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Jagadis Chandra Bose and His X-ray Research

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

Important Lessons on S&T Communication from the Other Side of the Atlantic

Dr. R. Gopichandran

I seem to be good at procrastination. Ironically I also learn my lessons and do my best to not postpone action as I progress on a daily basis. However at times, some challenges blind me to the schedule and this month's submission is a typical case in point. The kindness and persuasion of my colleagues in publishing DREAM 2047 created the window of opportunity to reorganize myself and deliver this editorial in double quick time. Million thanks to them indeed.

An equally emphatic thanks to some robust minds engaged in science communication in Canada I had the chance to interact with, this month, during recent efforts to consolidate India Canada bilateral links on science and technology. I deem it an honour because of the veracity they exhibited and their track record in communication. These included heads and other representatives of the Canadian Science Writers Association, researchers at the Laurentian University, Canada Agriculture and Food Museum, Canada Aviation and Space Museum and the Canada Science and Technology Museums Corporation. The common message from all of them was the need to enhance spread and depth of communication for greater public engagement. They wish to elicit appropriate responses from citizens in Canada to influence trajectories of science and technology with implications for value added services in agriculture, energy etc. The focus on methods of science through advances in aviation, origin and development of technologies in many spheres through an understanding of artefacts, training of teachers in STEM education appear to be equally important elements of engagement. These interests converge on the larger agenda to empower citizens on related aspects and hence a purpose that is common to India's efforts on science popularization, to a large extent.

The opportunity to engage with the specialists from the stated institutions came as part of preparations to consolidate outputs and outcomes through India Canada bilateral cooperation on science and technology forward. Science communication is an integral part of the coming together and is set to build on each other's strengths. The common interest to foster learning and awareness for action on the interface of science, technology and society with implications for sustainable development was palpable. This creates the context to communicate about principles and methods of science, heuristics and applications with an equal emphasis on continually evolving progress / output from science and technology research institutions in both countries. Science & technology communication activities cannot ignore the latter any more.

Can I justify the delay in submitting this editorial just by articulating the above? I went ahead and asked if calls for comparable action can be cited. I am happy to indicate some such parallels.

- Professor Les Field Secretary for Science Policy, Australian Academy of Science[1] recently highlighted the need to create and strengthen a grounds well through the public to draw attention to the need to foster developments in science. Communication should enhance awareness of science across all levels in the community.
- Baruch Fischhoff[2] in his paper refers to the May 2012 Sackler Colloquium on "The Science of Science Communication". Four important tasks to help fulfil the mission of science communication have been presented with the much needed scope for synergies between subject matter scientists, decision scientists, social and behavioural scientists and communication practitioners. Trust and robust channels of communication appear to be equally important in this context.

I will submit this editorial at this point and not test the patience of my colleagues any further. I do not want to derail this publication. Much as I delayed the submission I have also tried to compensate by attempting to assist the discerning communicator to capture some important leads in the field of science communication. I hope you find this useful.

References (gathered on 16 June 2015) from:

1. https://www.science.org.au/sites/default/files/user-content/documents/emcr-forum-science-pathways-2015-program.pdf
2. http://www.pnas.org/content/110/Supplement_3/14033.full.pdf+html

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Jagadis Chandra Bose and His X-ray Research

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That Jagadis Chandra Bose (1858-1937) discovered microwaves and the story that he demonstrated the use of microwaves by firing a pistol located at some distance away at the Town Hall in Calcutta (now Kolkata) in 1895 before the then Lt. Governor William Mackenzie are well known. His work on plant physiology showing that plants respond to external stimulus is also well known. What is less known is that Jagadis Chandra was the first person in India who produced X-rays using an apparatus built ingeniously by himself.

In the winter of the same year, Wilhelm C Roentgen, a German physicist working in the University of Wurzburg was investigating the properties of cathode rays using Crookes tube. He noticed that every time he produced cathode rays by applying a high voltage spark using a Ruhmkorff coil, there was a fluorescence observed on a barium platinocyanide screen located at some distance away in the laboratory. He kept himself engaged for the next six weeks to understand this mysterious phenomenon. Three days before Christmas, he brought his wife to the laboratory and took a photograph of her hand with the ring using these mysterious rays. Unable to understand exactly what it is, he called this ray X-ray. Thus X-ray was born. Roentgen announced the news on 28 December 1895. From the beginning of 1896, the news of the discovery started being published in all the leading newspapers of Europe and America. A young Indian scientist read about this fascinating discovery with immense curiosity and decided to investigate more about this new ray. He was none other than Jagadis Chandra Bose. With his exceptional acumen in devising apparatus he decided to build an X-ray apparatus on his own. He was then Professor of Physics at Presidency College, Calcutta. He built the apparatus within a year of the announcement of X-ray discovery. Incidentally, Jagadis Chandra called the X-ray machine '*Roentgen kol*'; *kol* in Bengali meaning 'machine'.

It will not be out of place here to mention that Father Lafont (1837-1908) of St. Xavier's College, Kolkata, brought a Crooke's tube from Europe in 1879, at a time when vigorous research was in progress in Europe using the device. Along with Dr. Mahendralal Sircar, founder of Indian Association for the Cultivation of Science, Calcutta, he initiated studies on discharge of gases in Crooke's tube. Incidentally, Crooke's tube is a partially evacuated tube with two electrodes, when a sufficiently high voltage is applied using Ruhmkorff coil between the two electrodes, a discharge occurs. Whether Jagadis Chandra used the Crooke's tube of Father Lafont or not is not known.

Fig.1. Jagadis Chandra Bose

There exists some reports mentioning Jagadis Chandra Bose building an X-ray apparatus before any X-ray machine was imported to Kolkata, possibly in India, but there is hardly any document available describing his apparatus or any photograph of his apparatus. As a result, we were completely in the dark about the look of his X-ray machine, whether it was different from the apparatus used by Roentgen, his idea about the photographic screen etc., till we were able to locate a Press Report titled "Professor Bose and the New Light" published in 5th May edition of the English Newspaper *The Amrita Bazar Patrika* (now extinct) of 1898. In the absence of the machine that he used or any of diagrams of the apparatus, we have tried to draw a schematic diagram of the X-ray machine Jagadis Chandra probably designed, based only on the press report published in *The Amrita Bazar Patrika*. This will, at least, give an impression of his ingenuity.

As mentioned earlier, Roentgen used Ruhmkorff coil as a source of transient high voltage in discharging the gas in the Crooke's tube. Ruhmkorff coil is an induction coil that produces high-voltage pulse in the secondary coil by electromagnetic induction when a direct current supply in the primary coil is interrupted by a mechanical contact. Every time there is an interruption there is a high-voltage pulse in the secondary coil. This secondary coil is connected with the discharge tube (Fig.2). When the voltage applied to the discharge tube is of the order of few kilovolts or more, cathode rays (electrons were then unknown) are accelerated to a sufficiently high velocity so that X-rays are produced when those electrons hit the anode or the

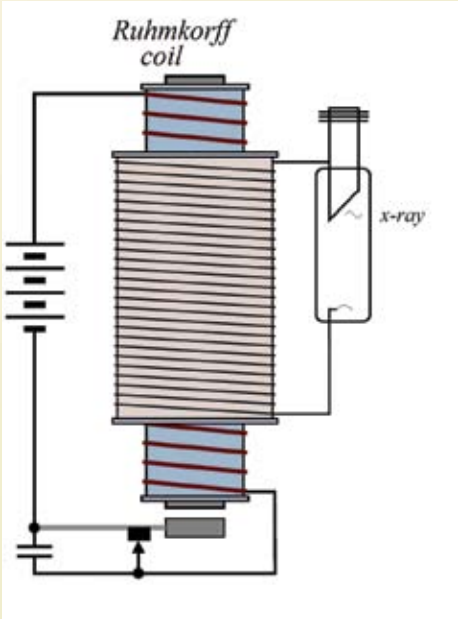

Fig.2. Schematic diagram of X-ray apparatus using a Ruhmkorff coil as a high-voltage source as was used by Roentgen.

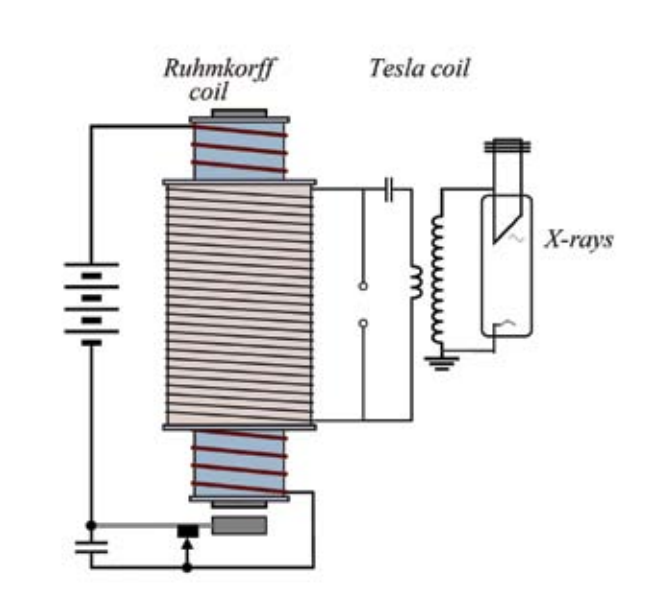

Fig.3. Schematic diagram of X-ray apparatus in which a Tesla coil coupled with Ruhmkorff coil used as a high-voltage source, as was possibly used by Jagadis Chandra Bose.

glass wall of the tube. Figure 2 represents the schematic diagram of the X-ray apparatus Roentgen used in which a Rhumkorff coil was used to produce discharge in the gas which subsequently produced X-rays.

