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Fifty Years of Moon Landing

INSIDE STORIES

EDITORIAL

Leave no kid behind

Nakul Parashar

During the past few years the country has achieved a number of milestones, indeed through advancements made in science and technology. The Department of Science & Technology of the Government of India has relentlessly taken up a number of new projects for the betterment of the country and its citizens, year after year; results from most of them have now started to show up in quick succession. In one of my previous editorials, I had mentioned about challenges of electric mobility and how scientists from the department had come up with plausible strategies to address them. It is heartening to see how quickly the electric charging stations have started to come up, sales of electric scooters are on the rise and similar is the scenario where e-buses have started to penetrate the public transport system. Standardisation of batteries is work-in-progress. All of it is moving towards reducing the dependence of fossil fuel and in turn, trying to build a healthy nation.

When we say a healthy nation, it becomes important that we build adequate immunity against a number of diseases. Vaccination is an obvious response. The vaccine is a biological preparation that contains an agent that stimulates the body's immune system to realise it as a foreign one, remember it and eliminate it. So, at a later point in time when the immune system encounters the same foreign body, it remembers it and eliminates it thereby protect the individual. Isn't it a matter of achievement for the country, when in 2014, the World Health Organisation (WHO) declared India a polio-free country after no cases of wild polio were reported for the last five years?

Indeed, it's worth mentioning is that vaccines have been highly successful in saving up to 3 million lives annually and globally. They've been able to protect the children from potentially deadly, highly infectious diseases such as measles, pneumonia, cholera, and diphtheria. Encouraging enough, statistics also reveal that due to vaccines, there has been a significant decline in the number of deaths from measles during 2000-2017. Indeed, vaccines are one of the most cost-effective health tools ever invented.

Way back in 2012, the 194 member countries of the World Health Assembly (the decision-making body of WHO) affirmed the launch of the Global Vaccine Action Plan (GVAP). The aim of this plan was to prevent millions of deaths by 2020 through vaccination. Many well-known agencies came forward to be a part of this worldwide initiative. Besides various governments and other global agencies, notable amongst them are the UNICEF, WHO, GAVI (the vaccine alliance) and the Bill & Melinda Gates Foundation. Since then, a great deal of work has been taken up and a number of awareness programs have been launched. The growing power of social media was simultaneously recognised. UNICEF launched a global campaign to stress on the efficacy of vaccines, especially amongst parents and ever-growing social media users. A successful week-long program was launched globally in the last week of April this year.

Yet, figures of deaths still remain quite startling. Reports indicated that an estimated 1.5 million children had died of vaccine-preventable diseases in 2017. But why? Is it due to lack of access to vaccines? No, in some countries, families are delaying or refusing to vaccinate their children because of complacency or scepticism about vaccines. The only way, therefore, is to create awareness through whatever medium that is available and effective.

A Twitter account called #VaccinesWork carries a lot of valuable information. A short sixty-second animated film called *Dangers* is made available in a number of languages like Hindi, Arabic, Russian, Tagalog, Chinese and many more. It has been found to be very effective.

We're nearing 2020, and GVAP seems to have achieved a quite a bit, but we've still to meet the objective: Leave no kid behind.

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Fifty Years of Moon Landing

Bhupati Chakrabarti

2019 is the golden jubilee year of the first Moon landing by humans. It was on 21 July 1969 that the American astronaut Neil Armstrong set foot on Earth's only natural satellite after travelling on board the Apollo-11 spacecraft along with two other astronauts, Buzz Aldrin and Michael Collins. Compared to the present-day technologies, facilities were much rudimentary fifty years back. It is difficult to imagine how a manned mission to the Moon could have been planned fifty years ago. Landing on Moon by Apollo-11 astronauts was very special in space exploration history.

2019 is the golden jubilee year of the first Moon landing by humans. It was on 21 July 1969 that the American astronaut Neil Armstrong set foot on Earth's only natural satellite after travelling on board the *Apollo*-11 spacecraft along with two other astronauts, Buzz Aldrin and Michael Collins. To be precise, it was 20:17 UTC(known as GMT at that time) of 20 July 1969 when the *Apollo* Lunar Module *Eagle*, carrying Armstrong and Aldrin, landed on the lunar surface. Armstrong became the first person to step onto the lunar surface six hours later on 21 July at 02:56:15 UTC; Aldrin joined him 19 minutes later.

The journey of the *Apollo*-11 spacecraft that took the three astronauts to the Moon started from Kennedy Space Centre in Florida, USA on 16 July at 13:32 UTC. The *Apollo*-11 spacecraft had three parts: a Command Module named *Columbia*, with a cabin for the three astronauts, and the only part that returned to Earth; a Service Module, which provided the propulsion, electrical power, oxygen, and water to the command module; and a Lunar Module named *Eagle* that had two stages – a descent stage for landing on the Moon, and an ascent stage to place the astronauts back into lunar orbit. The Command and Service Module remained attached till the final hours of the mission when Service Module got separated before the Command Module plunged into the sea.

After reaching the lunar orbit Armstrong and Aldrin entered the Lunar Module on 20 July to prepare for landing on Moon. The third astronaut Michael Collins stayed back, piloting and managing the Command and Service Module. He was entrusted with the duty of not only putting the Lunar Module on the right course but also had the responsibility of monitoring the safe return of his co astronauts to the Command and Service Module and finally back to Earth.

Earthrise viewed from lunar orbit prior to landing

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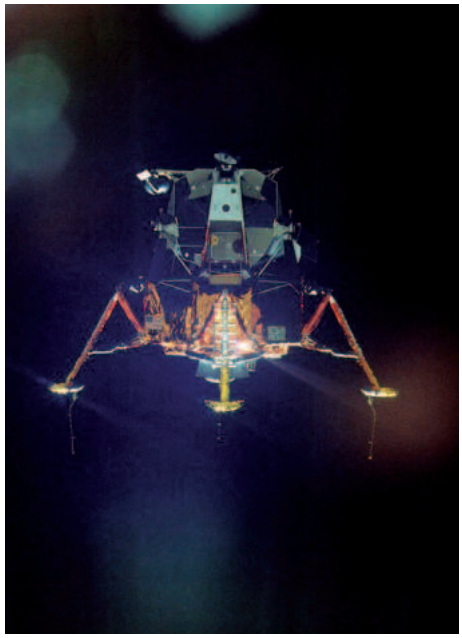
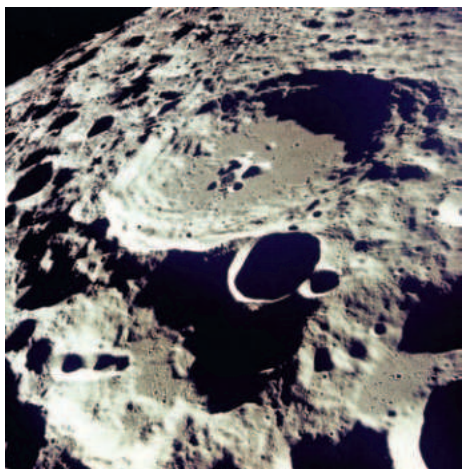


Lunar module inspection after undocking

Of course, the dates and times become irrelevant to the astronauts once they leave the Earth. Since they are not on Earth, they are not in any particular time zone. To avoid any confusion about time, there is a system of keeping the time for a space probe or spacecraft known as Ground Elapsed Time or GET. GET gives us in hours, minutes and seconds the time elapsed since a spacecraft left the ground. On that scale the GET for the landing of the Lunar Module on Moon was more than 100 hours; in other words, the Lunar Module landed on the surface of the Moon more than 100 hours after leaving Earth. To be exact, the GET for the *Apollo*-11 Lunar Module landing was 102 hours 45 minutes and 43 seconds.



Crater 308 viewed from orbit

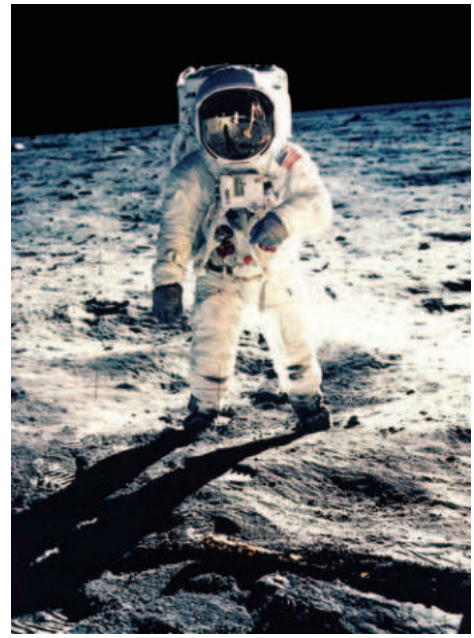
The Apollo missions were initiated by the US space agency National Aeronautics and Space and Administration (NASA) in the early 1960s. When, in 1961, the then US President John F Kennedy declared that US would send men to the Moon by the end of the decade, he not only tried to show the confidence on the technological capability of the US scientists and technologists but it was in a way a reaction to the success of the erstwhile Soviet Union that had put up Yuri Gagarin as the first man in the space before safely bringing him back to Earth.

