

VIGYAN PRASAR

DREAM²⁰¹⁷

January 2020 • Vol. 22 • No. 4 • Rs. 5.00



Nutritious Kiwi



**INTELLIGENT
CREATORS**



Time to redefine adolescence?

Welcome Twenty Twenty



Nakul Parashar

Wishing you a very happy new year – 2020.

As we step into 2020, I remember the book – India 2020, A Vision for the New Millennium. This book was authored by our beloved scientist and former president, Dr APJ Abdul Kalam with Dr YS Rajan in 1998. “I want to live in a developed India”, a ten-year-old girl had answered when Kalam during one of his lectures had asked about her ambitions. This book describes Kalam’s vision to see India emerge as one of the world’s top four economic and scientific powers by the year 2020. Based on statistical data and Kalam’s analyses, this book emphasises the importance of science and technology in developing a nation. An amazing, inspiring book with thirteen chapters that paves a path for generations to tread upon. Still relevant, this book emphasises on how planned and meticulous manufacturing and services sector can contribute to India of 2020. In tune with Kalam’s vision, our nation, continues to gallop forward with numerous technological advancements on a regular basis. Efforts are being made to connect scientific and technological research with common masses. Effective dissemination thus, is the key despite factors galore!

We all realise how important is the role of language in effective dissemination of knowledge. At Vigyan Prasar, we realised

its importance a year ago. Besides Hindi and English, we embarked upon effective science communication, popularisation, and extension in Bangla, Urdu, Tamil, Kannada and Gujarati. It’s time to go beyond these five and add Telugu, Malayalam, Marathi, Punjabi, Odiya, Assamese, and Nepali to the list. A monthly newsletter in each of these languages has been our first step last year. Encouraged by its acceptance, this would continue to be the first step in the new languages too that we take up in 2020. Books written originally in the corresponding language have also been well accepted and appreciated. We plan to increase the number of titles in this year. Needless to emphasise, we invoke the spirit of an author hidden in each of us and invite you to send us your manuscripts.

Besides periodicals and non-periodicals, electronic media continues to play an important role. We started a DTH and an OTT channel in 2019. The DTH channel, known as DD Science, is a one-hour slot on DD National. In this direction, all efforts are on to increase the period from one to two hours per day and later on, from two to four hours per day. Undoubtedly, content is the king.

Indiascience.in – the OTT channel – would see some positive changes in the new year. Named as Engage, the feedback

mechanism for this project would be launched very soon. It would help us and our producers of TV content to continually improve upon all three service level agreement parameters – turnaround time, quality and viewership satisfaction.

Our endeavour in digital media in the coming year would witness a brand-new portal and an app for hand-held devices. This would contain a platform for readers to send letters-to-editors, blogs, and even videos.

On the social media side, Vigyan Prasar would continue to build up new and much more effective content. A series of relevant content, especially on health is going to be our first focus. These short films/clips would bring to you the latest in healthcare and most common ailments. Later in the year, we intend to bring to our readers more about biosciences, and AI and robotics.

For the moment, it is all about accelerating the growth of science communication, popularisation and extension – initiatives that we started in the past year to the next level.

Mantra for this – well begun is half done! Isn’t it?

Wishing all of you a very happy new year!

Email: nakul.parashar@vigyanprasar.gov.in ■

Editor : Nakul Parashar
Associate editor : Rintu Nath
Production : Pradeep Kumar
Expert member : Biman Basu
Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016
 Tel : 011-26967532; Fax : 0120-2404437
 e-mail : dream@vigyanprasar.gov.in
 website : <http://www.vigyanprasar.gov.in>

Vigyan Prasar is not responsible for the statements/opinions expressed and photographs used by the authors in their articles/write-ups published in “*Dream 2047*”

Articles, excerpts from articles published in “*Dream 2047*” may be freely reproduced with due acknowledgement/credit, provided periodicals in which they are reproduced are distributed free.

Published and Printed by Dr. Nakul Parashar on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 and Printed at Chandu Press, 469, Patparganj Industrial Estate, Delhi 110 092 Telefax: 22424396, 22526936.

Intelligent Creators – Human Gods of 21st Century



Govind Bhattacharjee

Finally we have the pinnacle of artificial intelligence, with which we can even surpass the limitations of our organic bodies – to free our minds to roam among the vastness of the cosmos, among the galaxies and intergalactic clusters and beyond. That will be achieved through digital immortality. The Human Connectome Project launched in 2010 aimed to map the entire human brain and to build its "network map" (connectome) to connect its structure to function and behaviour.

In November 2018, the scientific world was badly shaken by an event that occurred in China. It led to heated debates in various corners of the globe, projecting terrifying scenarios about the future of humanity and demanding immediate government intervention. It revived the old debate on the question of ethics and morality vis-à-vis scientific progress.

In that month, two girls, twin babies named Lulu and Nana, were born in Shenzhen in South-Eastern China, a modern metropolis that links Hong Kong to China's mainland. The twins apparently had their genes modified before their birth to make them immune to HIV infection. The process, with their parents' willing consent, was conducted by a team of scientists from the Southern University of Science and Technology (SUST) working under Dr. He Jiankui. The technology used would, according to experts in the field, improve their cognitive abilities and possibly make them smarter than otherwise normally-born babies. Lulu and Nana are thus the first "designer babies" born into this world, so-called "enhanced humans". The long-term effects of such genetic manipulation upon their cognition or health, and whether the mutation can be passed on to the offspring and if so, with what consequences, are as yet matters of speculation. The parents of the babies declined to be identified or interviewed, and Jiankui refused to share any data about where they lived or where

the work was done. His claim could not be independently verified and since it has not been published in a journal, there is no possibility of the claim being subjected to closer scientific scrutiny and validated.

The technology allegedly used by the team is known as CRISPR, which is a simple and powerful tool for editing genomes applied extensively in plantations for correcting genetic defects, treating and preventing the spread of diseases and improving crop yield. CRISPRs, a shorthand for CRISPR-Cas9, are specialized strands of DNA. The protein Cas9 is an enzyme that acts like a pair of molecular scissors, capable of slicing strands of DNA. Microorganisms like bacteria and archaea use CRISPR-derived RNA and proteins like Cas9 to foil attacks by viruses and other foreign invaders by chopping up and destroying their DNA. Transferring these components into other more complex organisms enables scientists to manipulate or 'edit' their genes. The gene that was modified in Lulu and Nanas' case using CRISPR was CCR5, which the HIV virus needs to inject itself into the human blood cells.

In 2016, Alcino J. Silva, a neurobiologist at the University of California, Los Angeles, and Miou Zhou, a professor at the Western University of Health Sciences in California, showed how removing the CCR5 gene from mice could give a significant boost to their memory. Thus the gene was found linked to their cognitive abilities; it

The author is an ex-bureaucrat, currently a Professor at the Indian Institute of Public Administration, New Delhi. He has authored a trilogy on evolution published by Vigyan Prasar: *Story of Universe*, *Story of Evolution* and *Story of Consciousness*.
E-mail: : govind100@hotmail.com.

was also found helpful to human brain to recover itself after a stroke. The SUST team apparently used CRISPR to edit CCR5 out of the twins' DNA when they were still only embryos. The team claimed that some of the 31 embryos they had edited had gone on to become pregnancies, so some more designer babies may be waiting to be born, ushering in a community of smarter superhuman beings upon Earth. Most countries have banned the use of such experimental technology on humans, unsure how the DNA changes will affect the recipients of genetic mutations with unforeseen side-effects, transmitted to future generations with what effect. The claim unleashed a volley of global condemnation, forcing the Chinese government to open an investigation into this issue. In June 2019, China announced stiff fines up to five million yuan (US\$ 722,600) to control the use of human genetic materials in research without proper permissions, but fines are unlikely to deter such research. Even though Lulu and Nana's genetic code might have been edited in a medically improper manner, there is no dearth of potential "customers" – parents too willing to spend millions to have their designer babies who might be potential Nobel Prize winners, living encyclopaedias or future sporting or acting legends. Apparently after Silva's 2016 research was published, some unnamed, elite Silicon Valley leaders were expressing unusual interest in the CRISPR technology for upgrading their children's brains.

