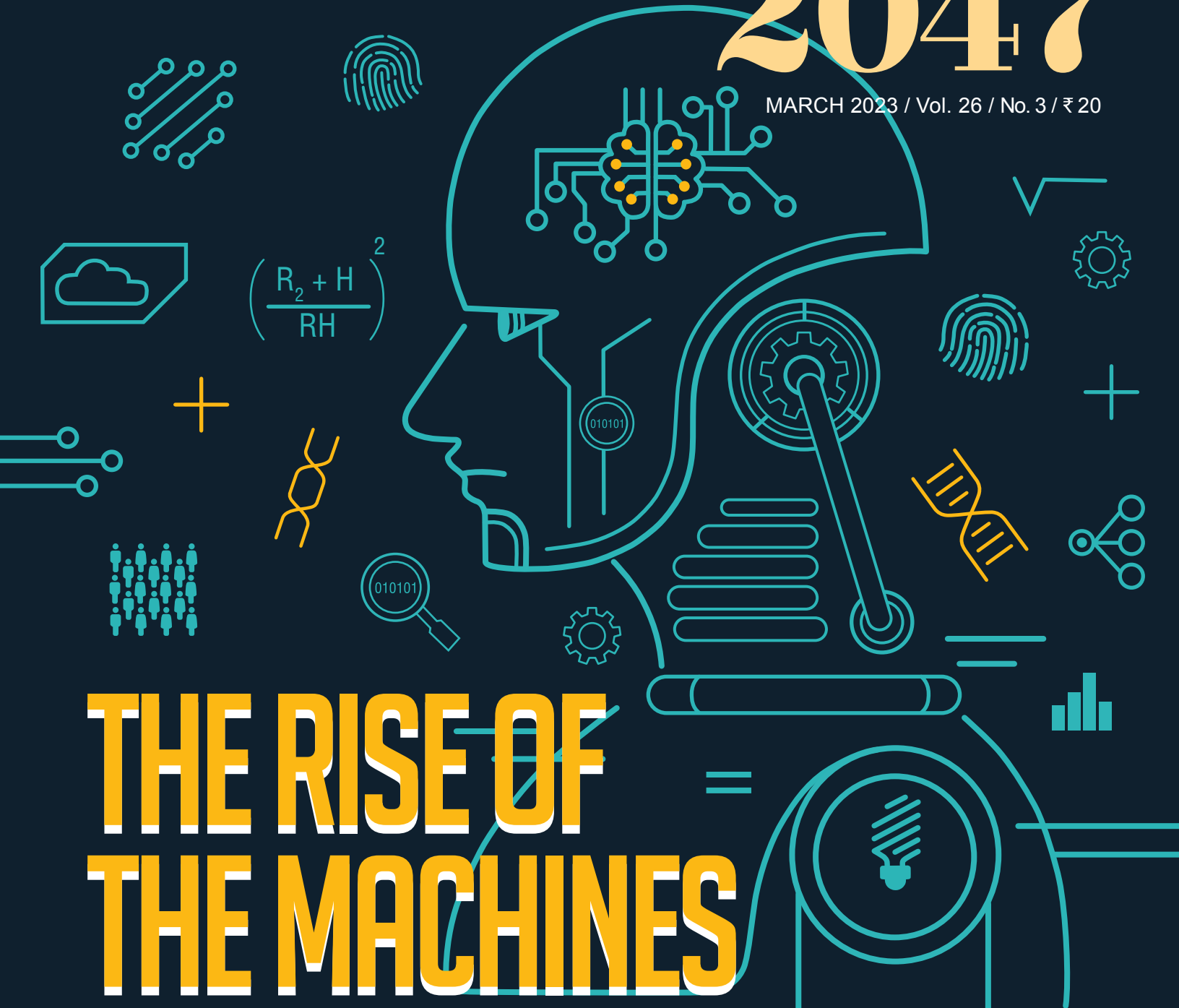


Dream

2047

MARCH 2023 / Vol. 26 / No. 3 / ₹ 20



THE RISE OF THE MACHINES

AGEING
GRACEFULLY

DIATOMS: HIDDEN ECOLOGICAL SENSORS
INSIDE THE MYRISTICA SWAMPS



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Published by Dr Nakul Parashar on behalf of Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 309, U.P. India.

Cover Design & Illustrations By: BIPRO KUMAR SEN

EDITORIAL**DR NAKUL PARASHAR**

Spring is here

SPRING IS HERE

once again. New leaves, shoots and several new years are all over the country in this month. It's time for hope and happiness. Thus, let's celebrate the month with more and more science & technology outreach initiatives. Let us come forward, join and strengthen the hands of all those working in this domain. Our honourable prime minister, through various forums, has repeatedly emphasised the need to develop and spread scientific temper in the nation. This, of course, is possible through science communication popularisation and its outreach or extension or SCoPE. For this, it is important to ensure that various programs that individuals and organisations like Vigyan Prasar have carried out are supported by participation at all levels of society. Thus, to build a completely scientifically aware nation, the show must go on. Isn't it?

Interestingly, the month of March begins with International Women's Day (March 8th). World over celebrations shall happen to recognise the contribution made by women in various spheres of our lives. In Science & Technology, too, women have played a very important role. At the recently concluded Indian Science Congress this year, the focus has been women. The theme at the congress was Science and Technology for Sustainable Development with Women's Empowerment. Thus, at Vigyan Prasar, this year SCoPE-for-Women esp. for scheduled tribal women, will take centre stage. The organisation will partner with a number of tribal universities to disseminate information about the betterment of women through science & technology. Print-electronic-social-digital, all possible media will be implemented to expand the scope of SCoPE-for-women. Content aggregation, editorial and product development will happen in major tribal dialects in a big way during the course of the year. Special issues of our monthly

magazines in various languages will be published, emphasising women's issues in tribal areas. The aim of this entire year-long endeavour would be to empower our women folk with scientific awareness.

One major attempt in this direction is Vigyan Vidushi. Vigyan Vidushi is a compendium of 75 women scientists by Vigyan Prasar. It is indeed a collector's item. Released on National Science Day this year, this book is now available for all. One can get it easily from Vigyan Prasar.