At that time, space programmes involved fierce competition between the USA and the Soviet Union as a fallout of the Cold War, as both the countries were developing their missile capabilities. Now it is very clear that the space programmes

The Apollo 11 crew relaxes during training in the month of May 1969

were undertaken by the two countries with the ultimate objective of dominating in the world. Today we know that the space programmes of different countries that includes our own, have contributed technologies like satellite communications, World Wide Web, live television broadcasts from the other end of the world, direct-to-home television, GPS and so many other things that have turned the world into what is known as a 'global village'.

The Apollo Mission started in 1962 and several spacecrafts in the series were sent to space to explore different aspects



Aldrin poses for portrait on the surface of the moon

with the ultimate goal of a manned mission to the Moon. Keeping this aspect in mind, NASA right from the beginning designed a spacecraft that could accommodate three astronauts with some space for their movements. In fact, the design was novel, and the movement area of the spacecraft provided room of the size of the inside of a large car. Before the *Apollo*-11 mission was launched there were several of its predecessors that gathered huge amounts of information and brought back a lot of data including that of a viable landing of a detachable component of the main spacecraft. This detachable part was named as the Lunar Module and was designed to get separated from the Control and Service Module while in lunar orbit, and then land on the surface of the Moon with

Armstrong in Lunar Module after historic moonwalk

the astronauts. The astronauts were trained to perform certain tasks on the surface of the Moon and then return to the Command and Service Module, riding in the Lunar Module, for their journey back to Earth. It is worth noting that even with today's technologies and communication systems at hand it is a daunting task. And fifty years ago, it was possibly an expedition with ultra-high risk.

Yet it succeeded. Neil Armstrong and Edwin Aldrin spent 21 hours 36 minutes on the surface of the Moon. Their first radio message to the NASA Mission control was, 'the *Eagle* has landed". As mentioned earlier, *Eagle* was the name of the Lunar Module that was designed to land on Moon. During their stay on the Moon, Armstrong and Aldrin collected various rock and soil samples and set up a number of equipment for the collection and future transmission of information from the surface of the Moon. They also spoke with the then US president Richard Nixon.

The Apollo missions started with the name AS (Apollo-Saturn) and the name Apollo was introduced later when NASA planned to have manned space flights. The original unmanned AS flights were also inducted in the Apollo series and renamed. However, the series included spacecrafts numbered*Apollo*-1 to *Apollo*-17 with *Apollo*-2 to6 missing. The first manned flight scheduled for this series was*Apollo*-1, which was to be launched on 21 February 1967. However, on 27 January 1967, this ill-fated spacecraft caught fire during a training session, killing all the three astronauts Edward H White II, Virgil "Gus" Grissom and Roger B. Chaffee, who were inside. It was the first disaster of this dimension that NASA had to face.

Apollo-8 was the first manned mission to the Moon. It carried three astronauts but was not scheduled to land on the Moon. Rather *Apollo*-8 orbited round the Moon before returning to Earth. Although *Apollo*-8 did not land on the Moon, the mission's smooth and well-charted course paved the way for Moon-landing later by*Apollo*-11.

Apart from the three astronauts of *Apollo*-1, two cosmonauts from the Soviet Union also died in accidents, but all played brave roles in the advancement of manned space programmes. To acknowledge their roles in the history of space travel by human beings, commemorative medallions were left on the surface of the Moon by the *Apollo*-11 astronauts. The one-and-a-half inch (3.8 cm) silicon disks, contained microminiaturised goodwill messages from 73 countries in different languages along with the names of the people's representatives of USA and the names of the scientists leading NASA.

A very special credit of Apollo-11 lies in the fact that the astronauts who landed on the surface of the Moon could collect some geological samples for the first time from outside the Earth. The Earth gets bombarded with meteorites and in the process, we do receive some samples of rocks or iron-rich minerals that do not belong to Earth. But this act of fetching the first geologic samples from another member of the solar system, namely the Moon back to Earth was very special. In all, *Apollo*-11 astronauts collected 22 kilograms of material in a systematic and planned way. They pulled together 50 pieces of rock, samples of the fine-grained lunar "soil" available on its surface and two core tubes that included material from up to 13 cm below the Moon's surface. It was important to get a hint of the subsurface characteristics of the Moon. Subsequent analyses did not reveal any water contained in these samples and they did not provide any evidence for living organisms at any time in the Moon's history.

Flight controllers during lunar module descent, the agony is obvious

The site of landing of the *Apollo*-11, known as the Sea of Tranquillity (*Mare Tranquilitatis*) basically had two main types of rocks – basalts and breccias. Basalts are solidified form of molten lava from volcanoes. The basalts found in the landing site of *Apollo*-11 were similar to that available on Earth. The dark areas on the Moon as we observe in the night sky are basically areas of basalt. The other type of rock collected from the *Apollo-11* landing site, namely breccias are essentially composed of fragments from various older rocks. On the surface of the Moon the meteorites incessantly bombard and go on making pockmarks. In the absence of any atmospheric cover the meteorites do not burn out or get lighter before reaching the surface of the moon. As a result, they strike the surface with lot of momentum and they break up older rocks on the surface of the Moon or get coalesced with other rocks. So, the breccias collected might have contained basalt as well as rocks from lunar highlands.

Compared to the present-day technologies, particularly the computers and the very fast, communication modes that we are familiar with the status of all these facilities were much rudimentary fifty years back. It is difficult to imagine how a manned mission to the Moon could have been planned fifty years ago. Apart from the political and technological competition between the USA and the Soviet Union during the days of Cold War, it is human endeavour that has inspired humanity to take huge risks to explore the unknown. Not all the efforts were successful as we have seen with some of the Apollo missions. But the craving was on. On a different scale it was like the different sea expeditions undertaken in the sixteenth or seventeenth century or even earlier. There was no clock for reliable record of time, no device or method to locate oneself as the determination of the latitude of a location was not in place even three hundred years back, leave aside the communication facilities. Yet people used to undertake long sea voyages. Numerous lives were lost, so many unsung heroes remained obscure, but sea routes were charted out. The different regions of the globe came to be known. May be the intention was not that noble always, but these efforts should be recorded as the part of human aspiration to break the glass ceiling and move literally up. And the landing on Moon by *Apollo*-11 astronauts was another very special addition to that list. ■

Zinc: the essential micronutrient

Susmita Barman and K. Srinivasan

Zinc is an important micronutrient for a strong immune system, healthy skin, insulin production and regulation, digestion and regulation of energy metabolism. Zinc also plays a powerful role in the prevention of diseases such as secondary complications of diabetes and cancer, learning, memory, and healthy brain function. Worldwide, approximately 30% of children below 5 years of age are stunted in growth, clearly pointing this out as a public health concern. It is estimated that up to 40% of Indian children suffer from zinc deficiency. Zinc fortification is recommended as an appropriate strategy to enhance zinc status in population.

Micronutrients are essential microminerals and vitamins needed by us in small quantities throughout life to orchestrate a range of physiological functions to maintain optimal health and also minimise the risk of degenerative diseases. Microminerals (also called trace elements) include iron, cobalt, chromium, copper, iodine, manganese, selenium, zinc, and molybdenum. In the first half of the 20th century, nutrition scientists understood that zinc - one among the micronutrients - is indispensable for normal growth and survival of all animals and plants. It is generally believed that zinc deficiency in humans is the consequence of many factors. Zinc deficiency is acknowledged as a widespread threat to human health, probably as much as that of iron deficiency. Clinical manifestation of zinc deficiency is however not always apparent. Ever since the manifestation of zinc deficiency was described for the first time in humans, namely, negative impact on the growth in childhood, deficiency of this micromineral has become a global nutritional problem, affecting both developed and developing countries. Newborn babies, children, pregnant women and elderly people are the vulnerable/high risk groups among the human population. Zinc status is generally assessed by several methods which include: serum zinc concentration, leukocyte and neutrophil zinc concentration, and the activity of selected enzymes such as 5′-nucleotidase and metallothionein concentration in RBC. Why zinc is so essential for our survival? How much zinc do we have in our body? And how much zinc can we lose before we encounter complications of its deficiency? What are the main dietary sources that ensure a reasonably adequate intake of zinc? These are the questions that will be addressed in the following paragraphs.

What makes zinc a unique trace element?

Zinc (symbol Zn) is a silver-grey coloured metallic element which is a profusely available element in Earth's crust. Zinc is the second most abundant trace element in the human body present in all the tissues, bones, and fluid. Zinc always can be found in the divalent (+2) state. The total body zinc content in humans is approximately 2 g. Skeletal muscle, bones, skin and other tissues account for roughly 60%, 30%, 5% and 5% of the total zinc content.

Proven health benefits of zinc

Helps in wound healing and treating acne - Zinc has promising benefits to skin health. Zinc helps conserve the integrity of skin and mucosal membranes. Skin ulcers are often treated with zinc supplements; zinc oxide is very popular amongst those. Skin disorders like leishmaniasis and eczema can be treated orally with 2.5-10 mg of zinc sulphate per kg for 45 days. Zinc is known to kill acne-causing bacteria and

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fights inflammation along with other anti-inflammatory antioxidants. Acne patients are usually low in zinc. Zinc and vitamin A function together in the body and play a critical role in cellular growth, repair, and healing of the skin and all tissues. An optimal dose for zinc is 15-30 mg per day, coupled with 10,000 IU of vitamin A per day, is usually recommended for a duration of 2-3 months. Zinc-containing creams and ointments can also help with healing scars and preventing herpes outbreaks.