The ingenuity of Jagadis Chandra led him to improve upon the Roentgen's machine by coupling a Tesla coil with the secondary of Ruhmkorff coil (which then acts as the primary of the tesla transformer), which produced a higher voltage, many times more, than that can be produced using a single Ruhmkorff coil (Fig. 3). The increase in the high voltage produced more energetic and more intense X-rays. The press report mentioned that the new arrangement increased "its power enormously and hence it is evident the new arrangement cannot but yield excellent results."

Encouraged by its application in medicine to identify defects in bones, Jagadis Chandra used his X-ray apparatus for radiological purposes to study fractured or broken bones in human body which is evident from a letter he had written to Rabindranath Tagore. In one of his letters to Rabindranath Tagore he mentioned that he has to be present at Presidency College at eight in the morning to investigate a patient who has broken his back, using the Roentgen *kol* (machine). It is believed that the letter was written sometime in February 1898. The press report published in 1898 also reported, "We were shown a photograph of human palm taken by the Professor with the new light, and the ghastly sight will long be vividly imprinted in our memory, for there, in the photograph, instead of the ordinary fleshy palm is seen depicted a long range of bones presenting a skeleton-like appearance."

Roentgen observed the image of an object on a screen coated with barium platinocyanide. Reading a newspaper account of Roentgen's discovery Jagadis Chandra set a young research assistant to prepare barium platinocyanide screens with which he took X-ray photographs of different objects like a human hand, coins placed in a purse, etc. Although the press report did not give detailed mechanism of the photographic process used by Jagadis Chandra, it was mentioned that the photographic process was a tedious one. Jagadish Chandra, being a scientist of excellent calibre, did not just stop by taking photographs of different objects but also started investigating the action of X-rays on various bodies and to improve the detecting screen. With the help of one of his colleagues in the chemistry department of Presidency College, he succeeded in finding another substance, potassium platinocyanide, which is more easily obtained than the corresponding barium compound, but is equally effective and hence may be substituted for barium platinocyanide in these researches. Unfortunately, this work is not included in his *Collected Physical Papers*, which prevents us from getting a first hand report on his X-ray research.

It is incredible to note that Jagadis Chandra Bose built an X-ray apparatus after learning about its discovery from newspapers within a year of the discovery of X-rays. This is astonishing not only because of poor communication systems at that time (no fax, no internet, no air mail, etc.), but more importantly, that he did not just replicate Roentgen's apparatus but made a major improvement on it in order to produce more intense and energetic X-rays.

The author was Professor and Chairman in the Department of Physics, Bose Institute, Kolkata. He currently teaches at Calcutta University and is Editor-in-Chief of the journal *Science and Culture.*

The Water We Drink and the Air We Breathe

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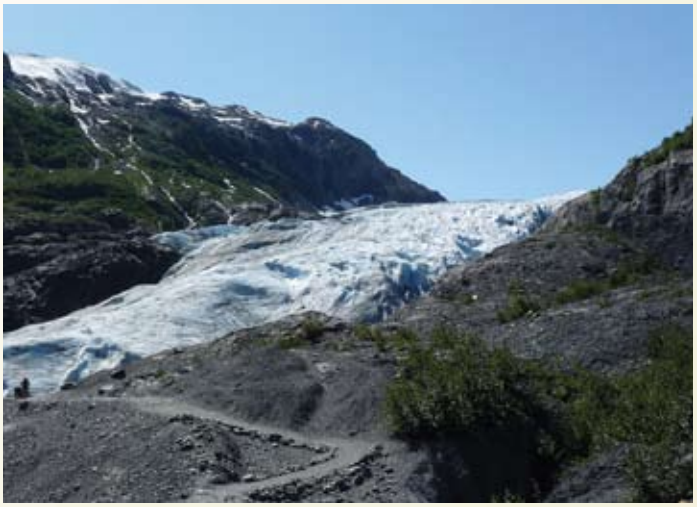
We cannot live without water. But did you know how do we get the water that we drink and use? Even what we call fresh water is actually recycled water – recycled from waste water and saline water of the oceans. A critical look will tell us that we do not prepare water that we drink, but just consume large number of water molecules that had been there for years, nay millennia. These molecules of water may not be there for long in the overhead tanks, in packaged form in bottles, or elsewhere, but it had been very much there on Earth for a long time. Then how do we continue to get such old stock? This is because of a number of phenomena, occasionally complex, connected in a chain to form what is known as a 'cycle' that repeatedly brings us back the same water molecules. This process is known as the 'hydrological cycle' or 'water cycle'.

Why do we really need to depend on an old stock of water that is being recycled time and again? We spoil the water after use. The waste water from our systems must take part in the hydrological cycle to make it reusable, as the amount of freshwater on Earth is only a small fraction of total water existing on our planet. Even if there had been more water available for our consumption the process would not have been different. The same cycle would have to go on and on.

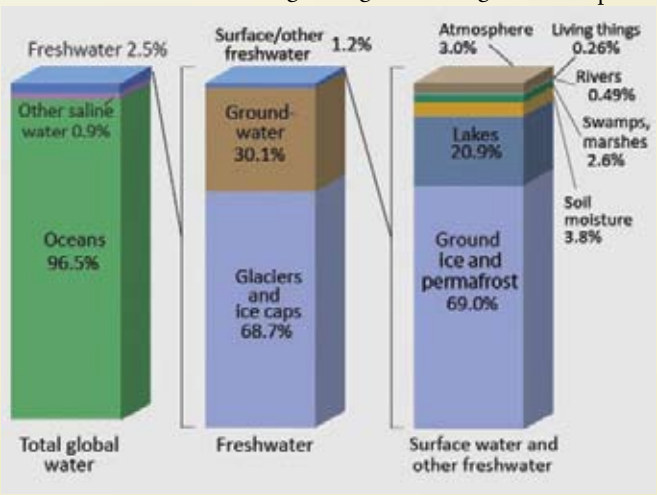
Let us take a look at the amount of freshwater we have on Earth. We must remember that freshwater implies that the salinity must be below 0.05%, i.e., the dissolved salt content of water should not be more than 500 parts per million. All of freshwater on Earth makes up only 2.5% of the total water on Earth. And that makes many concerned people feel that the world may fight over drinking water someday if we do not take special measures to stop its misuse.

The vast oceans on the Earth contain water that is too saline (salinity of about 3.5%). Whatever freshwater is present on Earth actually remains locked in places like Arctic and Antarctic ice, high mountains, and partly under the surface of the Earth. A section of aquatic animals do live in the oceans, but the huge number of life forms found in the lithosphere actually depends on freshwater.



Glaciar

Only a part of the freshwater can move from place to place through the hydrological cycle while rest remains locked for a long span of time. Ice, high up on the mountain ranges like the Himalayas also partly remains unaltered. But a part of it does melt and feed the rivers originating from the glaciers.



Water stored on the earth

Some experts feel, the global warming and consequent climate change may change this balance causing polar ice to melt and sea levels to rise. In that case we may have more number of water molecules participating in the hydrological cycle, but that may cause damage through other channels as the experts perceive.

Water molecules can take different forms like that of ice, snow, frost, water vapour, moisture, fog, cloud, etc. These molecules may exist in different forms in different parts of the Earth. For example, the rainwater that dropped on the roads of New Delhi on the Republic Day possibly got evaporated and became a part of cloud that might have moved over the slopes of the mountains of Himachal Pradesh and produced condensate as snow. So, the same set of water molecules may go on changing their physical characters while chemically remaining unaltered.

The rainwater that falls on the Earth flows through the rivers and gets collected in different water bodies and also partly recharges the underground water table by percolating the ground. Some of this water from rivers and lakes is pumped in the water processing units of different municipal bodies where they get purified and achieve the purity acceptable both from chemical and bacteriological point of view and are distributed through pipes to houses for drinking and other domestic uses. The water for our consumption is also drawn from the underground water table through manual tube wells or with the help of what are known as deep tube wells or submersible pumps.

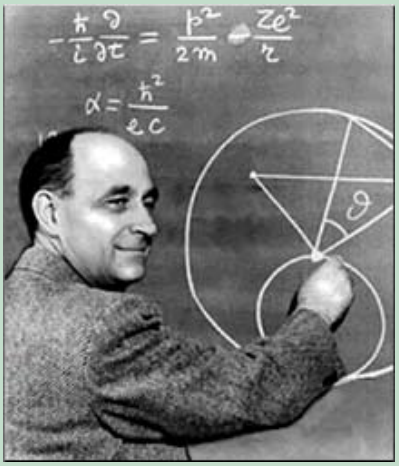
The water gets out of our body in the form of sweat and urine. These get into the drains or get evaporated into the atmosphere in the form of water vapour. Then the same set of

water molecules reaches the water bodies or rivers or lakes as they come down as rain. So we cannot prepare or produce new water. It is the old, very old water molecules that are getting recycled and circulated for several million years now.