The idea of using science to "engineer" better humans is, however, not new, in fact it goes back to the times of Plato. Selective breeding was tried during the days of slavery to produce stronger slaves who could be more hardworking and productive. Slavery was abolished in 1865, but the idea of selective breeding reappeared in a different form. During the late 1800s and early 1900s, a new science called Eugenics was developed, thanks to the ideas of Sir Francis Galton, a respected British scholar and a cousin of Charles Darwin, who first used the term Eugenics meaning "well-born." The objective of Eugenics was to improve the human race by selectively mating people possessing

specific and desirable hereditary traits. Galton tried to identify the reasons behind the success of the members of the upper class elite society in Britain and attributed this to their genetic makeup. Genetics was an infant science in the first decade of 1900, but following the experiments of Johan Gregor Mendel in the 19th Century and the famous study of Thomas Hunt Morgan in 1906 with the fruit fly *Drosophila melanogaster*, it was conclusively established by the end of the decade that genes are responsible for thousands of inherited characteristics of individuals.

Galton's plans to improve the human race through selective breeding, however, could not be tried in Britain, but they spread in the USA in the late 19th century, where scientists turned their focus on preventing



the transmission of negative or "undesirable" traits from one generation to the next – in fact, in 1911, a Eugenics Records Office (ERO) was established in Cold Spring Harbor, New York, to track the family histories of Americans to identify the people deemed unfit – they no doubt were from poor families, immigrants, minorities and persons with low standing in society. As a result, apart from stricter immigration rules, a government-run programme to sterilise "unfit" individuals was launched to prevent them from passing on their "negative traits", which were believed to be associated with mental illnesses, alcoholism, criminality, chronic poverty, blindness, deafness, feeble-mindedness, promiscuity, etc. It is believed that around 65,000 Americans were sterilised

during this programme which continued almost till 1915.

Meanwhile, during the 1930s, in Europe, another philosophy called "evolutionary humanism" was taking deep roots, especially in the Nazi-ruled Germany. It took a cue from the Darwinian theory of natural selection – the primary driver behind evolution that enforced the law of survival of the fittest. Natural selection ensures this by weeding out the unfit and ensuring the continuity and proliferation of better-adapted species. In the struggle for existence, competition was the key that ultimately ensured the survival of the fittest. Evolution does not give a damn to ethics, and hence from the evolutionary viewpoint, there is nothing wrong, immoral or unethical, in making the better, stronger, and fitter humans subjugate the weak and infirm, in the same the way that we humans feel no qualms in condemning millions of hapless chickens, pigs, cattle and other livestock to live a life of unending miseries before ending up with the butchers' knives.

Evolutionary Humanism propagated that in order to make the human race stronger and better, we need to eliminate the weaker humans; in this process, there is only a cold logic and no morality involved at all. It claimed that by protecting the weak and the infirm in the name of human rights, we ultimately harm the human race and preclude the possibility of its advancement. Nazis believed that those who refuse to recognise this simple truth couldn't and ought not to survive, and they justified the Holocaust, the Concentration Camps and all their unspeakable atrocities by this sinister logic. Once the horrors became known after the War, Eugenics lost its appeal and was all but forgotten.

Memories fade but do not die easily. With advancement in genetics, it gradually became established that a few specific genes were responsible for some debilitating, life threatening diseases. Thus, by substituting these problematic genes in their embryos, humans could be freed from these diseases and debilities that might affect them, sometimes fatally, in future. Within the cells in a human body, there are tiny organelles

called mitochondria, which produce energy for the cells and which have their own sets of genes and hence DNA molecules which constitute the gene and mutate like the other living molecules. In case the mutation produces a defective mitochondrial DNA which is transmitted to the offspring, it often leads to diseases and debilities in them. The mitochondrial DNA, however, are quite different from the DNA in the cell nucleus, and if the problematic mitochondrial DNA could be removed somehow, then the genetic diseases and debilities would not be transmitted to the offspring. Thanks to bioengineering, it is possible to remove the problematic genes using a third parent for a baby, whose nuclear DNA would come from her natural parents, while the mitochondrial DNA would come from a third person who does not have those defective genes. The procedure is banned in USA but was recently made legal in UK in 2015. CRISPR of course takes this possibility way ahead, ignoring all ethical and even biological consequences.

The debate between intelligent creation and evolution through natural selection is an old one, dating back to 1859 when Darwin's *Origin of Species* was published. The Christian Church held the Bible as the ultimate immutable truth, and fiercely contested and ridiculed the theory. But over the course of the next century, the Church was unable to disprove the huge mass of evidence that came up in support of Darwin and slowly lost its appeal as the last word in matters temporal, physical and spiritual. God lost his place and was slowly replaced by science and technology. Evolution came to be established as the ultimate truth, and creation was relegated to fiction. Humans came to believe that there is no intelligent design behind our world, and there exists no omniscient and omnipotent creator God who guides the destiny of billions of humans. In the 21st century, man is now assuming the position of god. He is becoming the intelligent creator who can, in fact, manipulate the existing life forms to

create altogether new forms of life.

In 2000, Eduardo Kac, a Brazilian artist, conceived what he thought was a new work of art – a fluorescent green rabbit he named Alba. A French laboratory he contacted, run by French geneticist Louis-Marie Houdebine, agreed to produce the creature according to his specifications, of course in exchange for a fee. Houdebine took an ordinary white rabbit embryo, and implanted in its DNA a gene known as GFP, actually a protein, found in the jellyfish, *Aequorea victoria*, that fluoresces green when exposed to blue light.

When Alba was exposed to such light, she literally glowed green. Alba is an animal that did not exist in nature, and was a product of conscious intelligent design. What effect,



if any, the genetic manipulation had in her mental world (rabbits do have a mind and emotions as the author knows from his own experience with his pet rabbit for 7 years, now dead), would however never be known. In 2002, a US reporter published an article stating that Alba was dead; her creator, Houdebine, contended that the GFP gene played no role in the poor animal's demise.

Since then, we have had many such examples of scientists trying to play God, with some their creations bordering on the bizarre and the creepy. In 2007, South Korean scientists produced a glow-in-the-dark cat by changing her DNA to make it glow in the dark; further, they took that DNA and cloned other cats from it – creating a line of fluorescent felines.

We had an 'Enviro-pig', called "Frankenswine" by critics. Pig manure is used by farmers as fertilisers, which often enters the water bodies or running streams.

Being rich in phytate, a form of phosphorus, it results in making algal blooms that deplete oxygen in the water, killing marine life. Adding the bacteria *E. Coli* and mouse DNA to a pig embryo, scientists created the environment friendly Enviropig that could better digest and process phosphorus, and thus reduced their phosphorus output by 70 per cent.

We have a goat that produces a spiders' web protein in its milk, which is used to manufacture a web-like material called Biosteel. Spider silk is highly valuable and can be used to produce a host of products from artificial ligaments to parachute cords. We have a genetically modified Atlantic salmon that grows much faster than usual, having an added growth hormone from a

Chinook salmon that produces growth hormone all the year-round. We have genetically engineered less-flatulent cows that produce 25 per cent less methane, a greenhouse gas produced by the cows during their digestion process, mice that chirp like birds (utility unknown, may be free entertainment of a different kind), the 'hamster' – a hamster that hums, produced in a bizarre experiment of injecting human sperm into a hamster's egg cell – something like a human-hamster hybrid,

besides bioluminescent fish, mouse, dog or even monkey – some of these are even available commercially.

Businesses and corporations are driving and funding such research, obviously for making profit and some of them are indeed earning loads of it. There is no end to such Frankenstein-esque adventures, or limits to bizarre ideas and experimentation. There is a species of voles, stout rodents which are highly promiscuous, except one form that exhibits strong monogamous tendencies and lasting relationships with their mates. Scientists claim to have isolated the gene responsible for their monogamy, and the day may not be too far when for arresting the socially-disturbing and persistent promiscuous behaviour of humans, the State may decree implanting the genetic material of monogamy from this vole species on every human embryo so that the humans will remain faithful to their mates all their

lives and thereby promote order in society! Huxley's *Brave New World* may just be waiting around the corner.