Hair health - Zinc has promising benefits of maintaining healthy hair. Zinc deficiency can lead to the deterioration of the protein structure that makes up the hair follicles. Use of zinc sulphate orally curbs hair loss and improves its quality. Use of shampoos containing one percent zinc pyrithione (ZPT) can treat dandruff.

Improves vision - The retina is known to contain a high concentration of zinc. Zinc helps in the formation of melanin, which is a pigment that protects the eye. Poor night vision and cloudy cataracts have also been linked to zinc deficiency. Researchers have proposed that zinc by its antioxidant influence delays the progress of age-related macular degeneration (AMD) and loss of vision, perhaps by averting cellular damage in the retina.

Builds immunity - Zinc plays a key role in building body's immunity to bacteria, fungi, and viruses. Zinc supplementation is found to decrease oxidative stress and suppress the generation of inflammatory cytokines. Zinc deficiency weakens the immune system in the body, increasing a person's susceptibility to colds and infections. Due to its inhibitory effect on viruses, zinc works wonderfully well in reducing the severity and duration of common cold symptoms. Zinc gluconate lozenges considerably reduce the duration of common cold.

Helps combat cancer - According to a study, zinc treatment reduces the development of inflammatory blood vessels and induces cancer cell death (apoptosis). There are also studies that have suggested that zinc can suppress the proliferation of esophageal cancer cells. Zinc deficiency along with deficiency of other nutrients (such as selenium, vitamin D, etc.) is seen in cancer patients, suggesting a link between zinc and the possible prevention of various forms of cancer.

Aids in the management of diabetes - Zinc is also very much needed for the production of the hormone insulin, which plays a central role in diabetes. Diabetics are found to become deficient in zinc consequent to excessive loss of this mineral from the body through urine and faeces. Zinc supplementation has been reported to have a beneficial effect on high blood-glucose and other metabolic abnormalities associated with diabetes. Zinc supplementation in diabetes to compensate for its excessive losses is also reported to result in the beneficial alleviation of secondary complications — diabetic renal disease, cataract and the risk of cardiac problems.

Protects the heart - As an antioxidant mineral, zinc is shown to protect the heart muscles against oxidative stress that might otherwise harm the heart in the long run. This antioxidant mineral strengthens the heart by helping the cardiac tissue deal with oxidative stress and its consequences. Zinc can also regulate heartbeat. Patients with congestive heart failure often have zinc deficiency. Studies have revealed that enough zinc intake could help prevent angina pectoris (severe pain in the chest). Zinc deficiency can lead to high blood pressure, which might eventually lead to cardiac issues.

Might help in weight control - Studies have revealed that obese individuals tend to have low levels of zinc. Chronic zinc deficiency has been shown to orient the body's energy reserves to fat storage rather than fat-burning. This suggests that boosting dietary zinc may have a positive effect on energy metabolism and weight loss. Obese patients on zinc supplementation have shown improved body mass indices and loss of body weight. This could be because zinc plays a strong role in energy metabolism, and a zinc deficiency reduces the body's production of ATP that fuels all body processes.

Strengthens the bones - Zinc is an important mineral for the health of our bones. Along with other nutrients such as magnesium, vitamin D, and vitamin K, zinc is found to have a beneficial effect on preventing and reducing bone loss. Thus, zinc can be used in various forms to prevent and treat osteoporosis. Zinc deficiency has been linked to deterioration of bone metabolism and is found to stimulate bone formation and mineralization. This is partly due to its important role in protein synthesis. There is also a little information that zinc can help with muscle growth and repair by aiding protein synthesis, thus suggesting that zinc can be beneficial in bodybuilding.

Promotes digestive health - People with zinc deficiency often experience digestive disturbances, especially difficulty in digesting protein. This is because zinc serves as a component of protein digestive enzymes (carboxy peptidase) secreted in the pancreatic juice. Zinc can enhance the health and integrity of the gastrointestinal (GI) epithelial barrier function, which can help GI issues, including diarrhoea.

Boosts men's sexual health - Zinc enables the male body to produce the hormone testosterone, and hence a deficiency of zinc can lead to erectile dysfunction. Zinc supplementation (15-30 mg per day) can increase testosterone production, thereby treating male sexual problems particularly erectile dysfunction.

Can be helpful during pregnancy - Zinc is one of the most important minerals for fertility in both men and women. Population studies have shown that over 80% of the world's pregnant women are deficient in zinc. Along with other nutrients, zinc is also found to promote favourable outcomes during pregnancy as well as lactation. Zinc deficiency during pregnancy might lead to intra-uterine deficiency. Maternal zinc deficiency can also compromise the health of the infant and lead to poor birth outcomes. It has been shown that mothers of low birth weight infants who were on zinc supplementation during pregnancy had a reduced risk of diarrhoea and dysentery.

Helps relieve PMS symptoms - Zinc has been found to relieve cramping and pain related to premenstrual syndrome in women, when taken along with extra magnesium (400-600 mg) and vitamin B6 (5-20 mg). This might be because it improves blood flow to the uterus and reduces inflammation.

Can boost brain health - Several studies have documented the beneficial effects of zinc on brain health. Incidentally, the highest amount of zinc in our body is found in the hippocampus portion of our brains. Zinc plays a significant role in neuroprotection. It protects brain cells through promoting healing processes in the brain and nervous system and modulating the body's response to stress. Zinc has been successfully employed to treat certain types

of schizophrenia. Zinc supplementation has also been found to enhance learning skill and memory.

Why zinc is considered as most important mineral in biological systems?

The essential trace element zinc possesses several physiologic functions, being pivotal for growth and effective for the immune system. Zinc is considered to be an essential mineral as it is a component of a large number of enzymes participating in different pathways. It stabilises the molecular structure of cellular components and membranes and consequently help to maintain cell and organ integrity. The divergent functions of zinc are briefly described below:

Component of metalloenzymes - Zinc is an integral structural component of over 300 metalloenzymes which participate in diverse metabolic pathways, thus imperative for many fundamental life processes. The list of zinc-containing metalloenzymes includes carbonic anhydrase (which catalyses rapid carbon dioxide release), alcohol dehydrogenase (responsible for the conversion of ethyl alcohol to acetaldehyde), superoxide dismutase (an antioxidant enzyme), etc.

Immune function - The body requires zinc for development and activation of T-lymphocytes. Zinc deficiency affects the immune system. It leads to abnormal development of immune organs; smaller thymus; loss of T cells; weaker T cell functions; and susceptibility to infectious diseases.

Zinc absorption

During digestive process, dietary zinc gets released from the bound protein and nucleic acids following the action of the respective digestive enzymes. Zinc is absorbed all through the small intestine, but it is more in the jejunal segment. It is estimated that one can absorb up to 60% of the zinc from the consumed food. The extent of zinc absorption, however, depends on the amount of zinc present in the food and whether the food contains factors that increase or decrease zinc absorption.

Diets with highly bioavailable zinc (50-60%) include mainly animal-sourced protein-rich food such as meat and fish, and refined diet low in cereal fibre and phytic acid content as phytic acid hinders the absorption rate of available zinc present in the food. Diets with moderately bioavailable zinc (30%) include lacto-ovo, ovo-vegetarian or vegan diets not based on unrefined cereal grains or mixed diet containing animal or fish proteins or milk. Diets with low bioavailable zinc (15%) such as diets high in unrefined, unfermented and ungerminated cereal grain, which are high in phytate, calcium and other inhibitors.

Factors affecting absorption

Zinc intake: The amount of zinc present in the diet itself affects zinc absorption. With increasing content of zinc in a meal, the fraction of zinc absorption (%) decreases. The diminished fractional absorption of zinc at higher ingestion is probably the result of saturation of the transport mechanisms for zinc.

Protein quantity and quality in the food: Protein is considered a major source of dietary zinc that helps in an amplified zinc intake and a higher bioavailability of the element concomitant with increased protein content of the meal. The nature of protein in a meal also affects the zinc bioavailability. For example, zinc absorption is higher from milk-based infant formula (containing whey proteins) than from cow's milk, which contains casein that has a negative influence on zinc absorption compared to whey protein.

Phytate and fibre content of the food: Phytates are antioxidant compounds found in whole grains, legumes, nuts and seeds. Most fibre-containing foods also contain good amounts of phytate. Phytates possess an inhibitory effect on zinc absorption. The phosphate groups present in phytate form strong and insoluble complexes with cations like zinc. Being unavailable for absorption, phytate-bound minerals get excreted from the body through faeces. Fibre also is often implicated as having a negative consequence on zinc absorption.

Interference from other minerals: Calcium possesses a negative effect on zinc absorption. It generally forms phytate complexes along with zinc which are insoluble and subsequently hampers zinc absorption.

