four mammal species, viz., cheetah, banteng, Sumatran rhinoceros and Javan rhinoceros are extinct in India.

Out of the 251 Scheduled mammal species listed under the India Wildlife (Protection) Act, 1972 and documented in the publication, about 180 fall under the "lesser-known" category, and very little information is available about their habitat, behaviour, and population.

Widening approach

ZSI has also started molecular taxonomic studies dealing with chromosomal mapping, polymerase chain reaction (PCR) and DNA barcoding in order to genetically characterise species and their variations in natural population. Molecular Systematic Laboratories have started functioning in the Headquarters in Kolkata as well as in the Regional Centres of ZSI at Hyderabad, Pune, Chennai and Dehradun. More than 250 DNA sequences have been barcoded in these laboratories.

Ratnadeep Banerji is a senior feature writer and a documentary maker

Knowing about Coeliac Disease— Diagnosis and Care

Dr. Yatish Agarwal
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Coeliac disease is caused by body's abnormal immune response to eating gluten, a protein found in wheat, oats, barley and rye. If undiagnosed, or neglected, this reaction results in inflammation that damages the small intestine's lining and prevents absorption of key nutrients. This poor absorption produces bloating, diarrhoea and weight loss. Over time, the brain, nervous system, bones, liver and other organs can be deprived of vital nourishment.

The diagnosis is presumed on the basis of clinical signs and symptoms, although a number of tests can come in useful.

Clinching the diagnosis

Tests and procedures used to diagnose coeliac disease include:

Blood tests

Since the symptoms of coeliac disease can be varied, it is often undiagnosed or misdiagnosed. A blood test can detect high levels of certain antibodies that suggest that a person may have coeliac disease. If the results are negative, the doctor may ask for additional tests, possibly including an analysis of the DNA to help get an accurate diagnosis.

Genetic tests

Genetic testing offers clinching confirmation. Two genes, namely DQ2 or DQ8, are considered necessary for a person to develop the disease. If a person does not have those genes, the doctor can rule out coeliac disease. However, the converse is not true; many people have the genes and still don't develop coeliac disease.

Capsule endoscopy

Capsule endoscopy uses a tiny wireless camera to take pictures of the entire small intestine. The camera sits inside a vitamin-sized capsule, which a person has to swallow. As the capsule travels through the digestive tract, the camera takes thousands of pictures that are transmitted to a recorder.

Intestinal biopsy

A biopsy of the small intestine can confirm the findings of the blood test and is most definitive. An endoscope is placed through the mouth and stomach into the small intestine and a small amount of tissue is removed. Coeliac disease damages or destroys the small, hair-like protrusions in the intestine.

Home Care

There is no cure for coeliac disease — but following a strict gluten-free diet will halt the symptoms and allow the intestine to heal itself.

Gluten-free diet

A number of natural foods do not contain gluten. They can be used freely if you have coeliac disease.

Gluten-free flours

People with coeliac disease can partake of foods and snacks made out of gluten-free flours. A number of grains, legumes, and tubers can be used to produce such a flour (Table 1).

Table 1: Gluten-free flours

- Rice flour
- Corn/maize flour (*makka*)
- Sorghum flour (*jowar*)
- Buckwheat flour (*kuttu*)
- Pearl millet flour (*bajra*)
- Finger millet flour (*ragi*)
- Bengal gram flour (*besan*)
- Arrowroot
- Water chestnut flour (*singhara atta*)
- Chickpea flour *(kabuli chana atta)*
- Soybean flour
- Potato flour
- Tapioca flour *(kassava)*
- Barnyard millet (*sama ke chawal*)

However, care must be taken to ensure that the flour does not get contaminated with a gluten-containing flour, particularly during the process of milling. Such contamination is likely if mills use the same production lines and equipment to process both gluten-containing and gluten-free products.