So water, irrespective of its source, is definitely not fresh as it has not been just produced by some chemical reaction. Moreover same water molecule that once got evaporated from a pond in say, Tamil Nadu, can very much be the part of the water vapour that has found place in a cloud moving towards Odisha. The rainwater collected in a pond in Odisha may quench the thirst of a domestic animal there and hence may pass through a new system. However, it cannot stay there for long and again comes out as waste water and through evaporation may become part of the cycle again. Sometimes, some molecules of water may not enter the system of any living being and may get evaporated from a water body to turn into water vapour to be dropped down again. If we could actually put on some tag on some of the molecules we could possibly track their movement. The water molecules that reach the underground water table stay there for relatively longer time before taking part in the cycle again. Formation of cyclones over Bay of Bengal or the Arabian Sea causes strong wind to blow to the coast from the sea. That often brings in water molecules from diverse places to the coastal areas. And a single water molecule may travel hundreds of kilometres in a single night.

So let us accept that the water we take from any source is old and must have passed through the systems of a large number of other living beings. If we assume that the water we are drinking today contains molecules that might have passed through the system of one of our forefathers who lived some hundred years ago, that is actually possible. If someone gets thrilled at the thought that the glassful of water he has just taken contains molecules that once passed through his favourite historical personality, say, Leonardo da Vinci, he cannot be challenged as there is a finite probability of such a happening. That way we can turn out to be a bit philosophic and feel that same set of water molecules have not only quenched my thirst and are helping me to survive, but also that these very molecules have been actually supporting the living world for millions of years. Living objects with specific

BOX : A Fermi problem on the last breath of Julius Caesar



Enrico Fermi, the Physics Nobel Laureate from Italy who later fled to USA, was a scientist of the highest calibre. He introduced the concept of estimation and getting an idea of the order of magnitude result in different situations not only in physics but in real life as well. The exercise involves logical thinking with realistic assumptions and some basic data on the issue to be handled as starting information. This approach has become very popular in the scientific community and problems of this type have come to be known as Fermi problems and are considered to be a very stimulating exercise for those interested.

One such problem that Fermi handled was to figure out if there is any chance that we are breathing some of the air molecules, i.e., the nitrogen, oxygen and carbon dioxide molecules that came out with the last breath of the Roman Emperor Julius Caesar (100 BC – 44 BC). This problem was worked out with some realistic assumptions. First, it is assumed that after more than 2000 years of Caesar's death all the molecules that were the part of his last breath have been evenly distributed in the atmosphere. Secondly, the density of air and Avogadro number were used to come up with an order of magnitude result making a very reasonable assumption that a person breathes in or breathes out about 1 litre of air every time. It could be found that there is a very high probability, that one molecule that was the part of the last breath of Caesar is also present in each of our breathe. In other words, it can be said, we continue to breathe the same air molecules as was done by Julius Caesar. In this connection we must remember that we breathe in air with nitrogen, oxygen and carbon dioxide and the composition is the same as the air locally available. However, when we breathe out, the air contains relatively more carbon dioxide and less oxygen while the amount of nitrogen remains practically the same.

We know that the density of atmosphere decreases with height. But if we can squeeze in the entire atmosphere and bring it close to the Earth's surface with the air having a uniform density of 1.25 kg/m^3 at NTP the belt of air that will encompass the earth will have a height of 50 km only. Assuming the radius of the Earth to be 6,400 km, we can calculate the volume of the air at normal atmospheric pressure. Now we already know that the temperature on the Earth is actually different at differ zones. If we take the density of air on the surface of the Earth at 0°C and at standard atmospheric pressure as 1.25 kg/m^3, that is a fairly good assumption. Volume of air in atmosphere $V = (4/3)\,\pi\,[6450^3 - 6400^3] \times 10^9\ m^3 \sim 2.6 \times 10^{19}\ m^3$

Mass of the gas molecules in air = $V \times 1.25$ kg $\sim 3.25 \times 10^{19}$ kg

We know from the vapour density of air and from the Avogadro number that 28.8 g of air contains 6.023×10^{23} no of molecules (of nitrogen, oxygen, CO_2 etc.)

No of air molecules in atmosphere $\sim 6.5 \times 10^{44}$

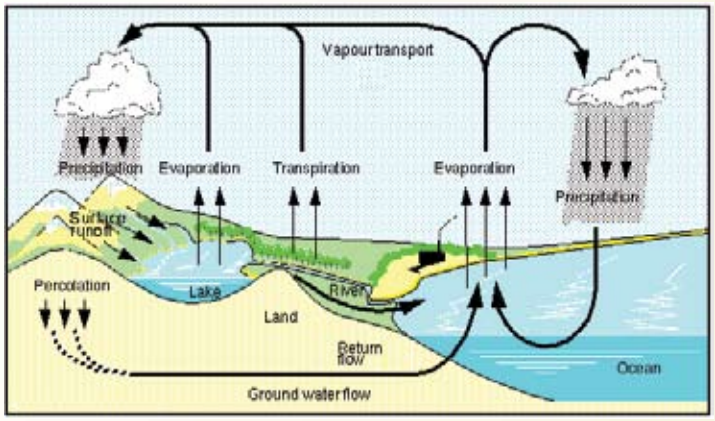
Since 22.4 litres of air at NTP will have Avogadro number of molecules, the number of molecules in one breath will be $\sim 10^{22}$

About one litre of air goes in or comes out from our lungs in a single breath. So the mass of the air involved is 1.2×10^{-3} kg. No of molecules in it is about $\sim 2.5 \times 10^{22}$

So we can say that one molecule in every 10^{22} molecules in air actually came from the last breath of Caesar. Since a person's breath has 10^{22} gas or air molecules it is practically certain that one molecule from the last breath of Caesar will get into our every breath. If it is not a molecule of a gas it is definitely one atom of oxygen that was present there and has now paired with a different atom of oxygen to produce a molecule of oxygen. So there is no running away from the last breath of Julius Caesar. Enrico Fermi with his very special ability just underlined that.

life span pass away, but the water molecules remain unchanged to take care of the generations down the line.

If we now turn our attention to another very important component of life, namely the oxygen we breathe, a similar scenario will emerge. Are we breathing the same oxygen that were breathed in by human beings and other living beings that were alive thousands of years ago? Well, there is another natural cycle involving oxygen that makes oxygen go round the cycle and the same oxygen gets into our breath over centuries. But this cycle is a bit more complex than the hydrological cycle. And because of that we may not breathe the same oxygen molecule formed by the same pair of atoms, but the oxygen atoms entering our system after forming a molecule are definitely the old ones.

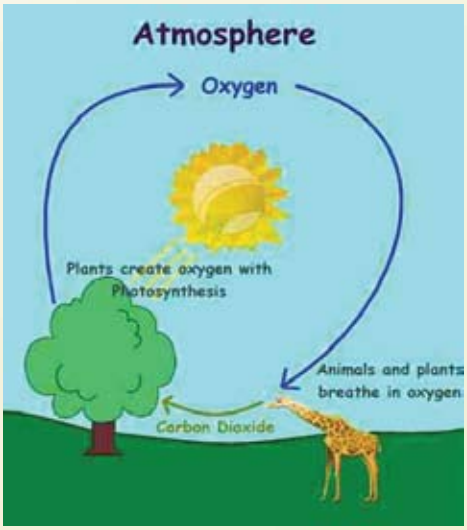


Water cycle or hydrological cycle

Oxygen molecules in air are made up of two atoms of oxygen while ozone contains three atoms of the same element combined together. Basically one oxygen molecule breaks up into two oxygen atoms while it participates in processes like burning, rusting, or any other form of oxidation. It forms carbon dioxide or other oxides and often remains locked-up for long periods of time. However, these atoms of oxygen do remain on Earth and under suitable conditions break down from the compounds to appear as oxygen again. This time-gap may be long but the process goes on and on. We are really running all the activities with the help of the very old stock of oxygen.

The oxygen cycle uses the old and same oxygen time and again. A part of the oxygen gets out of the cycle and gets locked while new oxygen enters the cycle through some other process. This is as if some oxygen molecules break down to atoms, form say, carbon dioxide take occasional leave from the cycle and get some rest, may be inside a living tree or living organism for some time, and then come back again. An oxygen atom partners with a new oxygen atom that is otherwise indistinguishable and forms another oxygen molecule to become the part of the cycle. So we can say that the same oxygen atoms come back again and again but the broken molecules are regenerated with the combination of atoms which might be tying up for the first time.

Now since good old oxygen is at least partially circulated again and again we are breathing the same oxygen that went into the respiratory system of our forefathers, literally. A few atoms in the molecules of oxygen going inside my system might have passed through the lungs of say a very famous personality of the last century while the very next breathe may have oxygen molecule that once helped a not so famous person to survive (See Box). Interestingly, some oxygen molecules may be



apparently new, but they may have formed by the combination of two old oxygen atoms that had never combined together earlier. But both of them might have passed through the system partnering different atoms on other occasions. This is like a touring cricket team where the stock of say 16 players remains the same but the playing eleven may appear different from match to match when the coach picks up and fields the team with different combinations.

As one can see in the atmosphere some oxygen is produced while water molecules break down due to electric discharge (lightning) and give us so to speak freshly prepared oxygen molecules. The trees and plants take in carbon dioxide (CO_2) for photosynthesis and give out oxygen. This oxygen looks like new oxygen because it is produced by the break-up of CO_2. So the oxygen cycle actually operates in conjunction with the carbon dioxide cycle and hydrological cycle. This is basically because both the carbon dioxide and water molecules both contain oxygen as one of the constituents. So they may break up giving rise to oxygen in addition to carbon or hydrogen atoms whereas oxygen molecule by breaking itself up can give only oxygen atoms. A significant part of oxygen on Earth is actually locked-up in the form of oxides and other compounds. This oxygen is not available to participate in the oxygen cycle. And we also cannot get this oxygen for respiration.