Low-molecular-weight ligands: Studies have claimed that addition of the metal chelator EDTA to the diet produces a positive influence on countering the negative effect of phytate on zinc absorption. EDTA helps solubilise zinc from more or less insoluble phytate-zinc complexes and form stronger complexes due to its high binding capacity to zinc. The Na-Fe-EDTA complex dissociates (partially) at the acidic pH of the stomach and Zn-EDTA complex is formed. This in turn may help zinc to stay soluble but also to be taken up by the enterocytes, or intestinal absorptive cells, even in the presence of inhibitors such as phytates. Inside the enterocyte, dissociation of the Zn-EDTA complex may allow zinc to become complexed with other, transferable ligands or to be transported in free form across the basolateral membrane that forms a barrier between the cell and the blood and/or other cells.

Food sources of zinc

The suggested dietary intake of zinc for Indian population is 16 mg per day for an adult person. Red meat and poultry provide most of the zinc in a non-vegetarian diet. Oysters contain more zinc per serving than any other food. Other good food sources of zinc include certain types of seafood (such as shellfish, crab and lobster), eggs, legumes like chickpeas, lentils, and beans, nuts (such as cashew), whole grains, fortified breakfast cereals, and dairy products.

Although zinc is present in small traces in most foods, other zinc-rich foods that can provide this mineral in our daily meals are:

Wheat germ	17 mg of zinc per serving of 100 g
Pumpkin seeds	10.3 mg of zinc per serving of 100 g
Sesame seeds	10 mg of zinc per 100 g
Dark chocolate	6.8 mg of zinc per 100 g
Mushrooms	1.4 mg of zinc per 100 g Edible mushrooms
Spinach	0.53 mg of zinc per 100 g fresh spinach

Zinc-rich fruits recommended for daily consumption in order to get zinc are:

Avocados	- (1 mg zinc per cup)
Dried figs	-(0.82 mg of zinc per cup)
Dry prunes	-(0.77 mg of zinc per cup)
Tangerine	-(0.53 mg of zinc per 100 g)
Blackberries	-(0.53 mg of zinc per cup)
Raspberries	-(0.52 mg of zinc per cup)
Apricots	-(0.5 mg of zinc per cup)
Pomegranate	-(0.35 mg of zinc per 100 g)
Raisins	-(0.32 mg of zinc per cup)
Dates	-(0.32 mg of zinc per 3 dates)
Kiwi fruit	-(0.25 mg of zinc per cup).
Bananas	-(0.23 mg of zinc per banana)
Strawberries	-(0.23 mg of zinc per cup)
Cantaloupe	-(0.18 mg of zinc per 100 g)

Side effects of excess intake of zinc

Side-effects of excess zinc supplementation include nausea, vomiting, stomach pains, loss of appetite, headaches, and diarrhoea. Excess zinc can cause complications during pregnancy and breastfeeding.

Symptoms of zinc deficiency

The most common symptoms include: Change in appetite, digestive problems (most commonly, diarrhoea), unexplained weight gain or loss, low immunity, chronic fatigue syndrome, poor concentration and memory, slow wound healing, hair loss, worsened premenstrual syndrome symptoms in women, and infertility in men.

Zinc deficiency among vegetarian population and the causative factors

Total body zinc content in an adult human is estimated at about 2 g. Skeletal muscle accounts for approximately 60% of the total body zinc and bones account for approximately 30%. Plasma zinc has a rapid turnover rate and it represents only about 0.1% of total body zinc content. It is hard to believe that this metallic element, present in such a small amount, can be so vital to health and recovery from a variety of diseases.

Inadequate dietary intake of absorbable zinc is one of the major causes of zinc deficiency among population dependent on plant-based diets. Diets predominantly vegetarian, which are based on cereals and legumes, are composed of components that inhibit as well as enhance mineral bioavailability, the former being predominant. Bioavailability of micronutrients, particularly iron and zinc, is low from plant foods, being negatively influenced by various dietary components, which are inhibitors of their absorption. Among inhibitors, phytic acid, tannins, dietary fibre and calcium are the most potent ones.

On the contrary, organic acids present in our food are known to promote iron absorption. Food acidulants like *amchur* and lime are shown to enhance the bioavailability of not only iron but also of zinc. Besides food acidulants, recent researches have indentified newer enhancers of micronutrient (including zinc) bioavailability that include sulphur compound-rich *Allium* spices like onion and garlic, β-carotene-rich vegetables like carrot and amaranth, and pungent spices like red pepper, black pepper, and ginger.

The daily culinary practices in the preparation of a vegetarian meal involve several domestic processing methods such as heating (boiling, pressure cooking, microwave heating, roasting, etc.), sprouting, malting and fermentation. Processing generally brings about alterations in the food matrix as well as in the inherent components of foods, thus probably affecting the bioavailability of nutrients, including minerals such as zinc. Pressure-cooking and microwave-heating generally reduces the bioavailability of zinc from cereals and legumes. The reduction in zinc bioavailability from legumes upon pressure-cooking being more prominent among the staple cereals and legumes.

Food grains such as green gram, chickpea and finger millet are often subjected to traditional processing involving germination and fermentation. Fermentation of the batter of cereal-pulse combination (rice + black gram) in the preparation of '*Idli*' and '*Dosa*' enhances the bioavailability of zinc. Malted grains are extensively used in weaning and geriatric foods. Malting generally improves the nutrient content and digestibility of foods. Bioavailability of zinc from wheat and barley has been reported to enhance by more than 100% as a result of malting. However, malting reduced bioavailability of zinc from finger millet. Thus, malting could be an appropriate food-based strategy to derive more of zinc from food grains. The combination of various food ingredients as well as the culinary practices may thus have a significant influence on the bioavailability of micronutrients from plant-based diets.

Prevalence of zinc deficiency in India

Worldwide, approximately 30% of children below 5 years of age are stunted in growth, clearly pointing this out as a public health concern. It is estimated that up to 40% of Indian children suffer from zinc deficiency. A high prevalence of zinc deficiency (around 55%) has been reported among pregnant women. Even in the US, about 12% of the population is probably at risk for zinc deficiency, while up to 40% of the elderly may be at risk due to inadequate dietary intake and less absorption of this micronutrient.

Zinc fortification

Zinc fortification is recommended as an appropriate strategy to enhance zinc status in population. Zinc fortification of cereal flour is a safe and appropriate strategy for enhancing the zinc status of population who consume adequate amounts of fortified cereal flour and is likely to be effective in controlling zinc deficiency.

Interactions with medications

In order to prevent anaemia and osteoporosis, respectively, iron and calcium supplements are usually prescribed to pregnant mothers. Since both these minerals consumed at supplemental levels are reported to inhibit zinc absorption, the negative impact of supplemental iron and calcium on body's zinc status is a cause for concern. In addition to adversely affecting zinc status, supplementary levels of iron and calcium, also significantly interfere with the recovery of zinc status from zinc deficiency during repletion with normal levels of zinc in the diet. The negative effect of excess iron and calcium on zinc status, however, can be effectively countered when exogenous zinc is also provided (4 times the normal

Continued on page 20

Climate Change: Causes and Consequences

M.A. Haque

Earth's average temperature is 15°C, maintained by the atmosphere, which acts like glass/plastic sheet in the greenhouse. If it were not so, the Earth would be frozen, and life would not be possible here. However, with stronger greenhouse effect the Earth's temperature can rise, as has happened in recent past. Earth's average temperature is rising. This is called global warming, which is directly affecting Earth's climate.

Weather, climate and climate change

It is not possible for most of us to differentiate between weather and climate. Fluctuations in weather conditions are often considered as climate change, which is not correct because weather is a local and short-term phenomenon while climate is a long-term phenomenon observed over a much larger area. In 1966, the WMO (World Meteorological Organisation) coined the term "climate change" to include all climatic variability – both natural and anthropogenic – prevailing for more than 10 years. On the other hand, weather fluctuations may happen on day-to-day basis. It is difficult to perceive climate change through casual observations. Only long-term records can give an indication of climate change.

A general definition of climate change is a change in the statistical properties (principally the mean and spread) of the climate system when considered over long periods. Fluctuations over periods shorter than a few decades, like El Niño, do not represent climate change. The term is now used to indicate changes caused by human activities vis-à-vis the changes resulting from natural processes on Earth. In environmental policy, climate change is synonymous with global warming caused by human activities. Global warming refers to increase in the Earth's surface temperature while climate change includes everything affected due to increase in levels of greenhouse gases in the atmosphere.

Global warming

Earth is surrounded by air (atmosphere) consisting of several layers of gases. At 100 km above the sea level there is an imaginary line, Karman Line, that defines the boundary between the Earth's atmosphere and outer space. Sun's radiations pass through the atmosphere and reach the Earth, which heats up and emits infrared radiation. This emitted radiation travels up towards outer space, but Earth's atmosphere has certain gases called greenhouse gases, which restrict the passage of heat from Earth to space. The system works like a greenhouse. Greenhouses are enclosures with glass walls and roofs. Now-a-days plastic sheets have replaced glass for economy and flexibility. Sunlight enters the greenhouse and warms the inside. When the heat waves try to go out, glass or plastic restricts free passage. That is why the inside of a greenhouse it is warmer than the outside. Greenhouses are used to grow plants at high altitudes and in places where the night temperature drops too low. Greenhouses protect plants against chill. We also experience the greenhouse effect in our daily life. When a car or bus is parked in Sun with glass windows shut, the inside becomes hot because of greenhouse effect.