Combinations of gluten-free flour

A variety of non-gluten flour combinations can be used safely to improve the palatability. Nutritionally, they make an excellent choice. A person with coeliac disease may try out the following combinations:

- Soybean flour (1 part) plus rice flour (3 parts)
- Rice flour (3 parts) plus Bengal gram flour (*besan*) (1 part)
- Rice flour (3 parts) plus chick pea flour (*kabuli chana atta*) (1 part)
- Arrowroot (1 part) plus potato flour (1 part)
- Corn flour (1 part) plus Bengal gram flour (*besan*) (1 part)

Gluten-free non-cereal foods

A large number of natural foods do not contain any gluten. A person with coeliac disease can safely enjoy a number of snacks made out of legumes, dry peas, nuts, and vegetable oils; plain meat (not breaded or marinated), eggs, soups and beverages, sweetening agents, and desserts (Table 2). Fruits and vegetables are also safe.

Table 2: Gluten-free foods

Snacks

- *Dosa, idli, vada*
- Rice *cheela, besan cheela, dal cheela*
- *Poha*
- *Chivra*
- Rice noodles
- Popcorn, sweet corn
- Roasted Bengal gram
- Potato chips
- Peanuts

Meats and eggs

- Fresh meat
- Fish
- Chicken
- Eggs

Soups and beverages

- Homemade soups
- Squash
- Sherbet
- Fruit juices
- Lime water *(nimbu pani)*
- Tea and coffee

Sweetening agents

- Honey
- Sugar and jaggery *(gur)*

Desserts and mithai

- *Rasgulla*
- *Paneer sandesh*
- *Gajar ka halwa*
- *Petha*
- *Kheer*: rice/carrots/*sabudana/ makhana*
- *Alu ka halwa*
- *Besan ka halwa*
- Besan ladoo

Alcoholic beverages

- Malt and scotch whiskey
- Wines, liqueurs, and ciders
- Brandy

Dairy products

Due to the damage suffered by the inner lining of the bowel, a large number of people diagnosed newly with coeliac disease carry a deficiency for lactase, the enzyme that helps digest the milk sugar. Such people must avoid milk and all dairy products until the intestine repairs itself. When the disease is under control, milk and other dairy products can be safely consumed (Table 3).

Table 3: Dairy products are safe

- Milk
- Buttermilk
- Curd, *lassi*
- *Paneer*
- Homemade milk shake

Supplements

A person with coeliac disease may benefit from vitamin and mineral supplements if the condition has caused a deficiency. They may require supplements of iron, calcium, vitamin D, zinc, copper, folic acid, and other B vitamins. The choice and the dose of these nutritional supplements must always be made in consultation with a doctor.

Stay on guard

People with coeliac disease must stay on guard against foods that may contain hidden gluten. Such foods may include processed meat, potato chips, French fries, breaded foods, sauces, and soups.

Lipsticks, postage stamps and medicine capsules are always suspect. Wine and distilled alcohol are generally safe, but most beers are not. Beer is made from grains and does not go through a distilling process.

Remember, coeliac disease has no cure, but if you are careful and follow a strict gluten-free diet, you can be symptom-free and live a near normal life.

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

Recent Developments in Science and Technology

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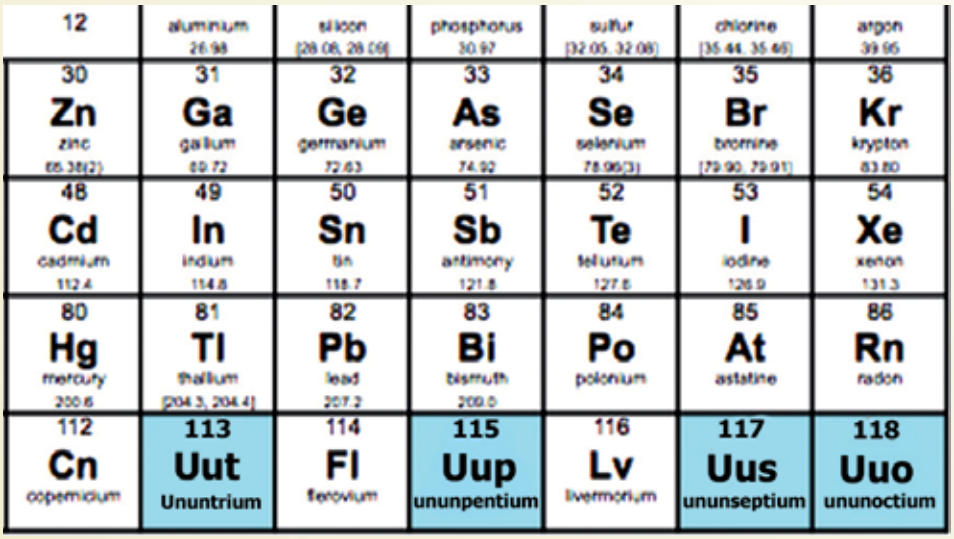
Four super-heavy elements officially added to the Periodic Table