March also marks the start of year-long campaigns under Azadi Ka Amrit Mahotsav 2.0. We shall witness Vigyan Sarvatra Puujate 2.0 with radio serials, short films and, interestingly, face-to-face with noted scientists and technocrats of the country. All of this will be brought to you by Vigyan Prasar under the theme of Atmanirbhar Bharat (Self-Reliant India), especially through science & technology. This reminds me of the interesting set of stories that are available free to download and watch at IndiaScience, the nation's S&T OTT channel. It is available for free on Android and Apple phones. So, why wait? Do download IndiaScience app available on your smart phone.

Continuing with the glory of March, March 14th is an important event in the science & technology calendar every year. Just to remind it is the birthday of a great scientist, Albert Einstein. From his many quotes, there's one that is quite apt for everyone working in the domain of science communication and popularisation. It says, "If you can't explain it to a six year old, you don't understand it yourself."

Wishing you all a very happy Holi, Ugadi, Gudi Padwa and much more that come this month too.

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Ageing Gracefully



Govind Bhattacharjee

In the early history of life, unicellular organisms like prokaryotes, protozoans and algae had ageless bodies and were immortal. About a billion year ago, advent of sexual reproduction boosted our chances of survival manifolds, but there was a trade-off; it also brought in ageing and death. Nature, however, behaves differently towards different life forms: bacteria do not die naturally unless killed by antibiotic or UV ray, strawberry plants clone themselves, and the tiny hydrozoans regenerative themselves to defy ageing and death. Cancer cells are also potentially immortal. But men age and die.

At independence, an average Indian was expected to live only 34 years. After 75 years, the average life expectancy of an Indian today is almost 70 years. It is the same all over the world, people today live longer and healthier. WHO data show that in 2020, the number of people

aged 60 years and above was 1.4 billion; they outnumbered children younger than 5 years. By 2030, one-sixth of the world's population will be 60 years or older. By 2050, their number would be 2.1 billion. The number of persons aged 80 years or older would triple between 2020 and 2050 to reach 426 million. This will lead to several socio-economic problems like increased pension liability for governments, higher dependency ratio and burden on children, loss of national productivity and hence GDP growth and myriads of other associated problems. The UN has already declared the present decade, 2021–2030, as the “UN Decade of Healthy Ageing” to bring together governments, civil society, international agencies, professionals, academia, media and the private sector for collaborative action to foster longer and healthier lives in a sustainable manner.

Longer life is generally associated with failing health and degenerative diseases, physical disorders and

pains, mental agony, depression and loneliness. Thanks to advances in science and medicine and social support systems provided by governments, old age is no longer a bundle of pain only. If the old remains healthy, society as a whole which stands to benefit from their rich tapestry of experience, wisdom and accumulation of knowledge in various fields. Indeed, many people today live healthy lives beyond 80 years and contribute productively to society. However, evidence suggests that the proportion of our lives we are in good health has remained broadly constant over the last century, and that the additional years we have added to our lives are generally spend in poor health. Aging is the biggest risk factor for cancer, heart disease, Alzheimer's, type 2 diabetes, arthritis, lung disease, and every major illness. Living longer is almost synonymous with years of debility, dependence and despondence. In general, as we age, some inevitable physical changes start taking place over



our bodies due to the accumulation of a wide variety of molecular and cellular damages over time, though these changes are not linear and do not affect all individuals in the same degree. These also vary with the support of our physical and social environments, genetic traits, socio-economic status, etc. But all of us ultimately go through the same process when our physical and mental capacities decline, diseases make inroads with diminishing immunity, our strength wanes, reflexes weaken and ultimately the will to live abandons us. Age also leaves its indelible marks on our faces - wrinkles appear, eyelids droop, skin sags. But is there is eternal fountain of youth whose elixir we may drink to live healthy and die young when we are just old enough?

But just how old is old enough? Evidence again suggests that despite our continuously rising life expectancy, the average human lifespan remains finite and bounded. In the developed world, only one in 6,000 reaches the century mark and just about one in five million makes it past 110. The record holder in human longevity is a French lady, Jeanne Calment, who died in 1997 aged 122 years and 164 days. These numbers are not eternity, but if human lifespan can be increased to, say, 150 or 200 years, that would be almost like attaining immortality. So, it is not actually death, but the span of life that is important and the secret to immortality may lie in slowing down our aging process somehow so that our extra years remain healthy and faculties intact. Nature provides many such examples. Blue whales live for 200 years and Greenland sharks for 272 years. Age of sharks can be measured by the number of layers in their eye tissues, and one has been found to be as old 512 years. In the Arctic Seas in winter, fishes and frogs are frozen solid when the sea turns into ice. They revive to life with the onset of spring when the ice thaws, emerging with vigour out of their extended wintry hibernation. For us humans, when our body temperature is lowered, ice crystals begin to form and grow within cells, eventually rupturing the cell walls and causing death. But for

fishes and frogs, their blood runs liquid even when they are frozen, because their blood glucose which acts as antifreeze, lowers the freezing point of blood which remains liquid and drives their body functions. For humans, however, that kind of glucose concentration in blood will be too toxic for life. Nature again treats different species differently.

Today Japanese people have the longest average lifespan of 85 years, of which most spend 75 without any disabilities. Is it possible to increase the average human lifespan beyond 100 years? To explore this question, let us try to understand the process of ageing and whether it is controllable by human intervention. Bodies age because the cells that constitute the body get damaged over time due to the underlying molecular processes gradually becoming slow and dysfunctional as we age. Research has identified the mechanisms that are responsible for our ageing; scientists call them “hallmarks”. They can be grouped into three categories depending on whether the mechanisms take place inside the cell nucleus or outside the cell nucleus, or in the inter-cellular processes and communications. Nucleus is the heart of the cell and contains DNA, the blueprint for life and all cellular activities and processes. Within the nucleus, our genes are arranged along twisted, double-stranded molecules of DNA called chromosomes. DNA can get damaged due to myriads of reasons, like a constant exposure to high pollution. The human genome - the entire set of DNA instructions codified in the 23 pairs of chromosomes in the nucleus and a small chromosome in the cell's mitochondria - contains all the information needed for an individual to develop and function, including instructions for repairing a damaged cell, but the process loses its potency after prolonged exposure to pollution. The nucleus has a process called DNA-methylation which involves the attachment of methyl groups (-CH₃) to DNA's building blocks. When methyl groups are present on a gene, that gene is turned off or silenced, and no protein is produced from that gene. When these attachments malfunction, genes can no

longer coordinate perfectly. Another very important factor is the protective end-caps on the chromosomes called “telomeres”; these caps shorten with age. Every time a cell divides, they get shortened and after 50-60 divisions they practically disappear. Then the chromosomes start falling apart and the cell stops functioning correctly, exhibiting signs of aging. We shall return to telomeres in a while.