Earth's average temperature is 15°C,

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maintained by the atmosphere, which acts like glass/plastic sheet in the greenhouse. If it were not so, the Earth would be frozen, and life would not be possible here. However, with stronger greenhouse effect the Earth's temperature can rise, as has happened in recent past. Earth's average temperature is rising. This is called global warming, which is directly affecting Earth's climate.

Greenhouse gases

There are several gases that show greenhouse effect. The important ones are:

Water vapour: Water vapour is the naturally-occurring and most abundant greenhouse gas present in the atmosphere. Water evaporates from oceans, lakes, rivers, ponds, soil, living organisms, etc., and enters the atmosphere as vapour.

Carbon dioxide: This gas is produced naturally when living organisms perform respiration. Most living organisms utilise oxygen and produce carbon dioxide which enters the atmosphere. But green plants utilise carbon dioxide and produce oxygen during photosynthesis and acts as a natural sink for the gas. Also, volcanoes emit carbon dioxide into the atmosphere. Fossil-fuel burning, and manufacture of cement are other major contributors.

Methane: This gas is generated in the digestive system of ruminant animals like cattle, sheep, deer, antelopes, and giraffes. It is also generated in wetlands due to decomposition of vegetation. Also, methane is generated in paddy fields. When coal, petroleum and natural gas are used as fuel, methane is generated. Landfills can also generate methane. That is why there is occasional fire in landfills as methane is highly inflammable.

Nitrous oxide: Nitrous oxide is produced naturally and due to human activities. Oxidation of atmospheric ammonia is an important natural source. Also, nitrogen in soil forms the gas. Nitrogenous fertilisers used in agriculture also produce the gas. Some nitrous oxide is generated during the burning of fossil fuels, biomass and on decomposition of animal manure.

Ozone: This gas occurs naturally in the atmosphere. Ozone present in the troposphere influences climate change. Ozone in the troposphere, extending from the ground up to the height of 7 to 20 km above mean sea level, is formed in the presence of sunlight. Also, hydrocarbons and oxides of nitrogen from automobile emissions react in the presence of sunlight to form ozone gas at ground level.

Important natural factors triggering climate change

Volcanoes: Volcanoes are part of the lithosphere (outer part of the Earth), about 100 km in depth. During 1979 to 2010 aerosols released by two large volcanoes (El Chichón in Mexico and Pinatubo in the Philippines) influenced the atmospheric temperature. But scientists, including those from US Geological Survey say that human activities generate much more (about 100 to 300 times more) carbon dioxide than volcanoes.

Oceans: Oceans cover about 71% of the Earth's surface. They play an important role in deciding the Earth's climate. Ocean currents move water in specific directions and carry vast amounts of heat across the Earth. But the entire Earth is not influenced uniformly. For example, the Humboldt Current affects Peru and adjoining areas in South America, but El Niño, which periodically warms the sea surface in part of the Pacific Ocean, affects the entire Earth, including India, reducing rainfall.

Forest fires: During past few decades, the number of wildfires has increased, and more areas are burning. In future it is expected that wildfires could become several times more. In recent years, there have been big fires in Siberia and many other places around the world where typically large-scale wildfires were not common. The affected areas are those which have become drier and hotter, and where spring comes earlier. Drier conditions and higher temperatures also increase the duration and severity of the wildfires. IPCC (2007) observed that during previous two decades, forest fires in Asia increased largely due to rise in temperature and decline in precipitation along with increased land use.

Anthropogenic sources of greenhouse gases

Fossil-fuel engines: We can say that global warming started in 1712 when British inventor, Thomas Newcomen made the first easy-to-use steam engine. That event led to the Industrial Revolution leading to large-scale burning of coal. In 1861 an Irish physicist, Karl Benz built the first practical motor car with internal-combustion engine. Since then energy consumption and release of greenhouse gases into the atmosphere have continuously increased.

By 1927 that carbon dioxide from fossil fuels burning and industrial activities were about one billion tones/year. In 1938 a British (Guy Callender) claimed that Earth's temperature had gone up in 19th century due to carbon dioxide entering the atmosphere. By 1975 global warming came in focus because a scientific paper written by US scientist Wallace Broecker explained that humans were disturbing the climate by adding excess of carbon dioxide

into the atmosphere. By 1989 carbon emissions from fossil fuel burning and industries reached six billion tones/year."

Aerosols: Aerosols are both natural and anthropogenic, containing a mixture of sulphates, nitrates, ammonium, organic carbon, black carbon, sea salt, mineral dust, trace metals and water. Aerosol particles scatter and absorb solar radiation and modify the properties of clouds. Black carbon causes warming; other particles result in cooling. Aerosols are less persistent compared to greenhouse gases, having mainly regional effects. In fact, aerosol cooling has masked some of the global warming. In the long term, carbon dioxide is the main driver of climate change.

Agricultural activities: Fertiliser industries emit greenhouse gases. When chemical fertilisers are applied, nitrous oxide is released from soil. Livestock, especially cattle are responsible for almost one-third of methane emissions from the agriculture sector. Also, livestock manure adds methane and nitrous oxide to the atmosphere. Rice fields are another source of methane. Burning of crop residues emit methane, carbon dioxide and nitrous oxide. Thus, agriculture plays important role in causing greenhouse effect**.**

Deforestation: Directly, about 25% of the total greenhouse gases are released on account of deforestation. Forests are a major storehouse for carbon dioxide. Scientists say that carbon dioxide stored in the forests is more than double the amount present in the atmosphere. When any area suffers deforestation not only is a large carbon sink destroyed but the carbon dioxide locked in the vegetation is also released.

In India, deforestation has been going on for centuries. During the colonial rule, exploitation of the forest resources was the maximum. Even after Independence the trend did not reverse. Industrialisation, urbanisation, infrastructure development, etc., have contributed substantially. In certain areas, slash-and-burn agriculture has been going on historically. In past the cycles were long to allow regeneration of the forests. With time the cycles shortened resulting in rapid deforestation.

Recently a new issue is there: crop residue burning. Changes in harvesting techniques leave residues which find no use. The farmers burn them in the fields, adding greenhouse gases and other pollutants to the atmosphere. UP, Punjab and Haryana contribute substantially. The issue comes into focus almost every year. Globally too, biomass burning contributes several times more greenhouse gases compared to natural forest fires.

Destruction of coral reefs and mangroves: Coral reefs, present in shallow waters of the tropical areas store about 2.4 kg per m^2/year calcium carbonate on average as the shells of corals are made of calcium carbonate. The Great Barrier Reef (Australia) collects about 50 million tonnes of calcium carbonate/year. Globally the production of calcium carbonate is about 900 million tonnes per year. Thus, coral reefs act as sink for about 111 million tonnes of carbon/year. In recent years, coral reefs have been getting destroyed due to human activities, e.g., dumping of wastes, acidification of water, navigation and mining of corals for calcium carbonate, etc.

Mangrove forests also capture carbon dioxide through photosynthesis reducing the greenhouse effect. However, mangroves are being devastated in many areas, especially in poor countries hampering their positive role in mitigating climate change.

A few consequences of global warming

Melting of glaciers and ice: According to WMO (World Meteorological Organisation), 2016 was recorded as the hottest year till now, 1.2°C above the pre-industrial baseline. Global warming is a potential threat for the two Poles. Satellite observations indicate that areas covered with snow and ice in the Northern Hemisphere are decreasing. In the Arctic region the impact of climate change is double than the Earth's average. Very recently in February 2019, a Russian town declared an "emergency" after more than 50 hungry polar bears invaded a town in the archipelago of Novaya Zemlya, which stretches into the Arctic. The bears generally hunt seals in the Arctic. As the Arctic ice is thinning due to climate change, the animals, mad for food, move ashore closer to human populations. Models suggest that Arctic sea ice is declining at about 13% per decade.

Some environmentalists, however, consider melting of snow and glaciers as an opportunity. Agriculture may become possible in areas presently covered by snow or ice. Places cut-off during the winters will become more accessible. Melting of ice may render navigation easier in Antarctica and the Arctic, and distances will be reduced. Exploration of gas, oil, minerals, etc., in those areas

will become easier and economical. But more important issue is that global warming will result in multiplicity of problems, which cannot be compensated by such small benefits. Also, people who may benefit will not be those suffering the most.

Impact on Himalayas: The Himalayan range is a big resource provider to several countries. The temperature in the Himalayas is rising faster than the global average. During the last one century the Earth's average temperature has gone up by less than 1°C while certain regions in the Himalayas have experienced a rise of 0.6°C in only the last one decade. This will adversely affect life in the region and the economy. There may be shortage of water in the Himalayas and downstream. Floods may be more frequent as the quantity of melt water will fluctuate drastically.