Four new elements have been officially approved by the International Union of Pure and Applied Chemistry (IUPAC) for inclusion in the Periodic Table. They bear the atomic numbers 113, 115, 117 and 118. Although officially approved only now, the newly added elements were discovered earlier. As early as 1999, scientists at Lawrence Berkeley National Laboratory in Berkeley, California, USA, had announced the production of atoms of element-118, temporarily given the name ununoctium (which means 1-1-8 in Latin). But in 2002, this result was retracted after it was discovered that some of the data had been falsified. Later, in 2006, scientists at the Joint Institute for Nuclear Research at Dubna, Russia, announced the synthesis of element-118. In 2003, Russian scientists had claimed to have spotted elements 113 and 115 – named ununtrium (1-1-3) and ununpentium (1-1-5). Element-117, ununseptium (1-1-7), was first discovered by a joint Russian-American team in 2010. It took more labs to confirm the existence of the new elements for IUPAC to approve it, mainly because of their extremely short half-lives, measured in milliseconds.

Now the IUPAC is finally satisfied about the existence of the four elements. It has given credit for element-115, ununpentium, along with element-117, ununseptium and element-118, ununoctium to a joint Russian/American team at Joint Institute for Nuclear Research in Russia and Lawrence Livermore and Oak Ridge national laboratories in the US. Credit for element-113, ununtrium, goes to a team at RIKEN Nishina Centre for Accelerator-based Science (RNC) in Japan. Element-113 is the first element in the periodic table to be discovered in Asia. The elements are now to be named by the teams that confirmed their existence. According to IUPAC, "New elements can be named after a mythological concept, a mineral, a place or country, a property, or a scientist".



Inclusion four new elements in the Periodic Table has been officially approved by IUPAC.

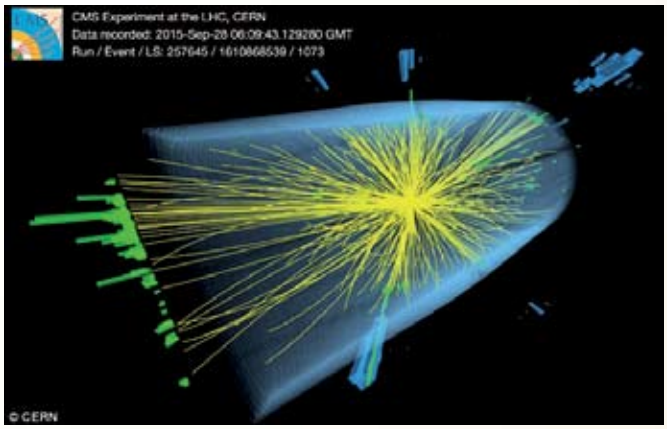
Before the current inclusions, the last elements to be added to the periodic table were flerovium (Fl, 114), named in honour of Russia's Flerov Laboratory of Nuclear Reactions where it was discovered, and livermorium (Lv, 116), named after the Lawrence Livermore National Laboratory, which collaborated with a Russian group on its discovery.