Inside the cell, in the cytoplasm or the fluid that surrounds the nucleus, there are small structures called mitochondria which produce 90 percent of the energy of the cell – they are the cell's energy centres and have their own genetic material different from the genetic material found in the nucleus. Any damage to them compromises the cell's functioning, causing it to degrade which ultimately results in sickness and disease. For example, the food that we ingest supplies the cells with nutrients; any imbalance in our food intake may exhaust the cell's capacity to metabolise the nutrients leading to toxic reactions and accumulation of toxins in cell. Another reason could be mitochondrial dysfunction. Mitochondria oxidises sugars to produce energy, and the process produces highly reactive molecules called reactive oxygen species (ROS), which are nothing but what are called “free radicals”, or molecules with an unpaired electron which are therefore highly reactive and hence unstable, because they can either accept or donate an electron to become fully paired and stable. In low amounts, free radicals can be useful for signalling stress and triggering repair, but their build up can lead to toxic effects and cause vital damage to mitochondrial functioning. Finally, to regulate chemical reactions within the cell, proteins that are produced must fold in precise, origami-like shapes. When the proteins themselves get damaged, they misfold and clump together becoming sort of ‘sticky’, which can lead to diseases such as Alzheimer's and Parkinson's.

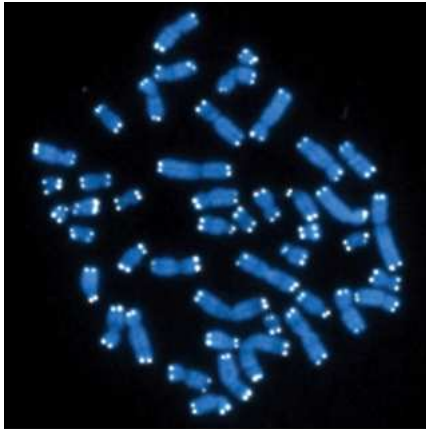
For the body's organs to function normally, cells also need to communicate and coordinate their activities optimally. Body's ability to repair tissues and organs

depends on healthy stem cells, which are the primary sources of production of new cells. Body's ability to replicate stem cells declines with age, impairing its ability to replace old cells with new ones. Further, defective cells may also stop dividing but they do not die but enter a state called "senescence". These rogue cells are then known as "zombie cells"; they can interfere with the normal processes occurring in the neighbouring cells. Any disruption of communication between cells due to whatever reasons including the action of zombie cells damages the ability of cells to repair themselves.

Coming back to the "telomeres" again, in 1961, American anatomist Leonard Hayflick showed that normal human cells cannot divide after about 50-60 cell divisions, a limit known as the Hayflick Limit which is fundamental to ageing.

Telomeres, in white, are structures at the tips of chromosomes (in blue).

The enzyme telomerase elongates the telomers and thus prevents them from shortening; when washed with telomerase, skin cells continue to divide far beyond the Hayflick limit, making these cells effectively immortal. Even cancer cells use telomerase to proliferate without limit, and hence it requires caution to avoid the unwanted by-product of cancer while trying to elongate the telomeres for improved health and longevity. Genetic remedies are based on the fixing and repairing of damages caused to the DNA. The promising candidates in this area are gene FOXO3, Human Growth Hormone (HGH) etc., though studies in this domain remain inconclusive. The chemical resveratrol present in red wine has been found to activate an enzyme called Sirtuin 6 which apparently slows down the DNA-oxidation process, and hence, ageing. Since seaweed is supposed to activate it, and since the Japanese consume large quantities of seaweed, this could one explanation behind their longevity. But all aging need not be related to short telomeres, and there might be various reasons for their shortening including stress, lifestyle issues or unhealthy eating habits. But short telomeres make cells senescent and too many senescent cells obviously accelerate human aging.



Source: Karen Weintraub, You may have more control over aging than you think, new book says (statnews.com)

Besides telomerase, calorie restriction has been found effective for slowing or reversing ageing, at least in animals. Experiments have shown that for worms, insects, rats, dogs and cats, 30 percent less calorie intake increases the average lifespan by as much. Animals are programmed by evolution to survive on the minimum diet, as they are not expected to find ample food always. They can live in a state of near-hibernation to prolong their lifespan by conserving energy. But calorie restriction has been seen to make the animals lethargic and disinterested in life, and no human has been tested as yet for this – obviously it will affect the quality of life. An alternative theory is the "programmed ageing concept", which holds that aging is a genetically-programmed, natural and irreversible process of deterioration over time, eventually leading to death. For humans, Nature apparently has already set the upper limit.

Two discoveries made in the recent past have reignited the hopes for finding an answer to the all-important question of reversing the process of cellular ageing. These have also led to the "Best financed start-up in history" in the form of a newly formed company called Altos Labs in January 2023 which has attracted \$3 billion funding from a group of high-profile tech entrepreneurs, including Jeff Bezos of Amazon, along with a galaxy of molecular biologists and age researchers to search for the elixir of life. One of these two discoveries is

the "Yamanaka transcription factors" named after their discoverer Yamanaka Shinya of Kyoto University. The 2006 discovery earned him a Medicine Nobel in 2012. The discovery revolutionized cell biology including treating diseases using a technique called cellular reprogramming or epigenetic reprogramming, to reverse aging and eradicate the illnesses that accompany ageing.

Yamanaka factors include four gene-regulating proteins that can practically return a cell to its "factory settings", to a state known as "pluripotency". Pluripotent cells can give rise to descendants capable of differentiating into a wide variety of specialised cells. The commonest pluripotent cells are the embryonic stem cells, which can give rise to practically all cells found in the tissues - a versatility that allows them to be used to regenerate or repair any diseased tissue or organ. Turning the relevant genes on under controlled conditions can return the cell into some kind of a "rude health", at least for mice. Experiments involving mice have succeeded in halting the progression of progeria, a mutation-induced syndrome that mimics rapid ageing, and can also promote the healing of injured muscles. Yamanaka is now an advisor to Altos.