Sea level rise: It is certain that global warming will cause sea level rise. Some regions will be affected more. By the end of 21st century, ocean warming will be about 0.3° to 2.0°C, causing volume expansion and resulting in water level rise. Another factor will be the melting of ice and snow. Ice in Antarctica and Greenland is already melting, and more water is being added leading to swelling of the oceans further. Estimates suggest that in recent times around 159 billion tonnes of ice are being lost every year. By the end of the current century the global glacier volume, excluding peripheral glaciers of Antarctica may decrease by 15 to 85%. During 2015 the level of Arctic sea ice was the second lowest in history. Some scientists believe that the entire Arctic ice may melt by 2050. Rapid melting of the Arctic ice has great potential to devastate. There will be rise in sea level, threatening coastal areas and islands. Number of people affected may go to hundreds of millions.

Evidence indicates that the average global sea level rise was 1.7 mm/yr during the period from 1901 to 2010. During the period 1971-2010 the rate became 2.0 mm/yr and between 1993 and 2010 the rate was 3.2 mm/yr. Tt is expected that there will be greater rise in future. By the beginning of the next century sea levels may go up by 20 to 40 cm. If the ice sheet in Greenland melts completely, sea level may rise by as much as 7 m. According to IPCC, the sea level rise will not be uniform all over. But by the end of the 21st century more than 95% of the oceans may rise. Also, it is projected that 70% of coastlines will experience sea level changes.

Marooning of coastal areas will displace millions; Bangladesh and Netherlands will be worst victims. Sea level rise will also intensify the storms. During 1960 to 1969 less than 20 instances of floods and severe storms were recorded in Southeast Asia. During 2000 to 2008 the number reached 120, i.e., a six-fold increase. Intrusion of sea water will create further aggravate water scarcity in coastal areas. In this regard it may be mentioned that of the ten largest cities of the world, eight are close to the coasts. Also, world over more people have been settling along low-lying coastal areas. In 1990 the number was 538 million. In 2010 the estimated number was 724 million, i.e., a 34% increase.

Water availability: Many parts of the world suffer from water scarcity. Climate change can intensify the problem. There will be more rains in some regions while others will get less. Also, the rainfall will be more erratic, resulting in floods or droughts. It is projected that the runoff will reduce for all the Indian river basins except for Narmada and Tapti. Already a decrease of between 6 to 8% in monsoon rainfall has been observed in the Northeast, parts of Gujarat and Kerala and eastern Madhya Pradesh. Also, the glaciers – an important source of fresh water – are being adversely affected. Even if the present targets about climate change are achieved, at least one-third of the glaciers in the Himalayas will face melting by the end of the 21st century. If the goals are not met, and greenhouse gas emissions continue as at present, the Himalayas may lose about two-thirds of its glaciers by the end of the current century. Himalayan glacial retreats will impact flows in perennial rivers like Brahmaputra, Ganges and the Indus.

Already a large part of India is water-deficient. Rising temperature will aggravate the problem further. Reports suggest that the Indo-Gangetic plain will face severe droughts if conditions do not improve. A group of Indian, Chinese and University of Cambridge scientists has concluded that extreme wet events and droughts may become more frequent. Another study has indicated that in the Indo-Gangetic plain, the probability of a drought was 45%. Cereal production is declining in the area since 2000 due to expansion of drought-affected areas from 20% and 25% to 50% and 60% respectively before and after 2000. The study included Haryana, Uttar Pradesh, Uttarakhand, Chhattisgarh, Bihar, West Bengal and parts of Madhya Pradesh and Odisha. Obviously, it will have serious implications.

Impacts on farming: Most of the global food comes through agriculture. According to scientists all over the world, climate change will make it difficult for plants, animals and even people to survive in their own habitats. Also, changes in weather conditions will adversely affect crops. Wheat and rice grow better in warm environment but maize and sugarcane cannot grow at high temperatures. Also, the crops require different degrees of rainfall. Climate change will alter the temperature regimes, and rain patterns resulting in failure of crops. Changes in the rainfall patterns will result in flooding of certain areas while others will face drought. We are already observing that floods and droughts regularly destroy crops in different parts of the world, including India. The problem will become more intense with time.

Indian Agriculture Research Institute (IARI) has confirmed that the impact on agriculture will vary greatly, region to region and on the crop type. Also, there will be boundary changes for certain crops. But rain-fed agriculture will be affected more. It

may be mentioned that in India and many other countries rain-fed agriculture accounts for high percentage of production.

There are some general conclusions. A temperature rise of about 2°C could reduce grain yields in wheat in most places. Wheat contributes more than 20% of the total food grains globally. More than 80% of the productions are utilised in the developing countries, locally. In India wheat contributes more than 35% of the total grains produced. If conditions remain as they are, climate change could reduce production by 6 to 23% by the year 2050 and by 10 to 40% by the end of the current century. For the Indo-Gangetic Plains, which is a major producer of wheat, heat stress will be important. Central and south-central regions of India with warmer climates are likely to suffer more. Another report says that temperature rise will adversely affect global food production, but India would be the hardest hit. Crop yield in India, the second largest producer of rice and wheat, would fall by up to 30% within a decade or so. According to US-based Universal Ecological Fund, higher temperatures will affect world agricultural output, but India will be worst hit.

Temperature rise will affect rice production as well; with maximum impact in eastern India. With reduced sunlight and higher temperature, the number of grains per plant will reduce and the grains will not be healthy. Rice plants become sterile (without grains) if exposed to 35°C or above for more than an hour during flowering season. Also, the International Rice Research Institute has concluded that there will be about 20% reduction in rice yield for every 1°C rise in temperature. Total yield may drop by as much as 30% within a decade.

Climate change can also affect soil properties. Increased temperature will decompose soil organic matter faster and more nutrients will become available. Plants may grow faster but with long-term nutrient deficiency. Faster growth of plants can also exhaust available water, triggering drought conditions. Also, pathogens, weeds, and pests, etc., will proliferate faster at higher temperatures.

Impact on plants and animals: Life on the Earth has been continuously changing with changing environment. Minor changes may not make substantial difference, but major changes could finish groups of plants and animals. We find fossils of large numbers of extinct plants and animals caused by environmental changes.

Change in the climate of an area affect temperature and rainfall patterns, important factors for plants and animals. The prevalent life on Earth took millions of years to adapt. If human-induced climate change is forced upon these organisms, there will be adverse implications. Organisms may disappear partially or completely, or they may change their habitats. If they cannot find suitable alternative habitats, they will be finished. Certain species of plants and animals are already responding to higher temperatures by moving to cooler areas. It is being suggested that climate change can result in extinction of about 25% of birds, animals and plants. Climate change also alters the life cycles of plants and animals. Changes in bird migration and pattern of flowering in plants, etc., have been recorded in recent years. For animals, changes in breeding time, migration time, spring appearance, etc., have been observed. In certain birds return migration is absent. They continue at the places of nesting.

Impact on human health: Humans will also be directly affected by climate change. People living in certain regions will face greater risk. Migration of population from coastal areas to inland will cause crowding inland, impacting all facets of life, including health.

Meteorological parameters like humidity, rainfall and temperature effectively influence transmission and intensity of infectious diseases. In 2007 the IPCC had warned that climate change could expand vulnerable areas for infectious diseases such as dengue, diarrhoea, etc. For developing countries, spike in diarrhoeal infections, cholera, dysentery and typhoid will be of great concern. Warmer climate will help many bacteria to survive longer, spreading diarrhoea, cholera, cryptosporidiosis, giardiasis and salmonellosis, etc. Even at present about 25% deaths of children in South Asia are caused by diarrhoeal diseases. Warmer climate will aggravate the problem. Floods in Bangladesh, India, etc., are generally linked with outbreaks of diarrhoea and infectious respiratory diseases. Also, leptospirosis and rotavirus have shown links with floods. Flood waters contaminated with municipal waste help spreading of various diseases caused by bacteria and viruses. Scarce clean water and inadequate sanitation facilities are important health factors. Increased pressure on water availability due to climate change will lead to greater problems.

Malaria is a serious problem in many parts of the world, including India. More than one million deaths are reported annually. Changes in temperature, humidity, rainfall and lower immunity levels can increase incidence of the disease due to mosquito population growth and better development of the parasite (*Plasmodium*). If temperature rise continues, malaria is likely to move towards higher altitudes and latitudes, putting greater number of people at risk. There are various other mosquito-related diseases like chikungunya, dengue, filariasis, etc., endemic to South Asia. Also ticks spread diseases. Their intensity may change, and geographical distributions may alter due to Climate Change. Similarly, rickettsial diseases, transmitted by lice or ticks will increase.