Much before *Jurassic Park* had fired our imagination, scientists had conjectured on bringing the prehistoric animals back to life. Now the plot seems closer to reality than science fiction. After succeeding in reviving the genetic material of an extinct predator called the Tasmanian tiger, a 2.7-metre-long giant marsupial that became extinct in 1936 from excessive hunting by humans, scientists are now trying to reverse-engineer a dinosaur from chicken (birds evolved from dinosaurs) by altering chicken genes known to have evolved since the Cretaceous. And not just dinosaurs, in a weird quest to inseminate an Asian elephant with woolly mammoth sperm and selectively breed a prehistoric woolly mammoth that became extinct some 3,800 years ago, Japanese scientists Kazufumi Goto and Akira Iritani along with Russian collaborators Kazutoshi Kobayashi and Pyotr Lazarev are trying to resurrect the prehistoric animals in a new form. The only difficulty is to find the intact genetic material to be used for fertilising a living elephant egg. It may not be mere fantasy – under the Siberian permafrost, mammoth bones or hair may still be lying intact, and that would help breed a line of creatures that would be increasingly mammoth. Unfortunately, the material – mammoth tissues found so far, is frozen and decayed, and the mammoth clone, supposed to have been produced by 2016, is as yet unborn.

Much of the cutting-edge research in genetics and bioengineering is funded by large pharma companies, for obvious reasons. In 1997, a bizarre photograph was published in newspapers and science journals across the world. It showed a hairless mouse with a human ear growing out of, and almost covering, its entire back. The photograph caused revulsion among scientific community and laymen alike and protests against genetic research became ever more louder. However, this was not a case of genetic engineering, neither was there any human DNA implanted in the mouse cell. The ear was actually grown from the cartilage cells taken from a cow and planted on what is called a “nude mouse” – one without any hair and without any immune system as well – the result of a random laboratory mutation. Though the absence of hair was immaterial, the lack of the immune system was critical

for ensuring that the mouse would not reject the foreign cartilage cells. The cells were moulded into the shape of a human ear, which of course could not be transplanted onto any human, which, being composed of cow cells, would automatically be rejected by the recipient human's immune system. This was rather a case of tissue engineering, but it showed the possibilities, ignoring the poor creature's suffering. The brains behind the experiment were two brothers – Harvard surgeons Joseph and Charles Vacanti, and an MIT engineer Bob Langer.

A human ear is indeed difficult to repair, having a complex shape and structure and made of cartilages and. If spare human ears, or for that matter any human organs, could be grown on an animal, the answers to some of the trickiest medical problems – sickness, old age and death – which have tormented humanity through the ages could be found. Old organs can then be replaced, and humans can be given a fresh lease of life by harvesting fresh organs grown on the bodies of animals whose only purpose in life would be to grow and supply them and die for humans. Ethics and morality be damned, humans are the new Gods with almost divine powers of creation and destruction, and it would be their ‘divine’ right to demand sacrifices of animals, like they have always been sacrificed before our imaginary Gods and may be, even now.

The same tissue engineering technology was indeed used by the Vacanti brothers on 12-year-old Sean G. McCormack, who was born without any bone or cartilage on his left chest, something known as the Poland's Syndrome, with his heart and lungs being protected only by the bare skin. The surgeons used the boy's own cartilage cells to grow a ‘chest plate’ the size of a CD on a synthetic biodegradable polymer moulded into the shape of his chest, and the seeded cartilage was then planted in his chest which continued to grow with him. Thus the technology is proven, and it is only a matter of time before it will be upgraded to serve human needs. The boundaries between medicine, ethics, religion and morality here get extremely blurred, but predictably such esoteric issues will not deter the humans from reaping the benefits of technology for their own good.

As Yuval Noah Harari says in his book *Homo Deus*, “humanity's next targets are likely to be immortality, happiness and

divinity. Having reduced mortality from starvation, disease and violence, we will now aim to overcome old age and even death itself.... We will now aim to upgrade humans into gods and turn *Homo sapiens* into *Homo deus*.”

Biological engineering is not the only tool that we have to turn humans into gods. There is bionic engineering – in which our bodies and even our minds may be reengineered to make us hybrid creatures – hybrids of organic body and inorganic devices like microchips or bionic hands, feet, eyes or ears; in other words, cyborgs – humans with upgraded sensory and other organs. Several of them already exist, being able to overcome their physical handicaps and disabilities inherited from birth or from accidents, and to lead their lives meaningfully, enjoying abilities much enhanced than their bodies would otherwise allow. One day, this engineering would allow us to overcome the limitations of our senses and vastly extend their outreach much beyond what our wildest imagination can conceive. Harari talks about a mind-reading helmet that can read the electrical signals passing through the brain and obeys the commands that the human minds conjure up as images, like turning the bedroom lights on or off.

And of course, finally we have the pinnacle of artificial intelligence, with which we can even surpass the limitations of our organic bodies – to free our minds to roam among the vastness of the cosmos, among the galaxies and intergalactic clusters and beyond. That will be achieved through digital immortality. The Human Connectome Project launched in 2010 aimed to map the entire human brain and to build its “network map” (connectome) to connect its structure to function and behaviour. Once the neural structure of the brain is completely unravelled, the state of the physical body will become redundant, while the mind can be uploaded into a computer that could control a robot that replicates a human in every respect. Our consciousness can then be dissociated from the physical body. While the mind remains trapped permanently inside the computer, its robot connectome will be free to explore the galaxies and experience its sights and sounds, heat and dust.

Will that also be the end of humanity as we know? ■

Tales of Fixing the Tails



Ajay Kumar

“Augmenting Writing Skills for Articulating Research (AWSAR)” is an initiative of the Department of Science and Technology, Govt. of India. It aims to disseminate Indian research stories among the masses in an easy-to-understand and interesting format. Under this initiative, PhD scholars and Post-Doctoral Fellows in science and technology are encouraged to write at least one popular science article during the tenancy of their fellowship and to participate in a national competition. For Ph.D. researcher, the top three essays are awarded a cash prize of ₹1,00,000, ₹50,000 and ₹25,000 respectively. For Post-Doctoral Fellows, the best essay is awarded the cash prize of ₹1,00,000. Apart from these, top 100 entries from Ph.D. and top 25 entries from Post-Doctoral Fellows are awarded ₹10,000 each, along with Certificate of Appreciation. For more information log-on to <https://www.awsar-dst.in/>

The article “**Tales of Fixing the Tails**” written by Ajay Kumar was awarded second prize in Ph.D. scholar category in AWSAR 2018.

“I don’t like this face mask. It looks very ugly on me”, rebelled Vedant, a selfie-conscious teen, while having a family evening stroll in the smoggy lawns of IIT Delhi.

“Papa why do everyone walk-with-these-masks?”, exclaimed Aarav in rhyming style, while jumping on the bandwagon of curiosity with his elder brother.

“Look, my boy”, I started to explain, but was cut short immediately by *The* lady

of the house, “No technical jargon, please”, pleaded the student of literature.

“OK”, I promised in order to earn a green nod from my lady. “So, these masks save us from the pollutants present in the air. Vehicles around us exhale many dangerous gases from their tails”, I said.

“Oh, like dragons fire from their mouths”, wondered the movie buff Aarav.

“Yes, but that will be more fitting for

chimneys of factories”, I responded.

“Can’t we fix these polluting tails and appear again like humans on our evening walks?”, was the most difficult question of the day asked by a visibly upset Vedant.

He awakened the researcher inside me and I responded enthusiastically, “Yes, people are trying and I am also playing a part in the solution. My research is focussed on developing materials for alternate power

sources that are non-polluting and efficient". I guess, the discussion made their mom conscious and turning around she signalled for concluding the walk and the talk, both. Obviously, we obliged with silent gestures of continuing later.