The oxygen or air molecules in a way are doing their duties without any discrimination. They provide support to all types of living systems irrespective of the latter's role in society or in the concerned ecological system. The growth of human population along with its activities has led to the enhanced demand for both oxygen and water and the hydrological cycle and oxygen cycle are operating incessantly to meet the demand. Importantly, whether the water molecules that we drink or the oxygen molecules we breathe in are old and have been reused time and again should not worry us because they are responsible for the survival of the living world. The same set of molecules that had rendered their services to the past generations over the millennia will continue to support the future generations provided of course the human interventions do not spoil the cycles and do not disturb the delicate balance irrevocably.

Dr Bhupati Chakrabarti was an Associate Professor and Head in the Department of Physics, City College, Kolkata 700009. He is now the General Secretary of Indian Association of Physics Teachers (IAPT). He regularly contributes science based articles in different magazines and journals in Bangla and English.

It Rains on the Sun

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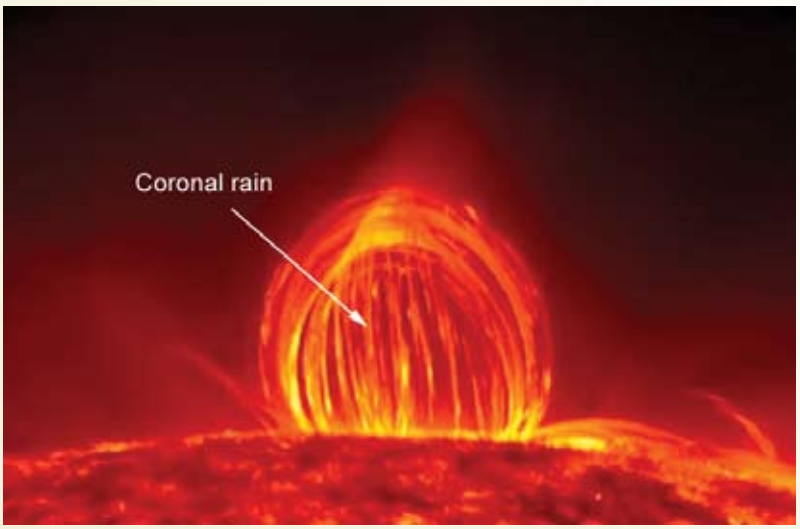
If we think being caught directly under rain is the most nasty thing to be encountered, then recently released photographs and videos displaying the 'rain' on the Sun, taken by NASA's Solar Dynamics Observatory (SDO) and ground-based observatories like the Swedish Solar Telescope (SST) could change our view about Earthly rain forever. The scientific team keeping watch on the surface of Sun has found that just like on Earth, the Sun also has spells of bad weather, with high winds and showers of rain. But, unlike the all-too-frequent storms occurring on Earth, the rain on Sun comprises cooled electrically charged gas known as plasma which falls back on the solar surface as 'coronal rain'. The thousands of droplets that make up the coronal rain follow the Sun's magnetic lines of force.

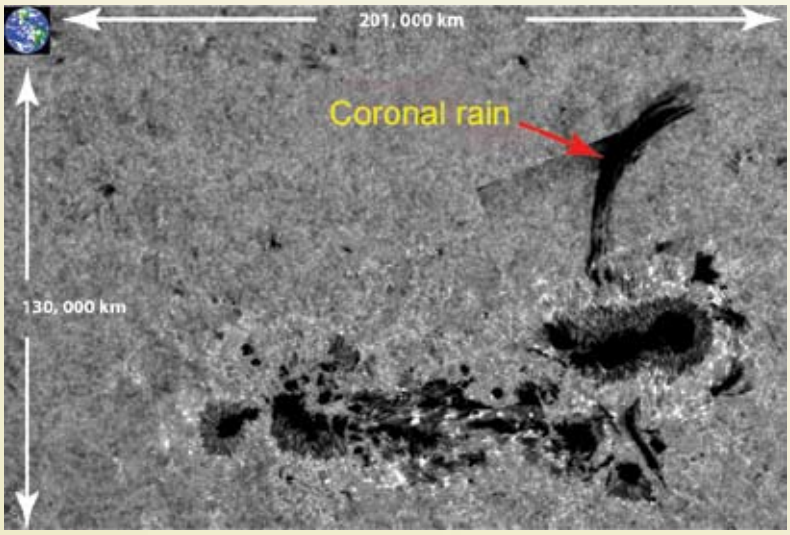


Solar coronal rain as observed by Solar Dynamics Observatory (Image credit NASA)

The awesome phenomenon of solar rain was first discovered almost forty year ago and since then the scientists are seeing regular and massive shifts in the solar 'climate'. But despite decades of research they have until now been unable to understand the physics of coronal rain. But with the advent of state-of-art Sun observatories like NASA's *Solar Dynamics Observatory* (*SDO*) and 1-metre Swedish Solar Telescope (SST), it is now possible to study this beautiful phenomenon in detail.

Surprisingly, it turns out that the process through which hot rain forms on the Sun is very much similar to how rain happens on Earth. If the conditions in the solar atmosphere are just right, then the erupting plasma are funnelled through massive arcs of magnetic field lines known as coronal loops. After being ejected from the surface, the clouds of hot, dense plasma can naturally cool and condense and eventually fall back to the solar surface looking like droplets of rain. These blobs of plasma which fall back to the surface of the Sun generate bright splashes where they hit.

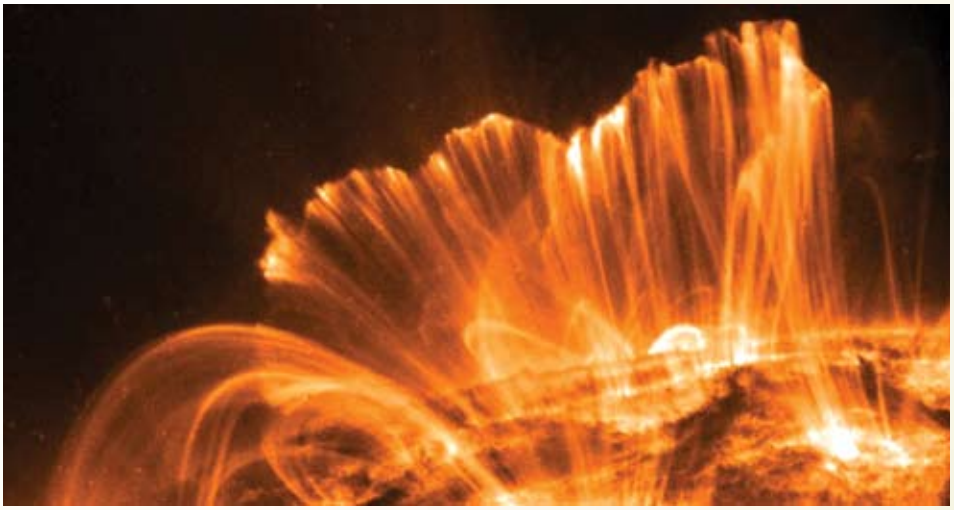
In another parallel with terrestrial weather, the material that makes up the hot 'rain clouds' on the Sun reaches the corona through a rapid evaporation process. But here the evaporation is caused by solar flares – the most powerful explosions in the Solar System that are believed to be responsible for heating the Sun's outer atmosphere. Further, these solar flare-driven torrential rainstorms may also play an important role in the occurrence of a very interesting but yet to be completely resolved puzzle known as the coronal heating, which makes the upper atmosphere of Sun (the corona) at least a million degrees Celsius hotter than the photosphere..



Coronal rain as observed on 15th November 2000 (Image credit TRACE Project, NASA)

A team of scientists led by Dr. Eamon Scullion of Trinity College, Dublin, Ireland along with Dr. Karel Schrijver of Lockheed Martin's Solar and Astrophysics Lab is studying the occurrence of solar coronal rain using imageries from the one-metre Swedish Solar Telescope in La Palma in the Canary Islands and analysing the unprecedentedly detailed videos received from the *SDO* and might have succeeded in solving the mystery by observing the conditions necessary for 'rain clouds' of plasma to form and then precipitate out. Using images from the Swedish Solar Telescope that produces some of the sharpest images of the Sun available in June 2012, the team observed a giant 'waterfall' of solar material pouring down from the outer atmosphere of the Sun into a dark sunspot on its surface. With the help of another set of images the team managed to assemble them into a movie and showed how a solar flare precedes a 'rain shower'.

They found that the plasma close to the photosphere becomes super-heated by the enormous amounts of energy that are unleashed by solar flares, causing rapid evaporation into the Sun's upper



Waterfall of hot plasma streaking back toward the surface of the Sun from the star's corona (Image credit: E. Scullion/SST)

atmosphere, the corona. When conditions are right the plasma cools and condenses, falling back towards the photosphere as 'rain'. Dr. Scullion has suggested an explanation of this mindboggling phenomenon using a model of 'catastrophic cooling', where an exceptionally rapid fall in temperature causes material to change from rarefied coronal gas to 'raindrops'. The process of heating and cooling releases energy into the corona, helping to keep it hotter than a million degrees Celsius.

Moreover, they also established that the torrential rainstorms, driven by solar flares, may play a fundamental role in controlling the mass cycling of the solar atmosphere and act as a kind of 'solar-scale' thermostat in regulating the temperature fluctuations of the solar corona. The origins of solar coronal heating remains one of the longest standing puzzles in solar physics.