Another important issue is the Zika virus, generally spread by mosquitoes. Certain studies suggest that the sudden spread of the virus in past could be linked to climate change. Also, in case of H1N1 virus, commonly called Swine Flu, climate change has been linked to faster spread of the disease. The disease has caused serious concerns in India too. ■

Recent Developments in Science and Technology

Biman Basu

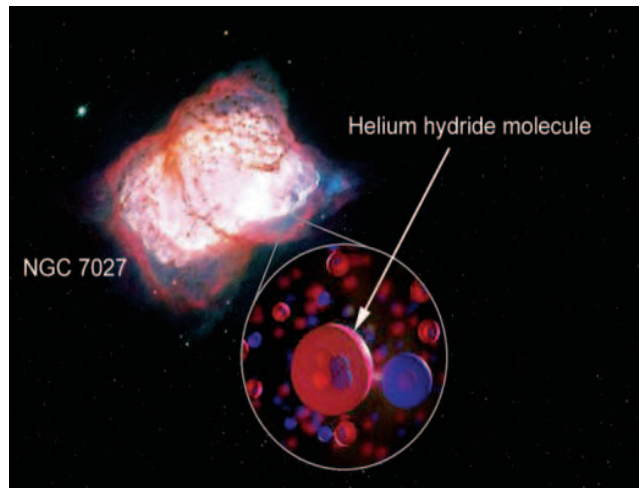
Renowned virologist and clinical scientist Dr Gagandeep Kang has become the first Indian woman to be elected a Fellow of the Royal Society (FRS) in its 360 years of history. Known as India's vaccine "God Mother", Dr Kang is known for her interdisciplinary research studying the transmission, development and prevention of enteric infections and their effect among children in India. She has pioneered work on safe and effective rotavirus vaccines that are now being used to prevent disease in Indian children and which will soon be used in vaccination programmes around the world.

Astronomers find first molecule of the universe

It is now well established that our universe was created in a Big Bang some 14 billion years ago. Astrophysicists have conjectured about what happened after the Big Bang and a tentative scenario is available. It is believed that when the universe was created in the Big Bang, it was so hot only a few atoms existed – largely hydrogen and helium atoms; molecules came later. As the universe cooled, helium ions combined first with free electrons to form the first ever neutral atom of helium. At that time hydrogen was still ionised (present in form of free protons). In course of time, helium atoms combined with these protons to form a molecular ion – the helium hydride ion (HeH^+), forming the universe's first molecular bond, probably some 100,000 years after the Big Bang. As recombination progressed, helium hydride ions reacted with then neutral hydrogen and created a first path to the formation of molecular hydrogen – marking the beginning of the modern universe, with its stars, galaxies and planetary bodies. Scientists believe helium hydride to be the first ever molecule, dubbing it the "primordial molecule".

The helium hydride ion or helium-hydride molecular ion is a positively charged ion formed by the reaction of a proton with a helium atom in the gas phase, first produced in the laboratory in 1925. It is isoelectronic with molecular hydrogen that is, the two have the same number of electrons. helium hydride ion is the strongest known acid, and it has been suggested since the 1970s that it should occur naturally in the interstellar medium.

Despite its importance in the history of the early universe, however, helium hydride molecule had so far escaped detection in space, although scientists were



The helium hydride molecule, long known to exist in the lab and long thought to be present in space under the right temperature conditions and in the presence of the right elements, has finally been detected: in the planetary nebula NGC 7027. It has not, however, been found as a relic from the early Universe, where it likely existed but was quickly destroyed. (Credit: NASA/SOFIA/L. Proudfit/D. Rutter)

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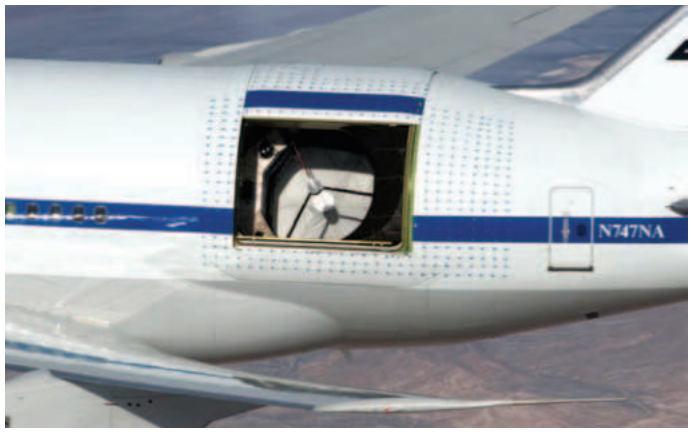


Stratospheric Observatory for Infrared Astronomy (SOFIA) with open telescope doors, showing a German-built telescope inside which detected helium hydrate in NGC 7027. (NASA)

able to create the molecular ion in laboratory in 1925, by coaxing the helium to share one of its electrons with a hydrogen ion, the molecule was extremely short-lived. Now, operating the GREAT (German Receiver for Astronomy at Terahertz Frequencies) far-infrared spectrometer onboard the flying observatory SOFIA, an international research team led by Rolf Güsten from the Max-Planck-Institut für Radioastronomie (MPIfR) in Bonn, Germany, has reported the unambiguous detection of the molecule towards the planetary nebula NGC 7027 (*Nature*, 17 April 2019 | DOI: 10.1038/s41586-019-1090-x). "This brings a long search to a happy ending and eliminates doubts about our understanding of the underlying chemistry of the early universe," said Rolf Güsten of the Max Planck Institute and lead author of the study, in a statement.

SOFIA, the Stratospheric Observatory For Infrared Astronomy, is a Boeing 747SP jetliner modified to carry a 2.69-metre-diameter telescope. It is a joint project of NASA and the German Aerospace Centre, DLR and was instrumental in the detection of helium hydride molecule – the first type of molecule that ever formed in the universe. The molecule has been detected in space for the first time, after decades of searching. As SOFIA flew high above the Earth's surface and pointed its sensitive instruments out into the cosmos, the scientists discovered the signature of helium hydride molecule in our own galaxy.

SOFIA detected helium hydride in a planetary nebula, a remnant of what was once a Sun-like star. Located some 3,000 light-years away near the constellation Cygnus, this planetary nebula, called NGC 7027, has conditions that allow this mystery molecule to form. The discovery serves as proof that helium hydride can, in fact, exist in space. Scientists say, this confirms a key part of our basic understanding of the chemistry of the early universe and how it evolved over billions of years into the complex chemistry of today.

Helium hydride is a finicky molecule. Helium itself is a noble gas making it very unlikely to combine with any other kind of atom although under certain circumstances it can combine with hydrogen to form helium hydride molecule. However, it did not survive long, even in the unique conditions of the early universe. Nevertheless, it played a brief but important role: Helium hydride's destruction gave rise to molecular hydrogen (H_2), which eventually permeated galaxies and led to the formation of the first stars. The existence of helium hydride is thus instrumental to understanding the chemical evolution of the early universe.

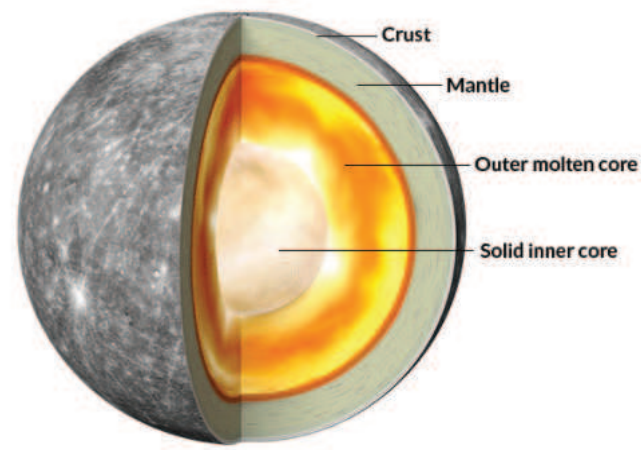
Mercury has a massive solid inner core

Astrophysicists often use innovative methods to learn about the inner structure of planets even without landing a probe on them. Recently, based on analysis of data from its *MESSENGER* (*ME*rcury *S*urface, *S*pace *EN*vironment, *GE*ochemistry and *R*anging) mission, NASA announced that the solar system's smallest planet Mercury has a massive solid inner core. *MESSENGER* ended its mission in 2015, but the data collected by the craft on the spin and gravity of Mercury is still being analysed and is throwing up new findings. The *MESSENGER* spacecraft spent four years observing Mercury. Data from the NASA craft's last days suggest Mercury has a solid inner core about 2,000 kilometres in diameter, making up about half of Mercury's entire core (*Geophysical Research Letters*, 10 April 2019 | doi: 10.1029/2018GL081135). In contrast, Earth's solid core is about 2,400 kilometres across, taking up a little more than a third of this planet's entire core.

According to NASA, the inner structure of a planet can be determined by observing "the way the planet spins" and then measuring how the "spacecraft orbits it – very, very carefully". This is exactly what the NASA planetary scientists did. As the *MESSENGER* spacecraft orbited the tiny planet, the probe pinpointed the poles that Mercury rotates around. One of the spacecraft's instruments also carefully measured small variations in local gravity.

It was earlier known that Mercury's core was huge, taking up about 85 percent of the planet's total volume. The idea that the planet's core was at least partially liquid came from radar observations made from Earth in 2007 which showed small variations in Mercury's spin rate. Then *MESSENGER* data revealed that the planet has a weak magnetic field generated by circulation of molten metal in that liquid core. But it was not clear if Mercury, like Earth, also has a solid inner core.

To study Mercury's inner structure, *MESSENGER* measured the distribution of



Of the rocky planets, only Earth and Mercury still have magnetic fields generated by their cores. Such fields can shield planets from being battered by charged particles constantly streaming from the Sun. (Credit: NASA's Goddard Space Flight Centre)

mass within the planet by tracking tiny shifts in the spacecraft's orbiting speed caused by subtle variations in gravitational pull. Those minute variations cause a spacecraft to speed up or slow down, just a bit, resulting from the presence of patches of the planet that are more, or less, dense than the average. These observations were particularly detailed near the end of the spacecraft's mission, when engineers sent the probe as close as 105 kilometres above the planet's surface, before crashing it deliberately on it.