On the way back home, I remembered many intense discussions held in our research scholars' room on the delicate situation of our environment. Overdependence of human race on the fossil resources for the survival and the unsustainable growth has nearly depleted the rich coffers of earth, which took millions of years to build up, within a century. Moreover, our hunger for energy-intensive essentials and comforts of life are severely polluting the air, water and land systems. Till date, the extraction of energy from the non-renewable fossil resources as in thermal power plants (roughly 30%) and automobile engines (20-30%), has been very inefficient. Nuclear and hydro power sources have their own complications, viz, safety concerns and disastrous ecological footprints. Undoubtedly, we need cleaner and efficient sources of power to extend our survival on earth. Solar cells seem to be rising on global scale but they too struggle with their efficiency issues.

Fuel cells and specifically, Solid Oxide Fuel Cells (SOFCs) are among the most promising candidates, which produce power very efficiently (approx 80%) and more importantly, they release only pure water vapours from their tails (exhaust), when run on hydrogen and oxygen. They have been successfully tested and have the added advantage of efficient extraction of power from these fuels as compared to conventional routes.

"So, what do you develop in your lab?", thus started the questions of my big boy, as we entered in our lobby.

"OK, just settle down and listen", I started to explain the partial intricacy of my graduation journey to our school boys. "You know it well, how much we are dependent on electricity in our daily lives, but do you know how much power is lost midway before it reaches our home? It is more than one-third. Even the vehicles around us burn their fuel very inefficiently and worse, we also get life-threatening pollutants like NO_x , SO_x and particulates from them.

Now, just imagine a power-producing device that has no moving parts, no irritating noises and is thin as a paper of

sheet. Interestingly, this compact device has a very clean tail (say exhaust) giving out pure water vapours. And it is not even like your gadget's battery that drains every now and then. As long as you supply it the fuels (say gases), you can generate clean electric power silently. A small suitcase-size unit of it can power our entire house, non-stop. It is called solid oxide fuel cell or SOFC, in short"

"Oh, is it so?", with surprise in his eyes, Vedant continued, "So, is that what you make in your lab?"

"Yes, we do that, but partially. I mean, we develop and test the performance of some components of these solid oxide fuel cells", I responded.

My response made him wonder, "Do you mean that this paper-size fuel cell has many components, really?"

"Of course, a single SOFC has a solid electrolyte sandwiched between two electrodes", I said.

"Sandwich! Oh yeah...hhh, my favourite", shouted the youngster, making us laugh with his unwavering attention to catch possibly the only meaningful word that made sense to him.

"Look, this is a rough sketch of SOFC", I drew on a paper, as in the figure.

To get some useful chunk of power, we need many cells because a single cell of one square centimetre area can generate only around 1 watt of power. So, another component known as interconnect comes to our aid and depending on the requirement, we join multiple cells using these interconnects. Though, the electrolyte and electrodes of a SOFC are made up of ceramic materials (as they have to transport ions across them), the interconnects can be made using metals also, while operating at lower temperatures."

"What do you mean by lower temperatures?", interrupted Vedant.

"Oh, I forgot to tell you that latest generation of SOFCs operate between 600-800°C. Wait wait..., I got your 'why' signal. It is because the chemical reaction, rather the electro-chemical reaction (as it involves electrons), needs that high temperature, to take place. Actually, for this reaction, the ions need to be pushed across the reluctant solid electrolyte and thus, that much thermal push is necessary to overcome the ionic distaste of electrolyte.

Thus, a single unit of SOFC is a layered structure consisting an interconnect,

anode, electrolyte and cathode, as you can see in the drawing. Combination of many such cells is known as the 'cell stack'. Now, let me explain about my contribution in this context", I set the pace.

"But papa, do we need some special fuel to run this device", asked a puzzled Vedant.

Also, I noticed that the young boy was already zooming in his dreams, so I tranquillised him with little heavier dose, "In ideal case, hydrogen gas on anode and oxygen gas on cathode will yield the maximum power output and pure water vapours from exhaust. But for practical purposes, air can be used at cathode side and many common fuels like biogas, syngas and gasoline can be efficiently utilised on anode side. Extra heat can also be put to use, if the situation demands".

So, as I mentioned earlier, metals can also be used as interconnects. But, they face many restrictions in their selection. In addition to their good electrical conductivity, they must have matching thermal properties with other ceramic components and must be stable in both hydrogen and oxygen environments in such hot condition. My work is related to improving the properties of such metallic interconnects, so that the life and performance of SOFCs stack can be enhanced."

"Hmmm...", he nodded slowly.

"We fabricate specific-grade stainless steel alloys and study their degradation behaviour under operating conditions of SOFCs. We have developed new and innovative routes to fabricate such alloys. Also, in our lab we test the interaction of these interconnects with cathode materials at high temperatures to look for their compatibility. And I can say that till now the results have been promising at lab scale".

"I think that much is enough for today. Though, I can't claim to understand everything you said but at least your 'tales of fixing the tails' seem interesting and are definitely part of the solution. I will read more about solid oxide fuel cells and get back to you with more doubts", Vedant hummed slowly and slipped into his bed swiftly.

"You people are still talking. Look at the clock! Switch off guys", commanded the slumberous voice. Lights went off immediately.

Time to redefine adolescence?



P. Surat

“20 Jan 2018 – A teenager, aged 18, shot his principal in her office as she ‘insulted’ him in front of his class in Haryana”
“Anita was concerned when she saw her eight-year-old develop tell-tale signs of puberty—acne, deepening of voice, and physical changes”.

These two examples show seemingly disparate issues: the increasing incidence of adolescent crimes across the globe and a consequence of the early onset of adolescence in children – both girls and boys (8-9 years). But they also hit at the defining questions of adolescent research—what characteristics define the beginning and end of adolescence? Can we define an eight-year-old undergoing puberty as an adolescent? At what age does an adolescent magically transform into a responsible adult? Is there a mysterious switch at the age of 18, which transforms an unruly teenager into an adult? This question also frequently comes up in juvenile crime scenes where an oft-repeated debate is if a 16/17-year-old should be testified as an adult or an adolescent?

Between 1949 and 1971, an American obstetrics and gynaecology specialist Dr. James Tanner performed a series of tests on young boys and girls to mark the various physical changes that mark adolescent growth. These boys and girls were from a charity-run institution near London (UK) that took in neglected youths, who were subjected to various tests that measured different physical features in each individual. This study led to the development of the famed ‘Tanner scale’ still used today to characterise the physical changes in teenagers.

The age bracket of 13-18 for an adolescent was defined almost 40 years ago. With the changes in the onset of adolescence, delayed social targets such as marriage and job, which used to define end of adolescence, and changes in the nutrition and diet, there is an urgent need to revisit how we define the period of adolescence.

The definition

The onset of adolescence is marked by several physical and observable features, such as accelerated height gain and voice change in boys; breast development and menstruation in girls. Tanner divided the youths into five stages based on their physical features alone: growth, beginning of menstruation, breast development, and pubic hair in girls; growth, pubic hair and development of genitals in boys. Stage I (age 9 and younger) is the pre-puberty stage followed by stages II, III, and IV. Menstruation and complete breast development in girls mark Stage V (age 14 and older), whereas increase in genitals signifies the final stage in boys. Although this scale is still widely used, it has come under a lot of contention as it is based only on the maturity stages of sex organs and not the actual age of the youths. Also characterisation of the end of adolescence is still very controversial. The start of puberty

P. Surat has done PhD in life sciences from Tata Institute of Fundamental Research (TIFR), Mumbai in Jan 2016. She is currently working as a science writer and editor.