Further, with the arrival of modern sensors aboard the *SDO*, the scientists could explain one more interesting phenomenon regarding the motion of coronal rain, which since the discovery of solar rain, has foxed solar physicists. They have been observing that due to some reason, coronal rain falls very slowly, a lot slower than one would expect for plasma falling toward a gravitational bully like the Sun. According to the calculations, the Sun's gravity should be pulling the material down much faster than it actually moves. So, the question "What's slowing the descent?" was bothering solar physicists for decades.

The scientists could finally solve this puzzle with the help of specially designed the temperature-sensitive instrument named Atmospheric Imaging Assembly (AIA) on-board the *SDO*, which is capable of imaging the solar atmosphere in multiple wavelengths to link changes in the surface to interior changes. They could observe that below the falling 'cold' coronal rain having temperatures in the range of a few thousand degrees, the temperature of 'hot' plasma is greater than a million degrees Celsius, which is many time higher than that of the coronal rain. The presence of this superhot plasma exerts pressure on the falling coronal rain against the gravitational pull of Sun, thus slowing down its effective speed.

The SST and *SDO* are continuously monitoring our dominant star and regularly revealing a multitude of spectacular features it shows off with grandeur. Yet it is only the beginning in our understanding of solar coronal rain and the associated phenomena. It may take some time for the puzzle to be completely deciphered.

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ASTRONOMICAL TELESCOPE MAKING WORKSHOP

05 - 16 October 2015

An excellent opportunity to learn telescope making and initiate observational astronomy:

1. The workshop is primarily aimed to attract professionals, amateurs and enthusiasts who would like to gain a first hand experience in the nitty-gritty of telescope making under expert supervision under one roof.
2. Successfully enrolled participants will be trained to make their own five inch (5") Dobsonian Telescope primarily from locally available material.
3. There is a provision for just 25 teams on a first come first serve basis. Each team should consist of maximum two members. Out of them one should be above the age of 18 years.
4. The last date of registration is 15th August, 2015.

Workshop Attractions: Participants will....

I. Grind, polish glass blanks, test their own-hand-made mirrors and fabricate the Dobsonian Telescope. This is to impart and enhance skills to secure precise curvature, focal length and the reflecting surface.

II. Learn through night sky observations, practical sessions on how to use telescope, lectures on elementary astronomy, tips on astrophotography, interactions with eminent astronomers from various research institutions and many more.

III. Become part of a country-wide network. They will receive regular e-mail updates on astronomy activities, night sky events, and other special events including seminars/ workshops/ training sessions.

Registration Details:

a. Each participant will have to pay a fee of Rs. 10,000/-.

b. If a team of two members comes together, the team has to remit a sum of Rs. 12,000/-. The members of the team should mutually agree to share the telescope for use.

c. Payments have to be made through a Demand Draft of any nationalized bank. The draft of required amount has to be made in favor of 'Pushpa Gujral Science City', payable at Kapurthala, Punjab.

d. This fee amount is meant to cover the cost of materials that will be used to make the telescopes and a working lunch over the days of the workshop.

e. Participants will have to meet their own travel, lodging & boarding expenses. However, assistance may be provided to locate a suitable accommodation depending on the requirement and the budget of the participants.

f. Only online registration is allowed at www.vigyanprasar.gov.in. List of selected participants will be displayed after the deposit of registration amount.

Nearby Locations to the venue:

- **Golden temple just 75 km away from the venue.**
- **Wagah border just 105 km away from the venue**
- **Jagatjit Singh Palace just 15 km away from the venue.**
- **Moorish Mosque just 10 km away from the venue.**
- **Shalimar garden just 20 km away from the venue.**

Memories

(First Telescope Making Workshop)

Last Date of Registration 15 August 2015

Venue

Pushpa Gujral Science City
Kapurthala, Punjab

Contact us

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Everyday Chemistry in the Kitchen

Dr. K. Srinivasan
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Introduction

Most of us participate in chemistry practicals every day in the kitchen, without being aware of it. In culinary practices of any food culture, while cooking the daily food, i.e., turning raw ingredients into finished meals, we would be taking recourse to sometimes simple and oftentimes complex chemical reactions. A meal is likeable if it possesses a pleasant flavour, attractive colour, enjoyable taste, and a palatable texture. These desirable attributes may be naturally inherent in the food ingredients used in the meal preparation or may not be originally present.

By employing the art of cooking, the lady of the house can skilfully turn the insipid food ingredients into an attractive and tasty meal or snack in the kitchen! And this whole process involves numerous changes in the chemicals present in the food ingredients and complex chemical reactions carried out during cooking! Even though our grandmothers and mothers are not graduates in chemistry, they are pioneers in practical chemistry without getting recognised and acknowledged so. Often in our kitchen encounter, every branch of chemistry is dealt with. Understanding the chemistry that makes our food turn from one physical state to the other (liquid to solid, or solid to liquid), from raw to cooked, insipid to tasty, native to fermented/ malted, etc., could make our cooking experience a fascinating one.

The Indian traditional food formulations show ingenuity in the choice of ingredients and additives with critical attention to wholesome nutrition besides taste. Indian cuisines have great aromas and in-depth taste profiles, which are derived from a complex combination of spices and preparation techniques. A well-balanced Indian meal contains all the six defined tastes, viz., sweet, sour, salty, pungent, bitter and astringent (Table-1). Besides balancing of these tastes, every meal aims to achieve a good balance between these sensations to promote digestion and well-being. Side dishes and condiments contribute to the overall flavour and texture of an Indian meal. The pungent, sour, and crunchy side dishes and condiments, whether chutneys, curries, or soups, enhance and provide balance to the overall flavour and texture of the main staple. Here is an overview of the various chemical processes happening in our kitchens almost every day!

Emulsifiers in the kitchen

It's a common knowledge that oil and water (or vinegar) doesn't mix. But certain preparations manage to make them mingle, and that is because of an emulsifier such as egg yolk. The proteins in the egg yolk essentially hold onto both the fat molecules in the oil and the water molecules in the vinegar, linking between them and preventing them from separating. While washing the greasy utensils in the kitchen, soaps work much in the same way. They have compound called phospholipids, which have a polar (water-loving) head and nonpolar (water-hating) tail. The nonpolar tail binds with grease and dirt, while the polar head allows them to be swept away with water.

Souring and curdling of milk

Souring of milk is an intentional cooking technique that uses exposure to an acid to effect a physical and chemical change. Addition of lime juice, lemon juice or vinegar to hot milk makes it curdle almost immediately. Milk is a colloidal solution of fat and of dissolved salts in water. Curdling is the breaking up of this emulsion through the physicochemical processes of flocculation, creaming, and coalescence. Milk and soy milk are curdled intentionally to make

Table-1. Chemicals in food ingredients contributing to taste

Taste	Food ingredient	Attributable chemical
Salty	Common salt, Rock salt	Sodium chloride Potassium chloride
Sour	Lime/ Lemon Amchur Tamarind Kokum (Malabar tamarind) Vinegar Curds, Butter milk	Citric acid Citric acid Tartaric acid Hydroxycitric acid Acetic acid Lactic acid
Pungent (Hot)	Red chilli Black pepper	Capsaicin Piperine
Sweet	Cane sugar Jaggery Honey	Sucrose Sucrose Glucose and fructose
Bitter	Bitter gourd Bitter orange	Alkaloids, steroid glycoside Flavonoid glycosides, limonoids
Astringent	Amla (Indian gooseberry) Jamun Tea	Polyphenols/tannins Polyphenols/tannins Polyphenols/tannins

cheese and tofu by the addition of enzymes (typically rennet), acids, or various salts (magnesium chloride, calcium chloride, or gypsum) and then pressed. Milk curdles because of a simple chemical reaction. The protein (casein) in milk, which is normally suspended in a colloidal solution, scatters light and gives milk its white appearance. When an acid is added and the pH of milk decreases, these protein molecules which were hitherto repelling each other suddenly attract one another and form clumps (curdling of milk), and these clumps float in a solution of translucent whey. Clumping of milk happens more swiftly at warmer temperatures than at cold temperatures. In the making of *paneer*, milk is heated to a designated temperature and then the acidic lemon juice or vinegar is added. Once the milk curdles, the solid proteins are then strained from the liquid whey and shaped into a round of cheese.

The acid can also be produced within the milk itself by a microbe such as *Lactobacillus*. The sugar lactose present in milk breaks down to lactic acid by microbial action. This lactic acid lowers the pH of the milk making it sour. Sometimes, especially in summer, if milk is kept at room temperature, microbial production of lactic acid starts spontaneously and when the milk is warmed, the casein (protein) molecules of milk begins to clump due to increase in acidity. The high level of lactic acid is also responsible for the sour smell of the spoiled milk.

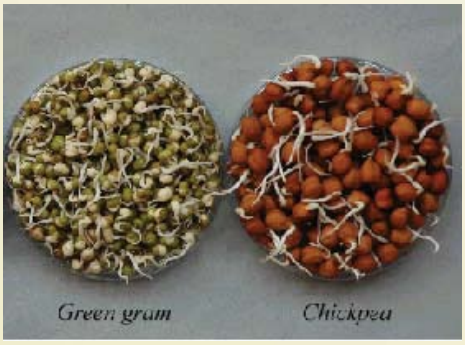
Making of curds, butter and ghee

For making curds, raw milk is boiled and cooled to near ambient temperature, and curd cultures are added. After letting at room temperature for around 12 hours, the curd is ready. The *Lactobacilli* present in the culture converts lactose sugar of milk into lactic acid which is responsible for the sourness of curds. Curd is churned to obtain a specific

type of cultured butter, which essentially constitutes the entire fat originally present in milk, and is an emulsion of water in fat. The characteristic flavour of butter is contributed by a chemical called diacetyl. This butter is converted into ghee by simmering the butter along with the milk solids so that they caramelise, which makes it nutty-tasting and aromatic.