Because all of these elements at the high end of the periodic table decay so quickly, they don't have any practical applications, but scientists are hopeful that one day will discover "an island of stability" at the heavier end of the Periodic Table that would contain more stable elements that would stay longer than just fractions of a second. In nuclear physics, the island of stability is the prediction that a set of heavy isotopes with a certain number of protons and neutrons will temporarily reverse the trend of decreasing stability in elements heavier than uranium. Although predictions of the exact location differ somewhat, it is generally expected to occur in the region near the isotope of element-120 with mass number 300.

The periodic table of the elements was first published in 1869 by Russian chemist Dmitri Mendeleev. At that time, it contained 63 entries. With the new elements added on 30 December 2015, the table now contains more than double that number. Plutonium (atomic number 94) and uranium (atomic number 92) were considered to be the heaviest elements found in nature. Elements beyond plutonium were later created in labs by bombarding elemental nuclei together.

LHC gives hints of a new particle

Particle accelerators are powerful machines used to accelerate subatomic particles to extremely high speeds and then make them collide to create new heavier particles. CERN's Large Hadron Collider (LHC) in Switzerland is currently the most powerful accelerator, capable of smashing particles together at record-breaking energy levels of 13 Teraelectronvolts (TeV = 1×10^{12} eV). The same machine had produced the long elusive Higgs Boson in 2012 by smashing accelerated protons, generating 8 TeV of energy. CERN announced last December that new experiments conducted with the LHC after it was restarted in March 2015 have produced data that indicate possibility of new particle discovery. Already more than a hundred papers on the new results have been posted online on arXiv – a repository of electronic preprints of scientific papers and many possible explanations have been



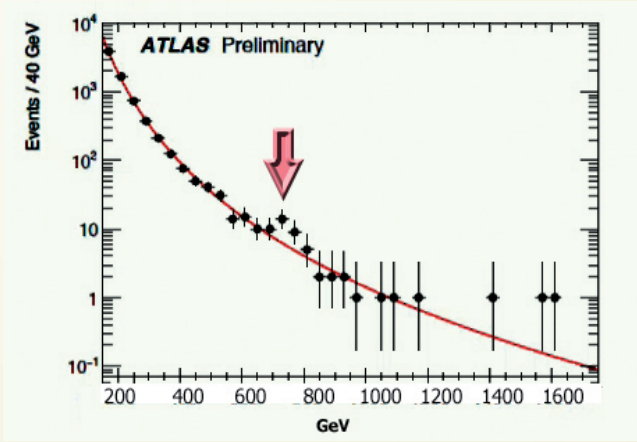
In this image, pairs of photons (shown in green) are produced in LHC collisions. (Credit: CERN)

offered, but scientists are yet to arrive at a unanimous conclusion.

When accelerated particles are collided in LHC, energy of the order of trillions of electron volts is produced, which occasionally transforms into extremely short-lived heavy particles that decay and produce other, less energetic particles. It is these secondary particles and other radiations like photons that are detected and give clue to the heavy particle initially produced as a result of the collision. One of the measures of a discovery in particle accelerator experiments is the number of "events" associated with it – which is one way to say that observers look for how many particles come streaming out of the wreckage of two protons smashing together. The rate of these events – how often the protons hit each other and produce smaller particles – can also hint at the validity of a finding. Normally, the number of events per unit energy (measured in GeV), when plotted should describe a smooth curve as the energy goes up, assuming that the physical equations scientists are using are correct. In the latest experiments, however, the LHC data shows something tantalizing – a "spike" on the curve of particle events, centred at an energy level of 750 GeV that could have come from the decay of a new massive 1,500-GeV particle. The spike showed up on both the ATLAS and CMS detectors of LHC, indicating that it is less likely to be a fluke.

According to physicists, the new particle could be a number of things, like a heavier version of the Higgs Boson, which makes up the theorised field that gives mass to particles and objects across the universe. It could also be a graviton – a hypothetical particle which if discovered would prove a long-standing theory about what carries gravitational force, in a way similar to the way photons carry the electromagnetic force.

Due to the nature of particle physics, however, there are still a lot of questions. There have been instances of anomalies, faults and even coincidences giving rise to 'false alarms' in the past. So the scientists will have to study further to check whether the new particle is genuine.