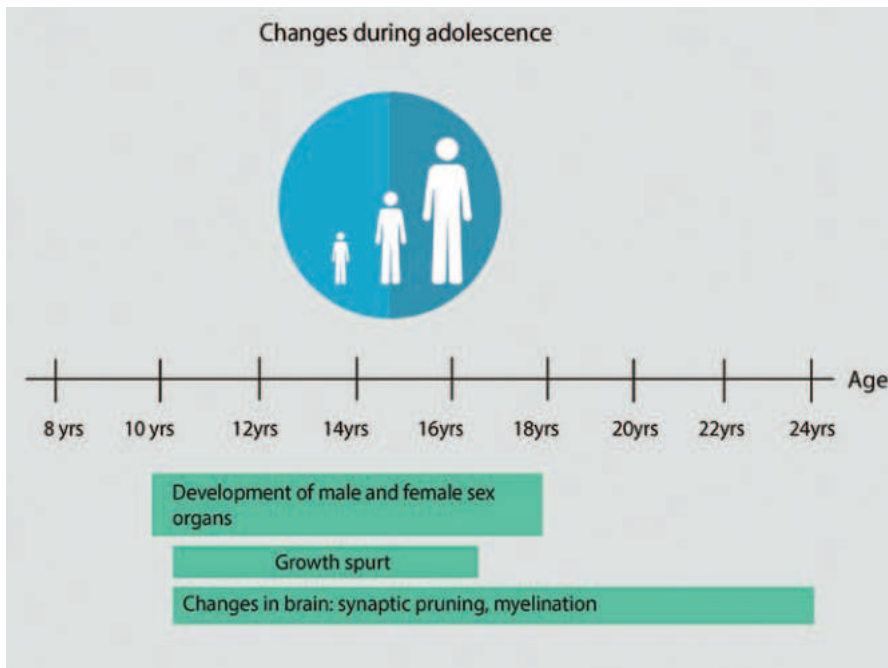
is marked by specific changes, but the end of adolescence does not have any clear traits. Although most of physical changes are complete by 16 or 17 years of age, some features such as development of wisdom teeth occur only in mid-twenties. Conventionally, this 'end' has been marked with taking up more social roles, including occupation, marriage and parenthood. However, as the timeline of school, job, marriage, and children has become more fluid, the demarcation of the end of adolescence has also become murky

Adolescence— a medley of physical, neuronal, and emotional changes

Adolescence is marked not just by physical changes – but also changes in brain and behaviour. In a study, the Centres for Disease Control and Prevention (CDC) in USA has found that the death rates are three times higher in adolescents than in middle-school children. The primary causes of these deaths were motorcycle crashes (30%), unprotected sex (39%), suicide (15%), and homicide (15%). It is well established that adolescents are more prone to taking risks. Evolutionarily, this can be explained, as risk taking leads to learning new skills and encountering newer experiences which provide more tools for survival and locating potential mates. However, this risk-taking behaviour has potential benefits as well as pitfalls.

As children progress into adolescence, they also start processing risk perception or visualise a situation and decide if it is risky or safe. Typically, behaviour can be divided into 'hot cognition' and 'cold cognition' where 'hot cognition' is thinking in highly emotional situations, whereas 'cold cognition' is thinking under not-so-intense situations. Teenagers have been found to perform poorly in 'hot cognition' situations.

Studies have mapped different brain



regions to find the neural basis behind these behaviours. It was found that amygdala, the region of the brain responsible for emotions and moods, increases in size during the pre-adolescent and adolescent years (9-11 years), contributing to the development of emotional intelligence. In childhood, the size of grey matter increases, which indicates formation of increased connection or synapses between the brain cells. Interestingly, starting from adolescence, almost 50% of these synapses are pruned or cut. Connections which are least used are cut making way for a more efficient and adult-like brain. Apart from differences in growth or pruning of different brain regions, there are also changes in the speed and efficiency of how information travels in the brain. Information travels in the brain as electrical signals, and neurons are covered with a fat-rich insulating material called myelin which prevents the dissipation of this signal, helping it to travel faster. Signals travel up to 100 times faster in axons (projections of neurons) which have the myelin coating versus axons which do not. Research has found that myelination increases during teenage years. Thus, there is change not just in the number of neurons and connections, but also in the speed of transmission of signals during adolescence.

What are the timelines for these changes?

So what can we call the 'adolescent

years'? What is the magical age at which these changes in our brain and body transform a juvenile into adult?

Interestingly, although changes in brain volume and amygdala – the emotional centre of the brain – are complete by mid-childhood, other changes such as pruning and myelination continue into our 20s. These changes in brain structure and function affect decision-making, social and emotional response and general well-being.

For example, schizophrenia is caused due to excessive cutting of brain connections or pruning during teenage.

The onset of puberty is also not set in stone. In most countries, including the USA, UK, and China, puberty starts earlier now. The age of menstruation (a marker of puberty in girls) has reduced by almost four years in the UK. The earlier occurrence of puberty has been attributed to better nutrition and health in children. Thus, there is a shift in the onset of puberty to 10 years, while the developments of cognitive and emotional centres happen into our 20s. In the January 2018 issue of the *Lancet*, scientists proposed that new age bar of 10-24 years better represents today's adolescent age rather than the Tanner scale of 13-18 years proposed in 1981.

Conclusions

Although some data is beginning to emerge from developed countries, studies from middle- and low-income developing countries on adolescent research and their mental and emotional development during different age strata is lacking. This information is critical in how we raise and define our teenage population. The absence of investment in resources and research in our adolescents is going to impact on how our future generations shape the world.

Ritucharya: Developing food habits in harmony with nature



Asmita Chhabra

Ayurveda considers living beings as an integral part of Prakriti-Purusha; the inseparable dyad of the manifest nature and pure awareness. No living entity can remain unaffected by the changes in nature. The nutritional habits are a function of the ever-changing nature. The ancient Ayurvedic practice of Ritucharya (or Rutucharya) aims to bring your nourishment in harmony with nature.

Food provides energy to the body and keeps it active. As per Ayurveda, what we eat eventually determines how we think. Therefore, food not only keeps us alive but also helps us remain healthy, dynamic, useful to society and at peace with our own self. Yet, we often ignore our dietary composition at great peril to our health. Most of us give precedence to taste over our well-being. This merits a question; should eating not be the most important function of our daily routine?

Ayurveda considers living beings as an integral part of *Prakriti-Purusha*; the inseparable dyad of the manifest nature and pure awareness. No living entity can remain unaffected by the changes in nature. The nutritional habits are a function of the ever-changing nature. The ancient Ayurvedic practice of *Ritucharya* (or *Rutucharya*) aims to bring your nourishment in harmony with nature.

There are two aspects of the *Ritucharya* system: whatever nature produces with changing seasons is best suited for the given environment and as thinking beings, humans should intake nature's offerings as per the environmental conditions. They should change their daily routines to meet this principle. However, factors like ignorance, work pressure and carelessness prevent us from doing so. Thus, this humble attempt to enlighten the common masses.

Today, better transportation and storage facilities have ensured availability of all fruits and vegetables at all places around the year. But unseasonal fruits and vegetables plucked unripe are not good from a nutritional point of view. These are expensive and not very nourishing. Therefore, it is better to eat only fresh fruits and vegetables.

Remember, our nutrition has to be in sync with nature. We should be mindful of what we eat in different seasons. Here are a few suggestions:

Winter

The winter season is considered as the time to replenish our health. We can not only regain lost health but also prepare for a healthy year ahead in winters with some precautions. Consider including the following in the diet during winters:

Enhanced roots: Root vegetables like carrots, turnip, and sugar beet are best for winters. Roasted carrot is a rich source of antioxidant beta-carotene whereas boiled turnip provides vitamin A and vitamin C. All root vegetables also provide fibres to the body and increase digestive bacteria in the small intestine. These food items also control sugar and fat in the blood thus preventing the risk of diseases like diabetes, heart ailments and intestinal cancer.