Sprouting of food grains

In Indian culinary practice, food grains generally undergo prolonged soaking in water which may result in sprouting, followed by cooking. This procedure reduces the level of



water-soluble and heat-sensitive toxins and anti-nutrients such as tannins, saponins, digestive enzyme inhibitors (lectins), as well as flatulence factors. It also partially degrades phytic acid, which is a potent inhibitor of mineral absorption. Thus, soaking improves the digestibility and nutritional value of grains.

Batter fermentation

Fermentation is a way to greatly improve the digestibility and nutritive value of grains. Typically, grains are soaked, ground, and allowed to sour ferment for overnight or longer. In addition to the reduction in toxins and anti-nutrients afforded by soaking and cooking, grinding and fermentation offer further benefit. Grinding greatly increases the surface area of the grains by breaking up their cellular structure, and releasing enzymes which are important for further transformation. Subsequent fermentation by lactic acid bacteria (naturally present on grains) rapidly acidifies the batter. The combination of grinding and sour fermentation causes grains to efficiently degrade their own phytic acid by the enzyme phytase released from the grain,

making minerals much more available for absorption. Fermentation also increases the concentration of the amino acid methionine and vitamin C. Fermentation followed by cooking increases the digestibility of grain protein, due to the destruction of protease inhibitors and the partial pre-digestion of grain proteins by bacteria.

Malting of grains

Specific cereal grains (*e.g.*, barley, finger millet, wheat) are germinated usually by soaking up to 12 hour in water, followed by draining and then rinsing seeds at regular intervals until they germinate or sprout (usually needs few days), and finally dried with hot air. This process is known as malting. Sprouts are said to be rich in digestible energy, vitamins, bioavailable minerals, amino acids, proteins, and phytochemicals, as these are necessary for a germinating plant to grow. Malting

Table-2. Chemical processes associated with cooking methods which alter the properties of foods

Cooking method	Food types	Chemical processes
Frying	Meat, fish, eggs, vegetables	Maillard reaction, caramelisation, polysaccharide degradation, loss of pigments, protein denaturation, vitamin loss, generation of undesirable and desirable compounds
Baking	Bread, biscuits, pastry, cakes	Caramelisation, Maillard reaction, polysaccharide degradation, protein denaturation, generation of undesirable and desirable compounds
Boiling	Rice, pasta, vegetables, pulses	Polysaccharide degradation, loss of pigments, protein denaturation, polysaccharide gelatinisation, vitamin loss, mineral loss
Grilling	Meats, fish, bread, vegetables, fruits,	Caramelisation, Maillard reaction, polysaccharide degradation, loss of pigmentation, protein denaturation, vitamin loss, generation of undesirable and desirable compounds
Steaming	Fish, vegetables	Polysaccharide degradation, loss of pigments, protein denaturation, vitamin loss
Roasting	Meat, vegetables, nuts	Caramelisation, Maillard reaction, polysaccharide degradation, loss of pigments, protein denaturation, vitamin loss, generation of undesirable and desirable compounds

grains develops the enzymes required to modify the grain's starches into sugars, including glucose, maltose, maltotriose, and higher sugars called maltodextrins. It also develops other enzymes, such as proteases, which break down the proteins in the grain into forms that can be used by yeast. Malted grain is used to make malted shakes and flavoured drinks, biscuits, beer, whisky, and confections.

Changes in chemical properties during cooking

Food ingredients are transformed into meals or snacks in the kitchen. Cooking is a means of processing food, without which many foods would be unfit for human consumption. Foods are often cooked by applying heat – by boiling, roasting. or frying in fat to make them edible and digestible. Cooking also destroys any contaminating microorganisms present in animal food. Cooking by heating causes a complex series of physical and chemical changes to occur that vary depending on the type of food being cooked and the cooking method (Table-2). The changes may improve the flavour, texture and colour of the food, making it more appealing. At the same time, cooking may also reduce the nutrient value of the food, or produce undesirable compounds.

Texture changes resulting from altered chemical properties

Texture of the food item is as much important as taste, flavour, and colour for an appeal. The texture of *roti* or *chapati* (the unleavened bread made from wheat flour) depends upon the amount of water and oil used in the kneading of the wheat flour as well as the baking procedure. The softness and layered structure of *chapati* is attributable to the presence of protein gluten in wheat. Black gram is an ingredient used in an appropriate proportion in the making of *dosa*, *idli*, and *vadai*. The softness or the crispness of these products is dependent upon the protein present in the black gram. Baking soda (sodium bicarbonate) is primarily used in baking as a leavening agent. It reacts with acidic components in batters, releasing carbon dioxide, which causes expansion of the batter and forms the characteristic texture and grain in pancakes and cakes. Baking soda is also used in the preparation of fried foods to enhance crispness.

Meat can be tenderised by the addition of the proteolytic enzyme papain (from papaya latex) or bromelain (from pineapple). The protein in soya bean can be processed to provide a texture similar to meat protein, which with an appropriate flavour and colour can mimic animal derived meat.

Vegetables maintain their rigidity by virtue of polysaccharides such as cellulose and pectin present in their cell walls. Cellulose and pectin are broken down into their monosaccharide constituents during cooking, resulting in a substantial softening of foods containing these polysaccharides. The storage polysaccharide of plant foods, viz., starch is similarly downsized under the influence of heat into dextrins, which are softer than the native starch. The heat can also effectively break-up the starch to release the glucose monosaccharides, which imparts a natural sweetness to the cooked food.

Foods containing starch (e.g. corn flour, rice flour, and potato) are often used to thicken sauces. An emulsion of starch with water, during mild cooking, would create simpler mucilaginous saccharides (process termed as starch gelatinisation), which cause the familiar thickening of sauces. The starch granule is made up of two polysaccharide components - amylose (linear chain of glucose) and amylopectin (branched structure of glucose units). When cooked in water, the starch granules absorb water and swell. Amylose leaches out of the granules and bonds to form organised lattice structures, which trap the water molecules causing the thickening of the sauce.

When proteins are heated they become denatured (unfolded) and denaturation of protein molecules in foods usually causes a substantial change to the texture of the product. This causes softening of the structure of the food material. For example, protein collagen of the connective tissue in meat has a tough, chewy texture. During cooking, the weak hydrogen bonds are broken and the degraded protein reacts with water molecules to form gelatine. This tenderises the meat, giving it a softer, more palatable texture. In some cases, proteins can form more rigid structures (e.g., coagulation of albumen in egg whites). Formation of a relatively rigid but flexible matrix from egg white is important in baking cakes.

(To be continued)...

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Low Blood Pressure – The Secrets You Must Know

Dr. Yatish Agarwal
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Low blood pressure, or as in the doctors' lingo, hypotension, is generally the most innocuous of conditions. If you are in good health, chances are that this may be perfectly normal for you. People who exercise regularly generally have a lower blood pressure than people who are not as fit. In fact, cross-sectional surveys carried out among people in different parts of the world indicate that people, who maintain a lower blood pressure, live healthily and enjoy a longer lifespan than those who have a perfect pressure of 120/80 points! Clearly, therefore, if the blood pressure is a bit on the lower side, that would seem to be something to strive for.

However, for a few people, low blood pressure also can be a signal of an underlying health problem. In that case, it is associated with definite signs and symptoms. Occasionally, the blood pressure can drop suddenly, and this, in severe cases, can be life-threatening.

What is blood pressure?

Blood pressure is a measurement of the pressure in your arteries during the active and resting phases of each heartbeat. The blood pressure readings consist of two numbers: systolic and diastolic. Here's what they mean:

Systolic pressure

The first (top) number in a blood pressure reading, this is the amount of pressure your heart generates when pumping blood through your arteries to the rest of your body.

Diastolic pressure

The second (bottom) number in a blood pressure reading, this refers to the amount of pressure in your arteries when your heart is at rest between beats.

Normal readings

Current guidelines identify normal blood pressure as lower than 120/80 mm Hg.

Variability

Although you can get an accurate blood pressure reading at any given time, blood pressure isn't always the same. It can vary considerably in a short amount of time – sometimes from one heartbeat to the next, depending on body position, breathing rhythm, stress level, physical condition, medications you take, what you eat and drink, and even time of day. Blood pressure is usually lowest during a period of rest and rises sharply following activity.

Defining the numbers

What is considered an abnormally low blood pressure for you may be normal for someone else. Most doctors consider chronically low blood pressure too low only if it causes noticeable symptoms.

Some experts define low blood pressure as readings lower than 90 mm Hg systolic or 60 mm Hg diastolic – you need to have only one number in the low range for your blood pressure to be considered lower than normal. In other words, if your systolic pressure is a perfect 115, but your diastolic pressure is 50, you're considered to have lower than normal pressure.

A sudden fall in blood pressure also can be dangerous. A change of just 20 mm Hg – a drop from 110 systolic to 90 mm Hg systolic, for example – can cause dizziness and fainting when the brain fails to receive an adequate supply of blood.

Any big plunges, especially those caused by uncontrolled bleeding, severe infections or allergic reactions, can be life-threatening.

Athletes and people who exercise regularly tend to have a lower blood pressure and a slower heart rate than do people who aren't as fit. So, in general, do non-smokers and people who eat a healthy diet and maintain a normal weight.