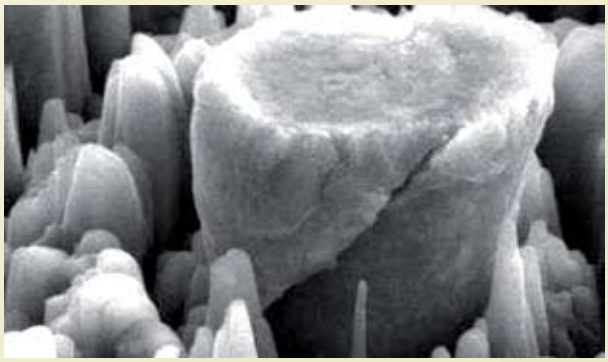
The "events" plotted at the ATLAS experiment in proton-proton collisions showing the spike (arrow), which may indicate a new particle.

New super-strong, lightweight metal developed

A team led by researchers from UCLA (University of California, Los Angeles) Henry Samueli School of Engineering and Applied Science has created a super-strong yet lightweight structural metal with extremely high specific strength and stiffness-to-weight ratio. The new metal is composed of magnesium containing a dispersal of silicon carbide nanoparticles. It would be ideal for making lighter cars, aircraft, and spacecraft and helping to improve fuel efficiency. To create the super-strong metal, the team found a new way to disperse and stabilise nanoparticles in molten metals. They also developed a method to scale-up the manufacturing method that could pave the way for more high-performance light-weight metals (*Nature*, 23 December 2015 | DOI: 10.1038/nature16445).

Structural metals are load-bearing metals that find wide used in buildings, vehicles and aircraft. Steel is one of most commonly used structural material because it is strong, but it is heavy. Aluminium is much lighter, but lacks in strength. Magnesium, at just two-thirds the density of aluminium, is the lightest structural metal. Silicon carbide is an ultra-hard ceramic material commonly used as an abrasive and in industrial cutting blades. Earlier it was observed that dispersion of microscale ceramic particles in metal results in a loss of plasticity. However, it has been found that nanoscale particles can enhance strength while maintaining or even improving the plasticity of metals. The UCLA researchers infused a large number of silicon carbide particles smaller than 100 nanometres into molten magnesium. After processing, the researchers tested the magnesium, newly infused with a dense, even spread of nanoparticles, and found the new material showed improved strength, stiffness, plasticity and durability under high temperatures.

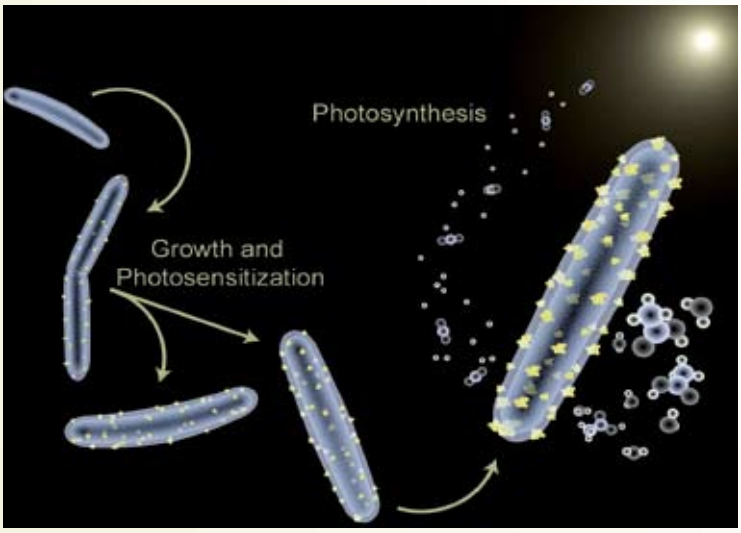
Usually, when added to molten metal, nanoscale ceramic particles tend to clump together rather than dispersing evenly, due to the tendency of small particles to attract one



Electron micrograph of new strong metal made of magnesium with silicon carbide nanoparticles. (Credit: UCLA Scifacturing Laboratory)

other. To counter the tendency to clump, the researchers dispersed the particles into a molten magnesium-zinc alloy, which stabilised the particles' dispersion and prevented clumping. The new metal (more accurately called a metal nanocomposite) is made up of about 14 percent silicon carbide nanoparticles and 86 percent magnesium.