Ms. Asmita Chhabra has done M.Sc. and PGCC in diabetes education. She is a popular science writer and writes on health and diet related issues. Email: asmita.gupta@gmail.com

Below is the list of easily available seasonal fruits and vegetables:

Month	List of fruits	List of vegetables
January	Strawberry, grapes, guava, pomegranate, papaya, pineapple	Spinach, brinjal, tomatoes, cauliflower, cabbage, carrot, radish, peas, broccoli, capsicum, sugar beet, ivy gourd (<i>kundru</i>), turnip
February	<i>Chiku</i> (naseberry), grapes, melon, oranges, guava, papaya, pomegranate, pineapple, strawberry	Cabbage, <i>Methi</i> (Greek clover), carrot, radish, green onion, capsicum, broccoli
March	Watermelon, mangoes (naturally ripened, Totapuri, Badami), grapes, oranges, pineapple, bananas, melon, strawberry	Spinach, <i>Methi</i> (Greek clover), capsicum, carrot, <i>parwal</i> (<i>Gourd vine</i>), Indian squash (<i>tinda</i>), <i>petha</i> (ash gourd), pumpkin
April	Watermelon, mangoes, (naturally ripened, Totapuri, Badami), grapes, oranges, pineapple, bananas, melon, strawberry, jackfruit	Ladyfinger, cucumber, <i>karela</i> (bitter gourd), <i>chaulai</i> (Amaranthus), <i>lauki</i> (bottle gourd), <i>petha</i> (ash gourd), pumpkin, beans, ivy gourd (<i>kundru</i>)
May	<i>Jamun</i> (Indian blueberry), mangoes (Alphonso, Kesar), litchi, naturally ripened papaya, watermelon, melon, jackfruit	Spinach, cucumber, <i>lauki</i> (bottle gourd), <i>karela</i> (bitter gourd), beans
June	Mangoes (Alphonso, Dussehri, Kesar)	Spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato
July	Mangoes (Kesar, Dussehri, Totapari), peach, potatoes, <i>bukhara</i> (prunes), cherry	Indian squash (<i>tinda</i>), <i>lauki</i> (bottle gourd), <i>cichinda</i> (snake gourd), <i>karela</i> (bitter gourd), spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato
August	Mangoes (Kesar, Dussehri, Totapari), peach, potato, <i>bukhara</i> (prunes), cherry, <i>sharifa</i> (custard apple)	Indian squash (<i>tinda</i>), <i>lauki</i> (bottle gourd), <i>cichinda</i> (snake gourd), <i>karela</i> (bitter gourd), spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato
September	Guava, papaya, pomegranate, <i>sharifa</i> (custard apple), passion fruit	Indian squash (<i>tinda</i>), <i>lauki</i> (bottle gourd), <i>cichinda</i> (snake gourd), <i>karela</i> (bitter gourd), spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato
October	Guava, papaya, pomegranate, <i>sharifa</i> (custard apple), passion fruit	Brinjal, tomatoes, soya, green onion, Indian squash (<i>tinda</i>), <i>lauki</i> (bottle gourd), <i>cichinda</i> (snake gourd), <i>karela</i> (bitter gourd), spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato
November	Oranges, date palm, guava, papaya, pomegranate, <i>sharifa</i> (custard apple)	Brinjal, tomatoes, soya, green onion, Indian squash (<i>tinda</i>), <i>lauki</i> (bottle gourd), <i>cichinda</i> (snake gourd), <i>karela</i> (bitter gourd), spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato, French beans
December	Strawberry, oranges, sweet orange (<i>mausambi</i>), figs (<i>anjeer</i>), guava, <i>sharifa</i> (custard apple), pineapple	Brinjal, tomatoes, soya, green onion, Indian squash (<i>tinda</i>), <i>lauki</i> (bottle gourd), <i>cichinda</i> (snake gourd), <i>karela</i> (bitter gourd), spinach, ladyfinger, cucumber, <i>chaulai</i> (Amaranthus), <i>gvarphali</i> (cluster bean), corn, capsicum, sweet potato, radish, carrot, turnip, sugar beet, <i>ratalu</i> (yam), mustard, <i>bathua</i> (<i>Chenopodium album</i>)

Oats: It is ideal for breakfast. The zinc in oats increases the body's resistance against diseases. It also has soluble fibres that keep the heart healthy.

Vegetable soup: This is also a great source of nourishment in winter months. Soups should not contain excessive salt and cream. Better to avoid soups containing red meat though chicken soup does no harm.

We can also incorporate roasted grains (like gram and puffed rice) in our winter diet along with soups.

Broccoli and cauliflower: These also enhance immunity and prevent infections during winter months.

Spices and herbs: Spices like turmeric, cinnamon, black pepper, dry ginger and herbs such as *Kesar kasturi* keep the body

warm and prepare us to bear the harsh cold.

Sesame: Foods based on sesame are beneficial to cure respiratory ailments like tuberculosis, pneumonia and cough. Applying floured sesame seeds to hair removes dandruff.

Dry fruits: They keep body temperature high and nourish the body with iron and vitamins.

What food to avoid in the winter season

We should prefer dark green coloured vegetables to the ones that are light green. Better to desist from hot spices. Using ginger instead of red chilli is better. This helps keep the digestive system healthy and improves immunity against diseases.

Fresh corn is hard to find during winter months; Brussel sprouts can be used instead.

Milk, cream and cheese can increase the risk of infections in winter; almond milk, soya cream or soya cheese can be used instead.

Cauliflower is a better option than tomatoes in the cold season. Likewise, apples are preferable to peaches, tangerine is better than strawberry and grapefruit is healthier than watermelons during these months.

Summer

Incorporate food items of cold nature during the summer months to beat the heat. These could be some of the options:

Vegetables: *Chaulai* (Amaranthus), ladyfinger, *lauki* (bottle gourd), cucumber, *petha* (ash gourd), pumpkin, chilli, tomatoes, brinjal, beans, ivy gourd (*kundru*), *cichinda* (snake gourd), *karela* (bitter gourd), spinach, and *turai* (ridge gourd) are some of the major vegetables of summer season.

Chaulai (Amaranthus) is full of nutrients also found in red or green spinach and is cooked in a similar manner. It nourishes the body with vitamin A and vitamin B6 and helps maintain low body temperature. It is also helpful in preventing malaria and respiratory diseases.

Lauki (bottle gourd) helps cure acidity and prevents excessive thirst. It is also helpful in containing dryness and fatigue while keeping body temperature low.

Cucumber is beneficial against skin diseases. It contains silicon and sulphur which are necessary for healthy hair. Cucumber is also handy for strong immunity against diseases and strengthens the heart.

Petha (ash gourd) keeps the body cool, improves the urinary system, prevents the growth of body worms and nourishes the body. The potassium and fibres contained in ash gourd keep blood pressure and diabetes under check.

Cichinda (snake gourd) helps regulate the level of liquids in the body and thus

decreases dryness. It also improves the nutritional system of the body.

Karela (bitter gourd) helps prevent skin ailments like acne, pimples and scars. It is also beneficial against herpes, high blood pressure and diabetes.

Spinach saves from heatstroke, removes body swelling and removes toxins from the body.

Turai (ridge gourd) purifies the blood and prevents diabetes.

Petha (ash gourd) is rich in vitamin B1, B3 and potassium. It also saves from heatstroke. Ash gourd is also beneficial against blood and respiratory ailments and keeps the excretory system healthy.

Fruits: Watermelon, oranges, raspberry, *jamun* (Indian blueberry), apples, blackberry, pear, peach, apricot, strawberry, avocado.

Curd: It provides protein and probiotic. Curd not only keeps the body cool but also improves the digestive system.

Drinks: Water is indeed the best drink. Green tea is another healthy option. It contains anti-cancer ingredients, keeps bad cholesterol under control, improves heart condition, strengthens metabolism and helps fight against dementia.

Dry fruits: Almonds, watermelon seeds, cucumber seeds, *lauki* (bottle gourd) seeds, *petha* (ash gourd) seeds, pumpkin seeds, pistachio nut, cashew nut, groundnut, and walnut are good for summer months. Hydrate them and remove chaff before eating. Do not overeat dry fruit in summer.

What not to eat and drink in summer

It is better to avoid red chilli and hot spices, dry fruits, coffee, fried foods, and alcohol in summer.

Rainy season

The rainy season is humid, and temperatures are moderate during this season. Humidity means sweat does not dry easily and skin can be greasy. This season is also fit for the breeding of microbes therefore food items tend to get spoiled easily. The body tends to remain lethargic. One should prefer food that enhances immunity and keeps the body cool while keeping it energised. Below is the list of some of the suggested foods for the rainy season.