David Sinclair, a geneticist at the Harvard Medical School, has modified the Yamanaka formula. Eliminating one transcription factor implicated in cancer, and then using partial reprogramming in mice with glaucoma-like conditions, he could regrow their crushed optic nerves, restoring their vision. Since vision, or optic nerves, are one of the first places affected by aging where we lose the ability to regenerate cells shortly after our birth, if turning back cellular age can recapture lost vision, it might be possible that the process can be replicated in case other debilitating functions related to ageing too, like spinal cord injuries and disorders of the central nervous system. But then mice and men are not the same, and what is true for mice need not be true for men.

The second important breakthrough was the discovery of the "Integrated Stress-Response (ISR) Pathway". One





of biology's most important concepts is homeostasis, or maintenance of a constant internal environment like body temperature, blood pressure or blood sugar level in the face of external stresses trying to change them. The ISR does precisely this at a cellular level. Once any external or internal source of cellular stress is detected—like deprivation of oxygen or nutrients or viral infection, or accumulation of misfolded proteins or activation of a potentially cancer-causing gene, etc., the ISR first tries to address it by resetting protein manufacturing, failing which it goes on to presses the self-destruct button, blowing up the cell it is in to stop it from becoming a pathway of diseases. This process is called apoptosis. These two discoveries offer the promise of bringing sick cells back to health. Since processes within the cells are too complex for human mind to decipher, the use of artificial intelligence is expected to model those processes to give the scientists much better insights into them. Doubts, however, remain about how controllable are the process of ageing and its underlying biology. Like everything in biology, the process of senescence is also regulated by natural selection, and death being the inevitable end of human life, all the ageing cells can never be renewed. But it is a fact that some groups of cells, for example, the reproductive cells which create new generations of individuals, have learnt to return to factory settings every time they reproduce. Thus, at least theoretically, the same property can be replicated in other groups of cells too. At the moment, this is only a distant possibility, and only time will tell if this ever becomes a reality.

Age research is always multi-dimensional. In 2019, in the journal *Aging Cell*, cryobiologist Gregory Fahy published an interesting study, though with small sample of humans, on reversing immunological aging by treating the thymus, a small gland in the chest that stimulates the development of disease-fighting T-cells, with injections of recombinant human growth hormone. Tests indicated that T-cell production did increase with the

treatment, thymus fat disappeared, and kidney and prostate health improved. But the interesting result was that the subjects lost an average of two and a half years of biological age, as measured by what's known as an epigenetic clock that uses blood to measure chemical changes to DNA that alter gene expression and mark the passage of time. Because the drug can raise the risk of type-2 diabetes. Fahy added two drugs, metformin and dehydroepiandrosterone (DHEA), which are used for blood-sugar regulation. Both the drugs are also thought to mitigate the effects of aging. Metformin, which is taken for diabetes by millions of people, are now also taken by many age scientists. Fahy is now planning for replicating the study with a larger sample.

Nobody knows when, or whether, these new-age technologies like cellular reprogramming etc. will be as useful to humans as they have been for mice. But even without them, traditional wisdom gives us valuable guidance. Harvard public health researchers analysed of data from 123,219 US adults to find that five habits may increase life expectancy by 14 years in women and 12 years in men; and these are what all of us have always known: good diet, regular exercise, healthy weight, non- smoking, and moderate drinking. There are end number of prescriptions by fitness experts about exercise regimens from yoga to jogging and by nutrition experts about diet plans from time-restricted eating to intermittent fasting for maximising wellness in old age, about the efficacy of which no two experts will ever agree.

Okinawa is a beautiful tropical island south of mainland Japan with some of the world's longest living humans. It has perhaps the largest concentration of centenarian people, and surprisingly even the oldest Okinawans are considered healthy and in possession of emotional, physical and intellectual capacity to live and function independently and productively. It attracted two journalists, Héctor García and Francesc Miralles, to discover the

secrets of their happy longevity. Based on insights gained from living and interacting with the community, they wrote an international bestseller, *Ikigai: The Japanese secret to a long and happy life*. Ikigai in Japanese means “reasons for living”. The essence of the book is described in the 10 principles as shown in the diagram.



Ikigai is about living an active life even after retirement, living in the present without regret for the past or dreams for the future. It is living with a purpose, and if there is none, to search for one. The purpose cannot be to earn money or build a business empire or chase impossible targets, but to enjoy every moment as they pass by, watching and wallowing in their pleasure, without hurrying – like enjoying a morning coffee or spending joyful time with friends. One can even have several Ikigai-s, from humdrum pleasures to working towards a goal that can redefines one's life. As the Japanese author Ken Mogi wrote in his book, *The Little Book of Ikigai*, the *ikigai*, the purpose of life may come “from the rich spectrum of a spectrum of small things, none of which serves a grandiose purpose in life.” Such simple sources of joy can fill one's sunset years with happiness and purpose, which in their turn, may usher in physical and mental wellbeing till it is time for a sublime and serene sundown.

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The Rise of the Machines

Soumya Maitra

We live in exciting times. The pace at which technology is evolving and disrupting our lives (for the better) is accelerating exponentially. We are now at a point in time where the human ability to adapt to technological changes is behind the rate at which science and technology are changing the world (see Figure 1). Humanity is at the cusp of the fourth industrial revolution, and this time it is not the power of coal, steam, or electricity that is driving the change. Instead, it is the innate attribute of our very existence—data—and its interpretation in many dimensions that is at the core of change. To get an appreciation of how fast change is happening consider this: nearly 90% of all the world’s data has been generated in the past couple

of years. This is true for almost every sphere of life, but the one field that is going to be a game-changer is at the intersection of artificial intelligence (AI) and the human brain.

AI has the potential to revolutionize many aspects of our lives, from healthcare and medicine to transportation and communication. However, the rapid pace of technological development can make it difficult for individuals and societies to keep up. As we continue to make progress in this field, it will be essential to consider the ethical and societal implications of these advancements and ensure that they are used to benefit humanity. Data is turning out to be the new currency, with machine learning and artificial intelligence taking on more and more human tasks and doing it better than before. AI’s very need to feed off of massive amount of data to become

intelligent and practically useful also acts as a double-edged sword.