The researchers say the ceramic-infused metal may be just the first of many ground-breaking manufacturing materials. That is because they have invented a new technique for infusing metals with nanoparticles without hurting the metal's structural integrity. Because magnesium is relatively abundant and the production technology can be easily scaled up, the researchers hope the metal's industrial applications will be quickly realised. They don't think it will be long before they have found a new metal-nanoparticle combination with impressive potential.



The bacterium Moorella thermoacetica is being used to perform photosynthesis and also to synthesise semiconductor nanoparticles in a hybrid artificial photosynthesis system for converting sunlight into valuable chemical products. (Credit: Peidong Yang, Berkeley Lab/UC Berkeley)

Common bacteria made to photosynthesise

Photosynthesis is a well-known process used by plants and some other organisms to convert light energy, normally from the Sun, into chemical energy in the form of glucose, using carbon dioxide and water. The process of photosynthesis occurs in two parts. The first part is called the light-dependent reaction. This reaction happens when the light energy is captured by chlorophyll. The second part of the process happens when glucose is synthesised, which does not need light. It is called the light independent reaction or dark reaction.

In green plants, the green pigment found in leaves known as chlorophyll acts as harvester of light for photosynthesis. There are also some special types of bacteria that contain light absorbing pigments and reaction centres which make them capable of converting light energy into chemical energy, but they all do not contain chlorophyll. While cyanobacteria contain chlorophyll, the other forms of photosynthetic bacteria contain a pigment called bacteriochlorophyll.

While most bacteria cannot photosynthesise, it has now been possible for the first time to train a non-photosynthetic bacterium to perform photosynthesis. Researchers at Lawrence Berkeley National Laboratory in California, USA, led by Peidong Yang, developed a hybrid photosynthesis system by incorporating cadmium sulphide nanoparticles in the non-photosynthetic bacterium *Moorella thermoacetica*. According to the researchers, "the hybrid approach combines highly efficient light harvesting power of inorganic semiconductors with the high specificity, low cost, and self-replication and self-repair of biocatalysts" (*Science*, 1 January 2015 | DOI: 10.1126/science.aad3317).

The bacterium, *M. thermoacetica*, is found naturally at the bottom of stagnant ponds. It is one of the most ancient organisms known. It is believed to be tied closely with what is perhaps the first life-originating reaction – the formation of a carbon-carbon bond from methane and carbon dioxide to form acetic acid. But it cannot photosynthesise.

Cadmium sulphide (CdS) is an inorganic semiconductor and an ideal harvester of light. It is widely used in making solar cells and light-dependent resistors/photoresistors for light sensors. By combining it with the bio-replication abilities of *M. thermoacetica*, the researchers created an efficient hybridised chemical production system that enabled the photosynthesis of acetic acid from carbon dioxide when exposed to sunlight. They used biologically precipitated cadmium sulphide nanoparticles as the light harvester to sustain cellular metabolism. According to the researchers, this self-augmented biological system selectively produced acetic acid continuously over several days of light-dark cycles at relatively high yields. It demonstrated a self-replicating route toward a solar-to-chemical process that can transform carbon dioxide to a useful product. Acetic acid is currently obtained from petroleum, mostly for use in fuels and plastics. But researchers have been looking for new, more sustainable ways to harvest similar chemical products.

Speaking about the new process, Yang says, "Our hybrid system combines the best of both worlds: the light-harvesting capabilities of semiconductors with the catalytic power of biology. In this study, we've demonstrated not only that biomaterials can be of sufficient quality to carry out useful photochemistry, but that in some ways they may be even more advantageous in biological applications".

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.