Vegetables: Beetroot, garlic, onion, ginger, *neem* (Margosa), *karela* (bitter gourd)

Grains: Barley, wheat, oats, corn, red lentils

Fruits: Pear, apple, pomegranate, mango, guava.

Spices: Turmeric, black pepper, cinnamon, green cardamom.

Dry fruits: Almonds

Drinks: Lassi made from curd, buttermilk, homemade soup, honey, ginger, black pepper mixed in hot water.

What not to eat and drink in the rainy season

Food that contains excessive sodium, and too much rice should be avoided. Better to avoid tomatoes and tamarind as they increase water quantity in the body. Intake of meat and fish should be minimised. Drinking too much tea and coffee must be avoided.

Better to avoid eating potato, cauliflower, ladyfinger, sprouted grains, kidney beans, *gvarphali* (cluster beans), and yellow lentils. Better not eat green vegetables like spinach and *methi* (fenugreek). Better to take only fresh fruits and vegetables in the salad. Fruit juices and frozen foods like ice cream should be avoided.

(Translator: Deepak Sharma) ■

VP website



Join Vigyan Prasar digital library to read online publications. You may also join the discussion forum to ask science and technology related questions and also answer fellow participants' queries. We also have streaming science videos, science radio serials, online science quiz, hand-on activities, and many more features and programmes related to science and technology. Log-on to www.vigyanprasar.gov.in

Nutritious Kiwi



Tara Datta Joshi

Kiwi fruit is liked for its distinct taste and rich nutrients. It has essential body acids, proteins, fibres and other solid supplements. The fruit is also a source of minerals like sulphur, calcium, chlorides, nitrogen, sodium, magnesium and phosphorus. The kiwi fruit can provide precious vitamins A, B (B6, B12) and vitamin C. In fact, it has 3-4 times more vitamin C than citrus fruits like lemon.

Kiwi is a light-brown fluffy fruit resembling *chiku* (Sapodilla). Scientifically known as *Actinidia deliciosa*, it is popular for its rich nutritional value. The fruit originated from China where it is known as Yangtao and Grosella. It was brought to New Zealand in the beginning of the 20th century. After 4 decades of research and efforts, the country had its first kiwi orchard in 1940. Owing to its taste, nutrition, wide range of adaptability and productivity, kiwi gradually became an international fruit. It is currently being grown on a large scale in many countries as one of the main commercial fruits.

Kiwi fruit was planted on Indian soil for the first time at Bengaluru's Lal Bagh garden. Here it was brought primarily as an ornamental plant. Later, the plant was cultivated at the National Bureau of Plant Genetic Resources (NBPGR) regional centre at Phagli near Shimla in Himachal Pradesh. The NBPGR's Phagli centre, which works under the Indian Agricultural



Research Institute, developed the Allison variety for the first time. More varieties were imported from New Zealand and planted at Phagli. Six more types of kiwi were grown at NBPGR's Bhowali (Niglat) centre near Nainital in Uttarakhand. Along with Allison, the Hayward variety of kiwi was successfully grown here in 1992. Currently, the fruit



is being produced in Uttarakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh and Kerala.

The kiwi fruit is liked for its distinct taste and rich nutrients. It has essential body acids, proteins, fibres and other solid supplements. The fruit is also a source of minerals

Shri Tara Dutt Joshi is a teacher and popular scienc writer. He regularly writes scientific articles for children. Email: write2tdjoshi@gmail.com

like sulphur, calcium, chlorides, nitrogen, sodium, magnesium and phosphorus. The kiwi fruit can provide precious vitamins A, B (B6, B12) and vitamin C. In fact, it has 3-4 times more vitamin C than citrus fruits like lemon.

Male and female flowers grow on separate kiwifruit plants. Male flowers produce pollen from the numerous stamens. Female flowers have a well-developed ovary with long sticky stigmas in the centre. Although female flowers have stamens, they do not produce functional pollen.

Nearly 50 varieties of kiwi fruit are grown across many parts of the world. Hayward is the most popular one. In India, besides Hayward, Allison, Abbott, Bruno,



Monty and Tomuri are the most widely grown varieties of kiwi fruit. All of these produce only female flowers except for Tomuri which produces male flowers. Only plants that bear female flowers bear fruit. However, one male flowering plant is grown

between every two female flowering plants on a farm for effective pollination.

Kiwi is grown at light sub-tropical and temperate regions in India that are anywhere around 800 to 1500 metres above the sea level. The ideal conditions for kiwi farming are an annual average rainfall of around 150 cm and a winter temperature of around 7°C. The fog at the time of sprouting can damage the crop. The flowers and leaves of kiwi plants also need protection from hailstorms, and heat. Deep alluvial soil or acidic alluvial soil with ample

facilities for water extraction and pH value of around 5.0-6.0 is ideal for kiwi cultivation. A kiwi plant starts bearing fruit within a span of 3-4 years. The pollination takes place through insects as well as air. Therefore, it is advisable to avoid spraying insecticides during flowering. Kiwi fruit takes 180-200 days to ripen in an ideal atmosphere. It may take slightly longer at higher altitudes. A fully-grown kiwi plant can give a yield of 20-25 tons of fruits per hectare.

A fully ripened kiwi fruit is peeled off before eating. Entire fruit, including its core, is edible. An over-ripe kiwi fruit can also be sucked like mango. It is also used to prepare jam, squash, candy, wine and salad. The fruit has many health and medicinal properties.

It is rich in folic acid and vitamin C and is especially beneficial during pregnancy as it has high content of iron.

The kiwi fruit has an enzyme called *Actinidin* that helps in protein assimilation. The fibres in it help cure stomach related ailments.

The kiwi fruit has a low glycemic index, which means it does not add much to the glucose level in blood. Therefore, kiwi fruit is beneficial for heart and diabetes patients.

The antioxidants in kiwi fruit increase body immunity. Some recent studies show antioxidants present in kiwi fruit protect DNA from oxidative damage.

The kiwi fruit has vitamin E that protects skin cells. Applying kiwi fruit slices to the skin can increase skin radiance.

Value of nutrients in Hayward kiwi fruit (per 100 grams)*

Sr No.	Nutrients	Amount
1.	Energy	61 kcal
2.	Iron	0.31
3	Proteins	1.14 g
4.	Fibre (total)	3.0 g
5.	Carbohydrates	14.7 g
6.	Sulphur	25 mg
7.	Calcium	34 mg
8.	Chloride	52 mg
9.	Sugar (total)	9.0 g
10.	Sodium	3.0 mg
11.	Magnesium	17 mg
12.	Phosphorus	44 mg
13.	Potassium	312 mg
14.	Vitamin A	87 IU
15.	Vitamin C	92.7 mg
16.	Vitamin E	1.46 mg
17.	Copper	0.13 mg

*Source: USDA National Nutrient Database for Standard Reference Release 28

(Translator: Deepak Sharma) ■

Recent Developments in Science and Technology



Biman Basu

Any student of science knows that chemical reactions become faster with increase in temperature. That is why food items and many other things are kept refrigerated to keep them fresh, as decomposition is a chemical reaction and at low temperature it slows down. But chemical reactions, which mostly involve molecules combining and breaking up, occur so fast that it is impossible to see them even at very low temperatures. Now a team of researchers from Harvard University have succeeded in carrying out and observing molecular reaction by cooling the reactants to a temperature of a few millionths of a degree above absolute zero.