Consider bias, privacy, and autonomy, for instance. AI systems that rely on human behaviour and responses as part of their unsupervised learning also risk being exposed to the infinite variety and nuances of bias innate to the human race. AI systems can perpetuate and even amplify such biases present in the data used to train them, leading to unfair and discriminatory outcomes. This is because AI systems, particularly those that use machine learning, are only as unbiased as the data they are trained on. If the data used to train an AI system contains biases, the system will also be biased.

For example, facial recognition systems have been found to have higher error rates for people with darker skin tones and women because the training data used to develop these systems was not diverse enough. Similarly, natural language processing systems have been found to perpetuate sexist stereotypes because the data used to train them was sourced from text written primarily by men, for men. In a study in 2018, it was found that a commercially available AI system used to predict future criminals was significantly less accurate for black defendants than for white defendants. It was also more likely to falsely flag black defendants as future criminals. This is mainly due to the data used to train the algorithm and the historical discrimination within the criminal justice system. In yet another study in 2018, researchers found that an AI system used for hiring was less likely to recommend female candidates for jobs in male-dominated fields because the

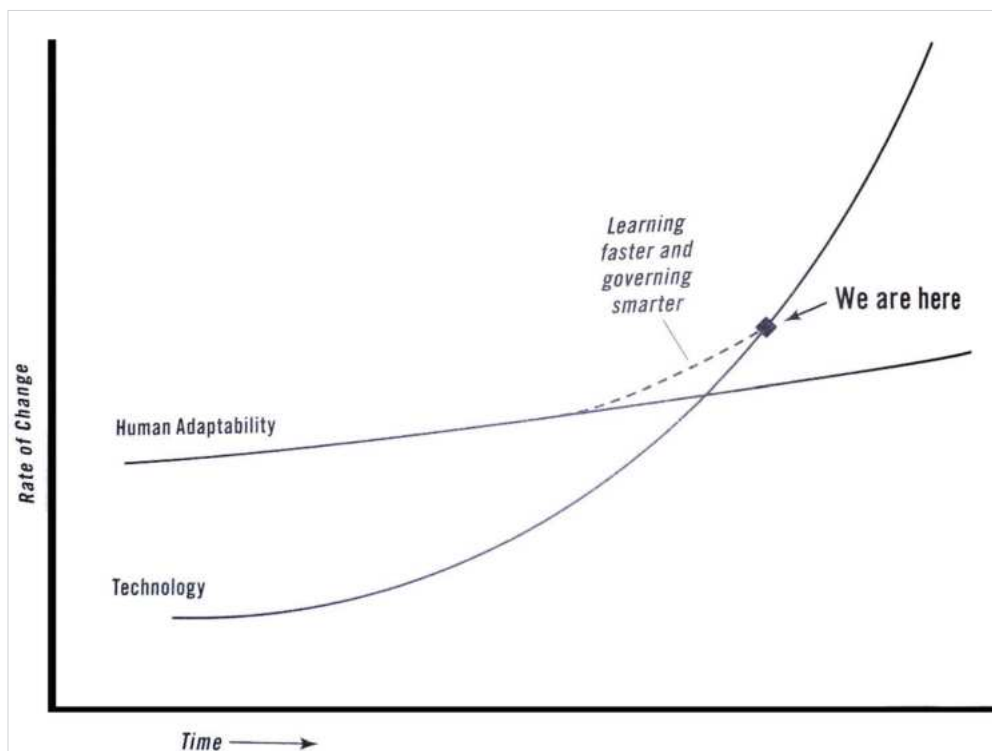


Figure 1: Eric Teller, CEO of Google X Research and Development Lab, used the above illustration to depict how the rate at which technological changes have exceeded the capacity of the human intellect to keep up with those changes. Source: “Thank you for being late”, Thomas Friedman, (2017).

training data used to develop the system was mostly from resumes submitted by men. In 2020, researchers found that an AI system for identifying hate speech on social media was more likely to flag tweets written in African American English as hate speech because the training data used to develop the system did not include enough examples of this dialect.

Besides, AI systems, like any other technology, can malfunction or can be hacked with malicious intent, resulting in intended or unintended consequences. In 2016, a self-driving car operated by Tesla was involved in a fatal accident in which the car's sensor failed to detect a white semi-truck turning across its path. In 2018, an AI-controlled trading algorithm caused a "flash crash" on the stock market, causing a rapid drop in the value of several stocks before they quickly recovered. In 2019, an AI-controlled robot killed a human worker at a Volkswagen plant in Germany. The incident was caused by a malfunction in the robot's safety system.

All these findings highlight the importance of having diverse and inclusive data sets when training AI systems and monitoring the performance of these systems to detect and address any biases. Additionally, it's important to have diverse teams working on the development and deployment of these systems to ensure that all perspectives are considered. It's important for researchers, developers, and policymakers to be aware of these risks and to take steps to mitigate them, such as thorough testing, safety protocols, and transparency in the development process.

So does all this mean AI is doing more evil than good?

Nothing can be farther from the truth. Today, AI is ubiquitous, touching our lives in ways more than we can

comprehend (see Figure 2). It is bound to have a few hiccups as scientists continue to try to understand the inner mechanics of the human brain that AI hopes and aims to mimic.

candidates. AI-based systems have been able to identify new drug candidates that humans would not have been able to find. In natural language processing, AI-based systems have been able to generate