As *MESSENGER* got closer to Mercury's surface, scientists were able to extrapolate how the spacecraft accelerated under the influence of the planet's gravity. The researchers then put all that data into a sophisticated computer program. The results detailed the interior composition of Mercury. The program showed that Mercury must have a large, solid inner core of about 2,000 kilometres diameter.

Now, the researchers are hoping to find even more discoveries about Mercury in *MESSENGER*'s archives.

Gagandeep Kang becomes the first Indian woman FRS

Renowned virologist and clinical scientist Dr Gagandeep Kang has become the first Indian woman to be elected a Fellow of the Royal Society (FRS) in its 360 years of history. A professor at the Vellore Christian Medical College, Dr. Kang is currently on a sabbatical, and is working as the executive director of Translational Health Science and Technology Institute in Faridabad. She is among the 51 eminent people elected as fellows of the Royal Society this year, which includes another Indian, Dr. Yusuf Hamied, chairman, Cipla.

Known as India's vaccine "God Mother", Dr Kang is known for her interdisciplinary research studying the transmission, development and prevention of enteric infections and their effect among children in India. She has pioneered work on safe and effective rotavirus vaccines that are now being used to prevent disease in Indian children and which will soon be used in vaccination programmes around the world. Kang has been working on diarrhoeal diseases for close to three decades and has helped develop Rotavac, India's first indigenous vaccine against the rotavirus that causes severe diarrhoea and is responsible for

Dr Gagandeep Kang, first ever Indian woman Fellow of Royal Society.

the death of 80,000-100,000 children in the country every year. The vaccine was first identified by researchers at the All Indian Institute of Medical Sciences (AIIMS) in New Delhi way back in 1985. Since then, with over $100 million in funding – including that from the Indian government and the Bill and Melinda Gates Foundation – it is now part of India-approved vaccines.

Born in 1962, Gagandeep did her MBBS from Christian Medical College in Vellore. After doing her MD in microbiology, she did not want to do routine research, so she decided to get into a place where she has different challenges every day and went to join a research group at the Christian Medical College and stayed there.

Kang says she was drawn to rotavirus research largely by accident. When she began research in microbiology as a faculty member, she discovered that one area that no one was interested in was diarrhoeal diseases; everyone else was studying much more glamorous things. So, she decided to study diarrhoea. She says in diarrhoea no one was studying viral gastroenteritis because it is much harder to do than studying diarrhoea caused by bacteria. That's how she got interested in the rotavirus.

Rotavac, the rotavirus vaccine that she helped develop, is an oral vaccine. But it has been known that oral vaccines are less effective in developing countries like India. Kang says despite being part of an eight-country study for about 10 years, no explanation has been found yet. Maybe it depends on "the overall effect of how children grow, how their gut functions, and their immune responses to vaccines".

Kang says so far, in India, there has never been an impact assessment study of a newly introduced vaccine and that is what is being done now – a large-scale safety and effectiveness study of the Rotavac is on, with the idea of measuring impact. She says the data will be ready early next year. "It's the first time this is being done in the country".

Zinc: the essential micronutrient (continued from page 28)

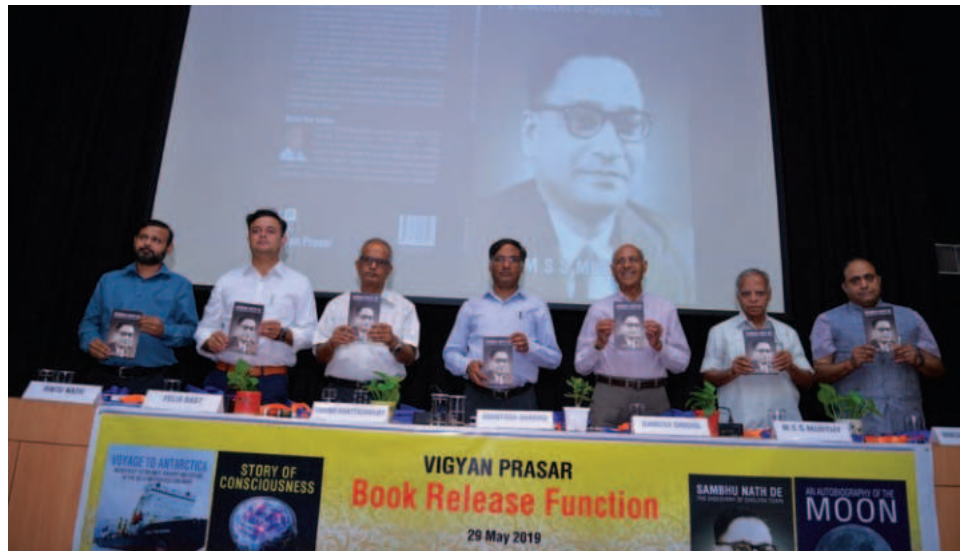
level) along with iron and calcium. It would therefore be prudent to recommend that whenever supplements of iron and calcium are prescribed, they should be accompanied with prescription of zinc supplements too.

Conclusion

Though needed in trace amounts, zinc is an important micronutrient for a strong immune system, healthy skin, insulin production and regulation, digestion and regulation of energy metabolism. Zinc also plays a powerful role in the preventing of diseases such as secondary complications of diabetes and cancer, learning, memory, and healthy brain function. Though present in a small amount in the body, zinc can be vital to health and recovery from a variety of diseases. Effects of its deficiency can be widely felt in many ways. Inadequate dietary intake of absorbable zinc is one of the major causes of zinc deficiency in population predominantly dependent on plant-based diets. It is important to include adequate zinc in our daily diet by wisely choosing its good sources. Prudent cooking practices and use of ideal combinations of food components can significantly improve zinc bioavailability from plant-based diets, which are otherwise compromised due to the presence of potential inhibitors of its absorption. ■

Book Release

Four popular science books published by Vigyan Prasar, titled (i) *Voyage to Antarctica* by Dr. Felix Bast, (ii) *Story of Consciousness* by Dr. Govind Bhattacharjee, (iii) *An Autobiography of Moon* by Dr. Ramesh Shishu, and (iv) *Shambhu Nath De – Discovery of Cholera Toxin* by Dr. M.S.S. Murthy, were released by Prof. Ashutosh Sharma, Secretary, Department of Science and Technology, at a function held at Indian National Science Academy (INSA) on 29 May 2019.



From left: Dr. Rintu Nath, Dr. Felix Bast, Dr. Govind Bhattacharjee, Professor Ashutosh Sharma, Dr. Ramesh Shishu, Dr. M.S.S. Murthy, Dr. Nakul Parashar

Prof. Sharma, who was present as Chief Guest, said popular science books serve a very important purpose of science communication. He pointed out that the efforts of Shambhu Nath De in discovering the cholera toxin are not known in his own country. The book on Shambhu Nath De may help change that situation. Prof. Sharma said that the book *Voyage to Antarctica* is an authentic popular science book on Antarctica. He said, the book *Story of Consciousness* explains how human consciousness has evolved over millions of years, marking a paradigm shift in the journey of mankind from the physical to the mental, a shift that would henceforth determine the onward march of civilisation. The book, *An Autobiography of Moon* has a nice storytelling format, where, the Moon is telling its interesting characteristics to the readers. The book will be attractive to young readers, Prof. Sharma said.

Addressing the gathering, Director, Vigyan Prasar, Dr. Nakul Parashar said that the primary focus of publication of books is to popularise science and take the message of science to the society.

Dr. Rintu Nath, Scientist F, and Head, Publications and Information Technology Group, spoke about the publication program of Vigyan Prasar and shared his experience in publishing these four books.

Voyage to Antarctica chronicles Dr. Felix Bast's first-hand experience during the expedition to Antarctica as part of the 36th Indian Scientific Expedition to Antarctica (ISEA) that he undertook during 2016-17. This book narrates the Antarctic expedition chronologically right from the inspiration for undertaking the expedition, acclimatisation training in the Himalayas and so on till many months after the completion of the expedition to assess the effect of the expedition on the author's personal and professional life. While the book is about Indian expedition, it thoroughly covers Antarctica in the international arena, explains the past, present, and future of the continent, and the science behind a number of the natural phenomenon of Antarctica and would arguably serve as the most authentic popular science book on Antarctica yet.

A section of the audience at the book release function

Story of Consciousness book focusses on multiple disciplines like biology, neuroscience, psychology, semiotics, linguistics, philosophy and even theology related to human consciousness. This book is third of the trilogy following *Story of Universe* and *Story of Evolution*. It is a story about the evolution of human consciousness and its impact on the growth of human civilisation.

An Autobiography of Moon deals with a lot of those secrets like its origin, how it changes its shape daily, why only half of it can be seen, and lots more. Especially discussing all these difficult things in an autobiographic style will make this book more attractive to young readers.

The book on Shambhu Nath De is about the great inventor S.N. De, who contributed significantly in identifying the cause of cholera and find ways to get rid of the disease to save our society. Life and works of this great scientist are discussed in this book with some unknown side and untold stories. ■