First recording of a blue whale's heart rate

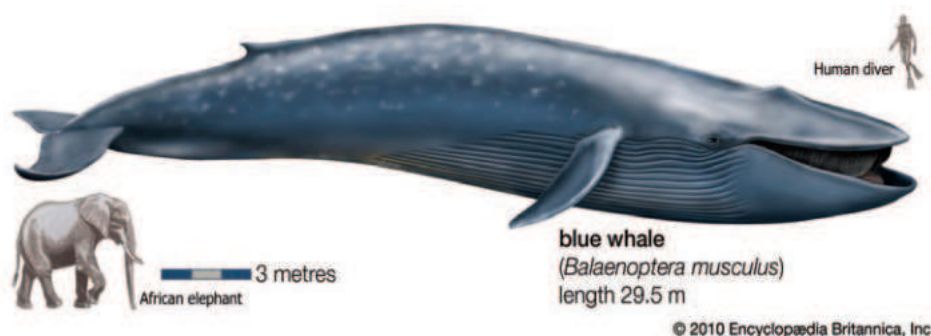
Scientists of Stanford University have achieved the unique distinction of recording heartbeats of the blue whale – the largest known animal in the world – in the wild, for the first time. And they have found a surprising fact: a blue whale's heartbeats show striking extremes, ranging from 4 beats per minute (bpm) to 35 bpm, which depended on the activity of the animal. When the whale dove, its heart rate slowed, reaching an average minimum of about 4 to 8 bpm – with a low of two beats per minute. At the bottom of a foraging dive, where the whale lunged and consumed prey, the heart rate increased about 2.5 times the minimum, then slowly decreased again. Once the whale got its fill and began to surface, the heart rate increased. The highest heart rate – 25 to 35 bpm – occurred at the surface, where the whale was breathing and restoring its oxygen levels (*Proceedings of the National*

Academy of Sciences, 25 November 2019 | DOI: 10.1073/pnas.1914273116).

The researchers used a lunchbox-sized electronic monitoring device attached to “exactly the right spot – just behind the left flipper” on the whale's body with suction feet to record the animal's heartbeats through electrodes embedded in the centre of two of the suction feet.

Riding on a large inflatable boat, the researchers slowly approached a blue whale that had surfaced in California's Monterey Bay and used a 6-metre-long pole to attach the monitoring device onto the whale's skin. After it was tagged, the whale went down for a foraging dive, reaching a maximum depth of 184 metres, and a few hours later, the sensor detached from the whale's body and floated to the water's surface. The team retrieved it and took it back to the lab.

Said Jeremy Goldbogen, assistant professor of biology in the School of Humanities Sciences at Stanford, “We had no idea that this would work, and we were



Blue whale, the largest animal in the world.

The author is a former editor of the popular science monthly *Science Reporter*, published by CSIR, He is a winner of the 1994 ‘NCSTC National Award for Science Popularisation’. He is the author of more than 45 popular science books. Email: bimanbasu@gmail.com

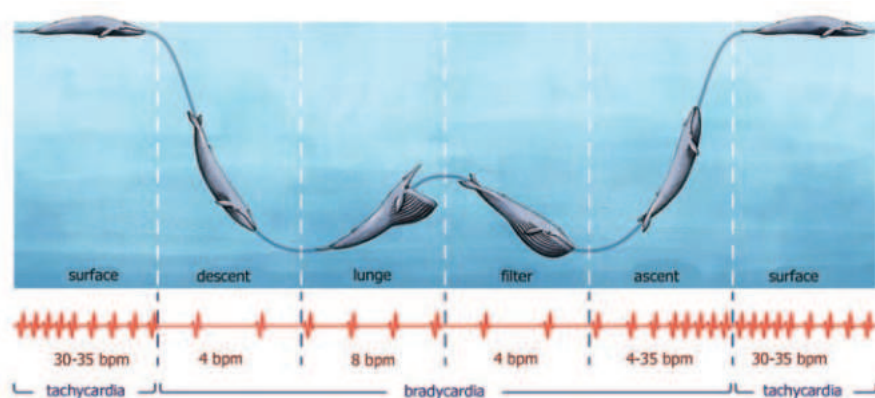


Illustration depicting how the blue whale's heart rate slowed and quickened as it dove, fed and surfaced. (Credit: Alex Boersma)

sceptical even when we saw the initial data. Paul Ponganis – our collaborator from the Scripps Institution of Oceanography – helped us find the first heart beats in the data”.

After downloading and analysing the sensor data, the team found that the whale – a 22-metre-long male – had a heart rate of only a few beats per minute, sometimes as low as two, when it dove, and then, when it surfaced, the whale's heart rate skyrocketed to as high as 37 beats per minute. The data also suggest that some unusual features of the whale's heart might help it perform at these extremes. Studies like this add to our fundamental knowledge of biology and can also inform conservation efforts, they say.

Interestingly, the researchers say, the whale's highest heart rate almost outpaced predictions while the lowest heart rate was about 30 to 50 per cent lower than predicted. Previous predictions were that the whales would have a resting heart rate of 15 beats per minute.

According to the researchers, the wide fluctuation in heart-rate shows “the quite extraordinary level of flexibility and control that these diving mammals have over their heart rate and blood flow.” The researchers think that “the surprisingly low heart rate may be explained by an elastic heart – a stretchy aortic arch that moves blood out from the heart to the body – which, in the blue whale, slowly contracts to maintain some additional blood flow in between beats”.

According to the researchers, the extreme variation in heart rates may also put a limit on evolution. Looking at the big picture, they think the whale's heart is performing near its limits, which may explain why blue whales have never evolved

to be bigger. In fact, this may also help explain why no animal has ever been larger than a blue whale, “because the energy needs of a larger body would outpace what the heart can sustain”.

Now, the researchers are trying to add more capabilities to the monitoring device, including an accelerometer, which could help them better understand how different activities affect heart rate. They also want to try their tag on other members of the baleen whales, such as fin whales, humpbacks and minke whales.

Coldest chemical reaction performed

Any student of science knows that chemical reactions become faster with increase in temperature. That is why food items and many other things are kept refrigerated to keep them fresh, as decomposition is a chemical reaction and at low temperature it slows down. But chemical reactions, which mostly involve molecules combining and breaking up, occur so fast that it is impossible to see them even at very low temperatures. Now a team of researchers from Harvard University have succeeded in carrying out and observing molecular reaction by cooling the reactants to a temperature of a few millionths of a degree above absolute zero – a temperature of 500 nanokelvins (1 nanokelvin = 10^{-9} Kelvin), which is much warmer than the coldest region in interstellar space which has a temperature of 3 billion nanokelvins.

In the Harvard study, the researchers worked with a gas made up of rubidium and potassium atoms consisting of rubidium-potassium molecules. When these molecules collide, they swap partners, creating a new

molecule made of two rubidium atoms and another with two potassium atoms. Normally, chemical reactions between molecules happens far too fast for scientists to see everything – especially the transient intermediates formed. Till now, scientists using even the most precise equipment could only watch the original molecules disappearing and the new ones appearing in their place. The middle step remained a mystery.

Kang-Kuen Ni, the Morris Kahn Associate Professor of Chemistry and Chemical Biology and a pioneer of ultracold chemistry at Harvard, set out to build a new apparatus that could achieve the lowest temperature chemical reactions. She was not sure her intricate engineering would work. But it exceeded her expectations. Ni and her team not only performed the coldest reaction yet; their new apparatus could do something even they did not predict. In the intense cold of 500 nanokelvins, or just a few millionths of a degree above absolute zero, their molecules slowed to such sluggish speeds that Ni and her team could see something no one has been able to see before: the moment when two molecules meet to form two new transient intermediate molecules. “In essence, they captured a chemical reaction in its most critical and elusive act”.

Chemical reactions occur in just a thousandth of a billionth of a second, better known in the scientific world as a picosecond. In the last twenty years, scientists have used techniques like using ultra-fast lasers like fast-action cameras, to capture rapid images of reactions as they occur. But they could never capture the whole picture. “Most of the time,” Ni said, “you just see that the reactants disappear, and the products appear in a time that you can measure. There was no direct measurement of what actually happened in the middle.”

It may be mentioned here that when Ni and her team reacted two potassium-rubidium molecules, the ultracold temperatures forced the molecules to linger in the intermediate stage for microseconds, which may seem short, but that's millions of times longer than usual and long enough for Ni and her team to investigate the phase when bonds break and form, in essence, how one molecule turns into another. The technique adds a new dimension to our understanding of chemical reactions.