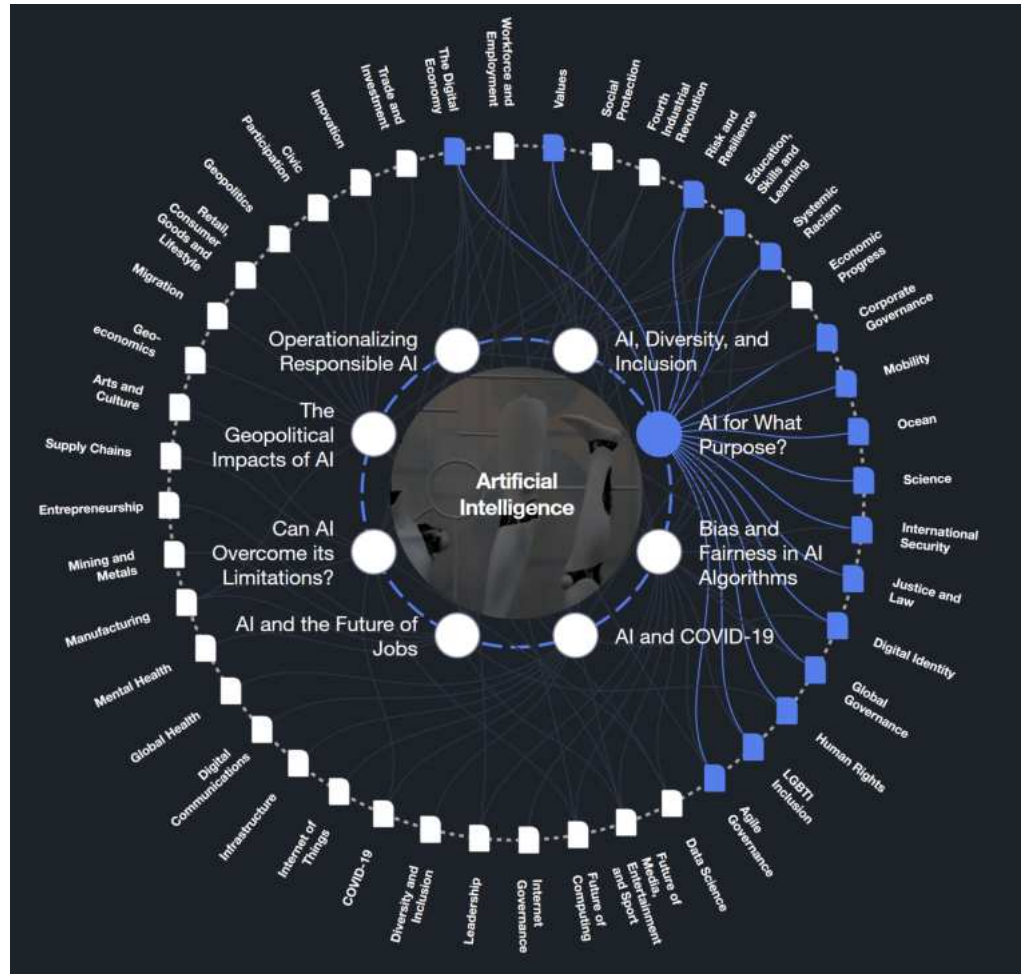


Figure 2: The many dimensions of Artificial Intelligence, and its impact on society, culture, technology. Source: World Economic Forum. (2020) Strategic Intelligence: Bias and Fairness in AI Algorithms.

In hindsight, AI has made some remarkable advances in the past few decades, the most famous of which was the game of chess in 1997, where IBM's Deep Blue beat world chess champion Garry Kasparov in a six-game match.

Today AI systems play an ever-increasing role in aiding and augmenting human intelligence. In medicine, AI-based techniques have been used to analyze medical images, such as X-rays and CT scans, with an accuracy comparable to that of human radiologists. In drug discovery, AI systems have been used to screen large numbers of chemical compounds for potential drug

human-like text, translate languages, summarize large text and even develop coherent and informative answers to complex questions.

In the field of computer vision, AI-based systems have been able to outperform humans in tasks such as object detection, image classification, and facial recognition. In the field of self-driving cars, AI systems have been used to control vehicles with high safety and reliability. Companies such as Waymo, Tesla, and Cruise are working on fully autonomous vehicles that can drive on roads with human drivers and are expected to be available to consumers in

the near future. In finance, AI systems have been used to improve the accuracy of stock market predictions and identify fraudulent transactions.

AI's utilitarianism is not limited to applied technologies alone. AI has been used to make significant strides in solving problems in mathematics and physics. It is used to simulate complex physical systems, such as the behavior of subatomic particles and the dynamics of fluids, and to analyze large data sets from particle accelerators and telescopes, leading to new discoveries in fields such as high-energy physics and astronomy.

These are but just a few amongst hundreds of different examples that demonstrate AI's ability to perform tasks that were previously thought to be the exclusive domain of humans. But how about something comparable to human creativity, such as art, music, or poetry?

In 2021 Open AI introduced their AI model DALL-E that can create artificial images, even abstract ones, based on prompts or themes provided by human beings. How is this possible? Researchers trained AI systems on large datasets of existing artwork to learn the styles and techniques of famous painters, and then used these systems to generate new paintings in the same style, and create new styles of painting, using techniques such as deep learning, generative models, and neural networks.

When it comes to music, Gil Weinberg, a professor of musical technology at Georgia Tech, USA, and founding director of the Georgia Tech Center for Music Technology, created a marimba-playing robot called Shimon. Shimon uses AI to listen to music like a human and uses machine learning to find patterns in the musical notes it hears. It is then able to morph various genres or styles of music together to compose new music. The end result in this artificial musical creativity could be a new musical played by Shimon in the style of "30% Miles Davis, 30% Bach, 30% Madonna, and 10% my own", says Professor Weinberg.

Sounds unbelievable?

In November 2022, Open AI released

its latest AI model on natural language processing (NLP) called Chat GPT. This model is trained to interact with humans in a conversational way that feels like human. On January 6th this year, I prompted Chat GPT to write a poem reflecting the synergy between humans and machines. This is what I got back from the AI model.

*Man and machine, two worlds
entwine,*

*Together we create, our hands
intertwined.*

*The power of thought, the speed of
light,*

*We work as one, to make things
right.*

*With tools at hand, we build and
craft,*

*Machines to help, our progress is
daft.*

*But as we grow, and technology
advances,*

*We must remember, our humanity
enhances.*

*For as we merge, and build a new
future,*

*We must not lose, our human
nature.*

While Chat GPT's AI model may not have the consciousness to understand the words it wrote, or how those words will make a human being feel, it surely was able to do a fine job at data mining. When I asked it to write a poem, it must have begun by selecting an appropriate language model trained on a poetry dataset. Next, it provided the model with a theme to generate the poem (in this case, 'on the synergy between humans and machines'). The model then developed text based on the patterns and correlations it had learned from the training data, creating a poem that followed the structure, style, and language of the poetry it had been trained on.

Does this mean the day is near when AI becomes conscious and a superhuman entity?