But in some rare instances, low blood pressure can be a sign of serious, even life-threatening disorders.

Knowing the symptoms and signs

In many instances, low blood pressure isn't serious. If you have consistently low readings but feel fine, you may not go to a doctor. You must recognise, however, that the causes of low blood pressure can range from trivial to the serious.

The secret is to find out what's causing your condition so that it can be properly treated. If you have any of the following signs and symptoms, think that this could be a signal of an underlying problem:

- Feeling dizzy, lightheaded, or faint.
- Feeling sick to your stomach or vomiting.
- Feeling more thirsty than usual.
- Having blurry vision.
- Feeling weak.
- Being confused.
- Lack of concentration.
- Feeling depressed.

- Being tired.
- Having cold, clammy, pale skin.
- Breathing very fast.

When to see a doctor

It is important to see your doctor if you experience any signs or symptoms of hypotension because they sometimes can point to more serious problems. It can be helpful to keep a record of your symptoms, when they occur and what you were doing at the time.

Still, if you face an occasional dizziness or lightheadedness, do not be alarmed. It may just be a relatively minor problem – the result of mild dehydration from too much time in the Sun or a hot tub, for example.

Conditions that can cause low blood pressure

A number of medical conditions can cause a lowering of blood pressure. These include:

Pregnancy

A woman's circulatory system expands rapidly during pregnancy. This makes it likely that the blood pressure may drop. Such a change is normal. The blood pressure usually returns to your pre-pregnancy level after you've given birth.

Dehydration

When you become dehydrated, your body loses more water than it takes in. Even mild dehydration can cause weakness, dizziness and fatigue. Fever, vomiting, severe diarrhoea, overuse of diuretics and strenuous exercise can all lead to dehydration.

Far more serious is hypovolaemic shock, caused by a decrease in the volume of circulating blood. It is a life-threatening complication of dehydration. It occurs when low blood volume causes a sudden drop in blood pressure and a reduction in the amount of oxygen reaching your tissues. If untreated, severe hypovolaemic shock can cause death within a few minutes or hours.

Heart problems

Some heart conditions that can lead to low blood pressure include extremely low heart rate (bradycardia), heart valve problems, heart attack and heart failure. These conditions may cause low blood pressure because they prevent your body from being able to circulate enough blood.

Endocrine problems

Thyroid conditions such as parathyroid disease, adrenal insufficiency (Addison's disease), low blood sugar (hypoglycaemia) and, in some cases, diabetes, can trigger low blood pressure.

Blood loss

Losing a lot of blood from a major injury or internal bleeding reduces the amount of blood in your body, leading to a severe drop in blood pressure.

Severe infection (septicaemia)

Septicaemia can happen when an infection in the body enters the bloodstream. This condition can lead to a life-threatening drop in blood pressure called septic shock.

Severe allergic reaction (anaphylaxis)

Anaphylaxis is a severe and potentially life-threatening allergic reaction. Common triggers of anaphylaxis include foods, certain medications, insect venoms and latex. Anaphylaxis can cause breathing problems, hives, itching, a swollen throat and a drop in blood pressure.

Lack of nutrients in your diet

A lack of the vitamins B12 and folate can cause a condition in which your body does not produce enough red blood cells (anaemia), and cause low blood pressure.

Medications

Some medications you may take can also cause low blood pressure. These include the following:

Diuretics (water pills)

Certain drugs which increase the output of urine such as hydrochlorothiazide and furosemide and are used in the treatment of heart failure, high blood pressure and a host of other conditions can lower the blood pressure.

Antidepressant pills

Certain types of antidepressants, especially tricyclic antidepressants, including doxepin, imipramine, protriptyline and trimipramine can bring the blood pressure down.

Male potency pills

Certain drugs used in the treatment of male impotency like sildenafil or tadalafil, particularly when used in combination with the anti-anginal heart medication nitroglycerin can push the blood pressure down.

Parkinson's disease pills

Drugs used in Parkinson's disease, such as pramipexole or those containing levodopa can also be responsible for a drop in blood pressure.

Blood pressure pills

Certain drugs used in the treatment of high blood pressure like alpha blockers, such as prazosin and labetalol; and beta blockers, such as atenolol, propranolol and timolol can also bring the blood pressure down.

[Next Month: More Secrets About Low Blood Pressure and Ways to Manage It]

Recent Developments in Science and Technology

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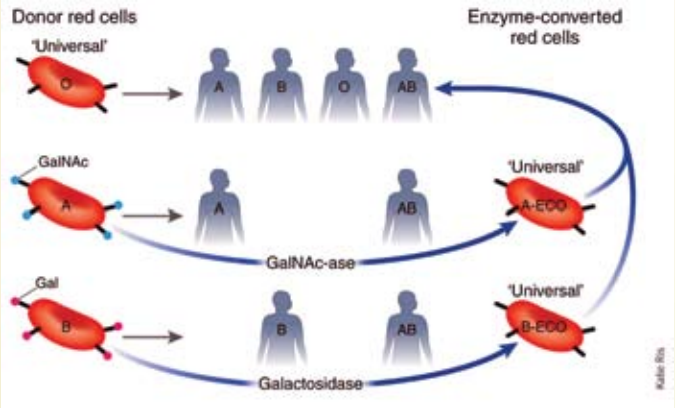
Changing blood groups made possible

Blood transfusion is an essential life-saving medical therapy that involves transfer of blood of one individual to another. Urgent transfusion of blood is essential in emergencies such as heavy blood loss due to an injury or in a surgery. Regular blood transfusion is also required in certain disease conditions such as thalassemia. But the main problem with blood transfusion is a special characteristic that divides blood into four groups (also called types) known as A, B, AB, and O. The basic difference between A, B and O blood groups is the presence of slightly different sugar structures, also known as antigens, on the surface of the red blood cells of each type. Group A and B blood cells each have a single additional sugar attached to their surface while group AB blood cells have a mixture of both. Group O blood cells have none.



Group O red cells are called 'universal' because they are suitable for transfusion to individuals of all ABO groups. Group A red cells can be given safely only to A and AB individuals, and group B red cells can be given only to B and AB individuals. Modification of A and B red cells by novel enzymes removes the sugars GalNAc and Gal, in principle rendering them suitable for transfusion to anyone. (Credit: Nature)

Every individual has antibodies to the A or B antigens that they lack: group A have anti-B; group B have anti-A; and group O have both. Individuals with blood groups A and B can only receive blood from individuals with the same blood groups, respectively. Individuals with blood group AB can safely receive blood from both A and B groups. Only one group, O, can be transferred universally to anyone who is in need, irrespective of the blood group of the recipient; that is why individuals with group O blood are known as 'universal' donors. All the other groups need 'matching' with the donor blood group. Transfusion of unmatched blood; for example, red cells carrying A or B antigens to a patient with the corresponding antibodies, will usually result in a severe immune reaction, which may be dangerous for the receiver and may even cause death. Because group O red cells lack both A and B antigens, group O donors are always in demand, and O-type blood is often in short supply.

For decades, researchers have been looking for a way to convert group A and B blood into group O and have found that some enzymes from bacteria can clip the sugars off red blood cells that give blood its "group." Until now the enzymes were not very efficient. Now, a team of researchers, including one Indian origin scientist, Jayachandran Kizhakkedathu from the University of British Columbia, Centre for Blood Research, along with Stephen G. Withers and colleagues have created an enzyme that could potentially solve this blood group conversion problem. According to Withers, "The idea of converting blood types by enzymatic removal of blood group antigens using specific sugar hydrolysing enzymes (glycosidases) has been around since the early 1980s, but a major limitation has always been the efficiency of the enzymes that can do this: impractically large amounts of enzyme were needed".

The researchers used a technique called 'directed evolution'; they used bacteria to create the enzyme and inserted particular mutations in the bacteria's DNA to make the enzyme even more powerful. (Directed evolution refers to a variety of methods for improving or altering the function of enzymes using a nature-inspired two-fold strategy of causing mutations followed by selection.) After growing the bacteria in culture over five generations, the enzyme became 170 times more effective. The enzyme works by snipping off the sugars found on group A and group B blood cells, making it more like group O (*Journal of American Chemical Society*, 14 April 2015 | doi: 10.1021/ja5116088).

Although the results are quite encouraging, the researchers caution that the current enzyme strain is not yet capable of removing 100 percent of the antigens from blood groups A and B, which is where it needs to get if the techniques is to be of any real use. The researchers are working to make the enzyme even more effective and are confident that it will soon be powerful enough to be used in a clinical setting.