AI systems are designed to mimic certain human brain functions, such as learning and problem-solving, but

they are not identical to the human brain in their structure or operation. Operationally it is quite different from the human brain, and we would be amiss to use brain as a metaphor to define AI. AI systems are typically based on algorithms and mathematical models, while the brain comprises complex neuronal networks that communicate through electrical and chemical signals. AI systems can be trained to perform tasks by being fed large amounts of data and using that data to make decisions, while the brain is able to learn and adapt in response to experiences and new information. The brain can reorganize itself after injury, while AI systems generally do not have this capability. AI systems are limited by their programming and the data they have been exposed to, while the human brain has the ability to make novel associations and connections. The brain is able to process and integrate a wide range of sensory information, while most AI systems are limited to processing data that they are explicitly programmed to handle. The brain is also capable of creative thought and abstract reasoning, while most AI systems are designed to perform specific tasks and do not have the ability to think creatively.

The human brain has had 300,000 years for its development in the human species, and nearly seven million years of evolution since the last common ancestor of shared by hominins. In comparison, artificial intelligence is relatively a new man-made technology, hardly a blip in time. A true test of AI's ingenuity would be whether it can spawn another artificial intelligence on its own, without human intervention. Until then, the squishy 1.4 kg organ of flesh and blood between our ears will continue to define what it means to be human.

Soumya Maitra is a science writer and is the author of the book *The Human Brain*, published by Vigyan Prasar. Soumya's popular science articles have been featured in *Dream 2047*, *Science Reporter*, *The Statesman*, and other magazines. He is an alumnus of Birla Institute of Technology and University of Toronto, and can be reached at **Email: Soumya.Maitra@gmail.com.**

Scientific Institution Founders Of Modern India

Tanmoy Deb

A scientist carries out research with utmost devotion. He is also burdened with administrative responsibilities. Later on, he is focused on building a team of able researchers who would carry forward the torch. Next stage is building of scientific institution from a grass root level in an uncharted field. Such task demands vision, scientific prowess, administrative skills, financial insight and leadership ability of superior order.

Discussed below are few such prominent institution builders of India post independence whose contribution led to the development of expertise in a specialized field which did not exist before. Their pioneering work led to necessary thrust and flourishing of a scientific discipline which catered to demands of a developing country. Colonisation of India for two centuries prevented the development of scientific base necessary for an underdeveloped country. These visionary leaders created institutions which played a major role in building a scientific base. They worked through fund shortages, bureaucratic hurdles, one upmanship and political tug of war. But their wisdom and abilities demolished all the obstacles and they went on to create a world class institution. These were right men at the right place at the right time!

1. ATOMIC ENERGY

(i) Homi J. Bhabha—He was born into a wealthy Parsi family who studied physics at Cambridge University, UK. He is credited with setting up of Tata Institute of Fundamental Research (TIFR) by managing to raise funds from the Tata Trust. He was able to convince political leadership that this



Homi Bhabha

would attract scientists for research and facilities would be comparable to that of west! TIFR gave birth to Atomic Energy Commission. Indian Space programme also developed within Atomic Energy Commission till they moved to separate place.

Even though, he died in 1966 in air crash but he had already imparted enough momentum. He is also credited with inviting Govind Swarup from Stanford University to develop facilities for Radio astronomy in India.

(ii) V. S. Ramamurthy—He was a silent leader who as a member of core team executed Pokharan nuclear test in 1974. He stayed in atomic energy



V. S. Ramamurthy

programme for 13 years contributing to nuclear fission, thermodynamics of nuclei, and applications of low energy reaction. Later, he joined Institute of Physics, Bhubaneswar as Director and brought 3 MW accelerator. In 1955, as a secretary of Department of Science & Technology, he started a scholarship programme—Kishore Vaigyanik Protsahan Yojna to encourage students to study science so as to create a pool of scientific manpower. He also started a fellowship programme to provide support to outstanding young scientists to boost scientific research in the country.

(iii) Anil Kakodkar—He was an expert of reactor engineering and

was intimately involved with the construction of largest nuclear reactor “Dhrv”. He was also involved with India’s first nuclear test in 1974 at Pokharan, Rajasthan. As chairman of Atomic Energy Commission, he deftly negotiated Indo-US nuclear deal to buy Uranium for nuclear reactors.

2. ATMOSPHERIC, OCEANOGRAPHIC AND GEOLOGICAL SCIENCES

(i) R. Narasimha—He realized the importance of monsoon phenomenon and created a research group in Indian

Institute of Science (IISc), Bangalore. This led to the creation of Centre for Atmospheric and Oceanic Sciences. He was the brain behind setting up of Ministry of Earth Sciences. He influenced several



R. Narasimha

research programs and national policies.

(ii) Vinod Gaur—He used technology innovatively in geophysical studies. Using a cheaper global positioning system, his team determined the velocity of tectonic plates with respect



Vinod Gaur

to Eurasian plate thereby allowing study of strain build up under northern Himalayan region (relative movement of these plates' lead to earthquake).

As secretary, Department of Oceanic Development, he implemented several programmes such as mapping of sea surface temperatures from satellite data to spot marine fishing areas, measure atmospheric carbon concentration across different seasons etc.

3. ASTRONOMY

(i) Vainu Bappu—He is the only Indian to have a comet named after him as a PhD student in Harvard University. He was admonished for not focusing on his research studies! He got



Vainu Bappu

a job in Uttar Pradesh observatory and got it shifted from Lucknow to Nainital. Later, he moved it to Kodaikanal Solar Observatory. He developed observatories (optical telescope based) as important infrastructure for Indian astronomers.

This was a pioneering effort in optical astronomical sciences.

(ii) Govind Swarup—Vainu Bappu was a pioneer in optical astronomy while Govind Swarup developed radio astronomy in India (truly called father of radio astronomy in India). He conceived and set up Ooty radio telescope with existing equipments. This project took 10 years to finish and became 4 times bigger than biggest telescope in the world. It is still largest single frequency radio telescope in the world. He then set



Govind Swarup

up Giant Metre Wave Radio Telescope (GMRT) near Pune, Maharashtra. He trained a large radio astronomy group in the country to carry forward the research work.

He was also instrumental in conceptualizing Indian Institute of Science Education & Research (IISER) to give an impetus to development of pool of scientific manpower for research.

4. BIOLOGICAL SCIENCES

(i) K. Vijayraghavan—He was a chemical engineer who got interested in biology after a project at the All India Institute of Medical Sciences. He became



K.Vijayraghavan

part of biology group at TIFR and the it became National Centre for Biological Sciences (NCBS). The institute then moved to Bangaluru. He assumed directorship in 1996 and played a key role in shaping up of this nascent institute for 13 years. His leadership allowed the research to bloom. He was later shifted to Department of Biotechnology as secretary and became

principal scientific adviser to the prime minister. He developed NCBS as hub of research activities.