Use of mobile devices by kids worrisome

Curiosity is a hallmark of babies. They are ever eager to find out about things they see and handle. Smartphones and tablets are commonplace gadgets today found in almost every home and mobile devices are the fastest growing technology in human history. In most families young children have easy access to these devices, but little was known about children's age of initial exposure to mobile media and frequency of use. A recent survey has brought out surprising results. It has

Little girl taking a 'selfie.' (Credit: Fotolia)

shown that more than one-third of babies are tapping on smartphones and tablets even before they learn to walk or talk, and by one year of age, one in seven toddlers is using devices for at least an hour a day. The survey found that by age 2, most kids were using mobile devices in some way. Their usage increased as they grew up, with 26 percent of 2-year-olds and 38 percent of 4-year-olds using devices for at least an hour a day. The objective of the survey was to determine the age of initial exposure and use of mobile media among young children. The findings of the survey were presented at the Paediatric Academic Societies (PAS) annual meeting in San Diego, California, USA on 25 April 2015. Interestingly, the Academy

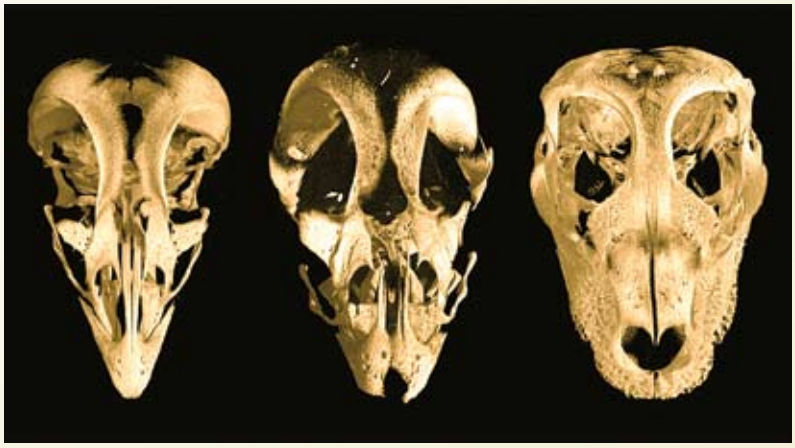
The survey included 370 parents. Children were evenly distributed across age groups ranging from 6 months to 4 years. 51 percent were girls. Families included White Americans; African American, Hispanic Americans. Overall, technology available in the homes was common – 97 percent of the homes had TVs, 83 percent had tablets, 77 percent had smartphones, and 59 percent had Internet access.

For the survey, the researchers developed a 20-point questionnaire to find out when young children are first exposed to mobile media and how they use devices. Parents of children ages 6 months to 4 years old were asked about what types of media devices they have in their household, children's age at initial exposure to mobile media, frequency of use, types of activities and if their paediatrician had discussed media use with them.

It was observed that most parents let children play with mobile media while running errands or doing chores around the house. They did it to calm the child or to put the child to sleep. By 1 year of age, 14 percent of children were spending at least one hour per day using mobile media, 26 percent by age 2, and 38 percent by age 4. The survey revealed that children are exposed to mobile media devices very early in life, and most children are using them by age of two years. According to lead author Hilda Kabali, the results are surprising and also worrisome, because the American Academy of Paediatrics discourages the use of entertainment media such as televisions, computers, smartphones and tablets by children under age 2. But, according to some experts, a better understanding of the use of mobile media in young children and how it varies by population groups may help develop educational strategies for both parents and health providers.

How birds got their beaks

Although evolution of species is an established fact, palaeontologists occasionally come across what appears to be a dead end. Most evolutionary biologists seem to agree, based on fossil record, that the birds of today are direct descendants of dinosaurs, and that the first bird ancestors evolved some 150 million years ago. When birds got their wings, they lost the clawed fingers wielded by their dinosaur relatives. But they evolved agile beaks of all shapes and sizes, from the gulping gape of a pelican to the needle nose of a hummingbird that have enabled the 10,000 species of birds to thrive from the Arctic to the tropics, build intricate nests, and live on a wide range of foods – from the nectar of flowers to fruits, nuts, insects, and even small animals. But it was never established how birds got their beaks. Now we seem to have the answer. A team of researchers led by Bhart-Anjan Bhullar of Yale University and Arhat Abzhanov of Harvard University, who have been studying everything they could get their hands on about bird's beak formation and evolution, have identified two genes which may have been responsible for the transformation of the snout seen in some dinosaur species, including the present-day alligators, into bird beaks (*Evolution*, 12 May 2015 | DOI: 10.1111/evo.12684).



The skull of a chicken embryo (left) has a recognisable beak. But when scientists block the expression of two particular genes, the embryo develops a rounded "snout" (centre) that looks something like an alligator's skull (right). (Credit: Bhart-Anjan S. Bhullar)

The bird's beak, also known as the bill, is essentially made out of two parts: the upper and lower mandible. The upper mandible grows out of the skull, just like our upper jaw and teeth grow out of our skull, while the lower mandible can move independently, since it is hinged. It is the lower mandible that allows birds to peck or eat. In fact, the bird's beak is primarily meant for feeding, but many birds use it for other purposes. For example, the pelican uses its huge beak as a fishnet, the hummingbird as a sophisticated straw and the woodpecker uses its beak as a jackhammer to pick wood and find insects.

Bhullar's fascination for bird beaks arose from the importance of the beak to bird anatomy. He says, "The beak is a crucial part of the avian feeding apparatus, and is the component of the avian skeleton that has perhaps diversified most extensively and most radically – consider flamingos, parrots, hawks, pelicans, and hummingbirds, among others. Yet little work has been done on what exactly a beak is, anatomically, and how it got that way either evolutionarily or developmentally".

To hunt for clues about the origin of the beak, the researchers have been studying various kinds of animal embryos, from birds like emus and chickens to non-bird reptiles like alligators and crocodiles, which are birds' closest living relatives. Their work led them to two specific genes that code for proteins called Fgf8 and Lef1. These genes are usually active in the middle of the face-forming region of bird embryos, but not in the middle of that region in the embryos of other animals.

What Bhullar and his team did was a kind of reverse engineering; they tried to see what would happen if they blocked the effect of the two localised genes. To explore these genes' roles, the researchers treated bird embryos with chemical inhibitors of the Fgf8 and Lef1 proteins. When the two

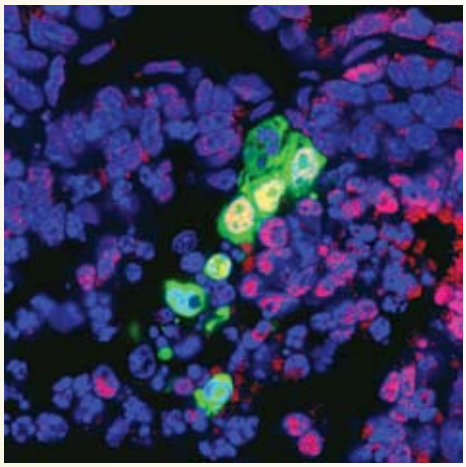
signals were most curbed, the chicks did not develop pointed beaks; instead they developed rounded snouts like alligators and lizards. "Instead of the normal bone structure that would form a beak," Bhullar says, "these chicken embryos had a pair of small, rounded bones that looked like those in a dinosaur, like archaeopteryx, or in any other reptile – like an alligator…This was unexpected and demonstrates the way in which a single, simple developmental mechanism can have wide-ranging and unexpected effects". So, now we know how birds got their beaks.

New type of stem cell identified

Stem cells are mother cells that have the potential to become any type of cell in the body. One of the main characteristics of stem cells is their ability to self-renew or multiply while maintaining the potential to develop into other types of cells. Stem cells can grow into cells of the blood, heart, bones, skin, muscles, brain, or any other tissue.

Stem cells can be of different types. Pluripotent stem cells possess the capacity to divide for long periods and retain their ability to make all cell types within the organism. The best known type of pluripotent stem cell is the embryonic stem cell present in embryos that helps babies grow within the womb. Research has enabled scientists to derive pluripotent cells from adult human skin cells. These are termed induced pluripotent stem cells or iPS cells. Scientists have recently discovered a new type of pluripotent stem cell that could be easier to grow in the lab than embryonic stem cells. It could help provide a model for early human development and eventually allow human organs to be grown in large animals such as pigs or cows for research or therapeutic purposes. Scientists previously knew about two other types of pluripotent stem cells, but growing them in large numbers or guiding them to mature into specific types of adult cells has proven difficult.

The new type of pluripotent stem cells were isolated from early mouse embryos and from monkey and human stem cell lines by Juan Carlos Izpisua Belmonte, a developmental biologist at the Salk Institute for Biological Studies in La Jolla, California, USA and his colleagues, while attempting to graft human pluripotent stem cells into mouse embryos (*Nature*, 6 May 2015 | doi:10.1038/nature14413, 2015). The new cell type is easier to grow in vitro and grafts into an embryo when injected into the right spot. The researchers call them region-selective pluripotent stem cells (rsPSCs). According to the researchers, because the region-selective cells grow more quickly and stably than other pluripotent cells, they may be more useful for developing new therapies.



In this image, a novel type of human stem cell is shown in green integrating and developing into the surrounding cells of a nonviable mouse embryo. The new stem cell, developed at the Salk Institute, holds promise for one day growing replacement functional cells and tissues. (Credit: The Salk Institute for Biological Studies)

Belmonte and colleagues discovered the new cell type when trying to transplant known types of human pluripotent cell into mouse embryos *in vitro*. They found that the cultured pluripotent cells did not graft well into the mouse embryo. To pinpoint the factors that could be preventing the grafting, the researchers injected the human cells into three different regions of a 7.5-day-old mouse embryo. Thirty-six hours later, only the cells that were grafted into the tail of the embryo integrated and differentiated into the correct cell layers, forming a chimeric embryo – an organism with DNA of different origins. Because these cells seemed to prefer one part of the embryo, the researchers dubbed them 'region-selective'. The researchers further found that they could easily use DNA-cutting enzymes to edit the genomes of the region-selective stem cells, which is usually hard to do in pluripotent cells grown *in vitro*.

While the researchers are hopeful that the new stem cells would make it possible to grow human organs in animal systems, they acknowledge the concerns that immunity issues and ethical questions about creating viable human-animal hybrids would raise. Belmonte says, "The ethical implications behind creating a human-animal chimera for the purpose of obtaining human tissues and organs to save lives of millions needs to be carefully evaluated."