(ii) Samir Brahmachari—He developed the field of Genomic Sequencing in India. He tried unsuccessfully to persuade molecular biophysics unit of IISC to start genomics. He then decided to start a foundation. However, due to untimely death of B K Bachhawat, who promised to be its chairman, the dream end there. He was offered the directorship of the Centre for Biochemicals in Delhi. He converted this institute into Institute of Genomics and Integrative Biology. This helped to kick start first genomic programme in India in 2006.



Samir Brahmachari

5. CRYSTALLOGRAPHY

(i) Gautam Desiraju—He joined University of Hyderabad in 1979 soon after PhD in structural chemistry from the University of Illinois, Urbana



Gautam Desiraju

Champaign. Due availability of very basic level facilities, he decided to use facilities abroad for analysis of diffraction data. He became famous for crystallography and developed the idea of supramolecular synthesis (it is a idea of creating organized assemblies from small units).

6. CHEMICAL SCIENCES

(i) M.M. Sharma—He was instrumental in shaping chemical engineering discipline in India. When he began work from University



M.M.Sharma

Department of Chemical Technology (UDCT), Mumbai, he found that there were no infrastructures for research. He approached and persuaded companies to hire PhD candidates. He started shaping students and research facilities for the industry and soon demands outstripped supply. He later became consultant to industry and government and influenced policies course of chemical industries for four decades.

(ii) J.B.Joshi—He was a student of M.M. Sharma who became an expert on multi-phase reactors (it bubbles a gas into liquid to start a reaction and make a



J.B.Joshi

product). Industries relied on his expert advice to increase production. After becoming Director of UDCT, he lobbied with university officials to get autonomy from Bombay University.

(iii) K. Venkataraman—He was the first to work on synthesis of plant pigment Flavones and got the result published in Current Science. Around the same time, Wilson Baker published a similar synthesis. The reaction is now known as Baker-Venkataraman rearrangement.

Later, he became the first Indian Director of UDCT and ushered in scientific research. This led to the creation of research hub producing large number of entrepreneurs and supplied technology to industry.

(iv) Goverdhan Mehta—He was interested in organic molecules and had worked at University of Hyderabad;



Goverdhan Mehta

IIT, Kanpur and IISC, Bangalore. His research group did synthesis of 50 biologically active compounds such as garudane, golcondane, laderane etc. He developed hybrid drugs for cancer. The group also developed potential applications for nanotechnology using certain carbon compounds.

As Director of IISC, he initiated many new programs including policy for faculty members to start company.

(v) S. Vardarajan—After PhD from Cambridge, he joined Hindustan Levers Ltd. where he developed an excellent R & D centre that produced a large number of commercially successful products such as detergents, perfumes and nutrition products. This R & D centre became one of the key laboratories of industrial research in India.



S. Vardarajan

In 1974, he became Managing Director of Indian Petrochemical Corporation Ltd. (IPCL) and built first integrated petrochemical plant. He persuaded Vergese Kurien of Amul fame to switch from milk bottles to polyethylene (LDPE) packets which had a major impact on distribution of milk all over India. Later, as a Director General of CSIR, he safely decommissioned Union Carbide plant after Bhopal gas tragedy.

7. DYESTUFF INDUSTRY

(i) B.D.Tilak—His research was instrumental in establishment of dyestuff industry in India. He became

Director of UDCT after departure of K. Venkataraman to National Chemical Laboratory. He initiated import substitution and indigenous technology programmes. He up scaled technology from few grams to tonnes. This focus on development of indigenous technology led to the expansion of dyestuff industry in India.

8. LEATHER INDUSTRY

(i) Y. Nayudamma—He was scientist leader who got training in UK and USA. He joined leather industry in



Y.Nayudamma

India after his PhD. Central Leather Research Institute (CLRI) and leather industry worked separately in silos. He persuaded leather units to utilize CLRI facilities for their business. To fulfill this objective, he organized many conference and social gatherings with industry resulting in positive outcome.

(ii) T. Ramasami—Influenced by Nayudamma, he studied leather technology in Madras (now Chennai) and got a PG degree from CLRI. He



T.Ramasami

joined CLRI and led emission clean up from leather units in Tamil Nadu which were facing heat from Supreme Court for closure for non-adherence to emission level. This meant loss of livelihood. In this mission critical, he developed a combination of solutions which resulted in their continuous operation. It was all due to his sincere efforts that these units continued to function.

9. METALLURGICAL SCIENCES

(i) **V.S. Arunachalam**—He started as a metallurgist at Bhabha Atomic Research Centre (BARC). He then joined National Aerospace Laboratories, Bangalore and later as Director of Defense Metallurgical Research Laboratory. He laid the foundation for series of high technology programmes for defense forces. Some of his products are—MiG aircraft brake pads, armour for Arjun main battle tank, nickel super alloy for gas turbines and extraction of titanium.



V. S. Arunachalam

As head of Defense Research & Development Organization (DRDO), he initiated a number of programs such as integrated missile programme, light combat aircraft, defense system for chemical and electronic warfare etc. He was instrumental in bringing APJ Abdul Kalam from ISRO to lead missile programme.

(ii) **T.R. Anantharaman**—He developed department of metallurgy at Banaras Hindu University (BHU) as research oriented department. His research mainly focused on phase transformation of metals. He developed mechanism of funding which attracted best metallurgists to BHU. He also started first M.Tech. Programme in this field.

10. METEOROLOGICAL SCIENCES

(i) **Anna Mani**—She worked



Anna Mani

under C.V. Raman at IISC after BSc honours. She submitted her doctoral dissertation but was denied PhD due to absence of master degree. She went to England and worked in Metrological department with special interest in weather instruments. After her return, she joined Indian Meteorological Department as meteorologist in 1948. She developed sophisticated instrumentation laboratory and developed standards for nearly 100 instruments. She also worked on solar energy and atmospheric ozone measurement and helped ISRO set up a meteorological laboratory.

11. MISSILE TECHNOLOGY

A. P. J. Abdul Kalam—He worked at Aeronautical Development Establishment where he designed India's



A.P.J. Abdul Kalam

first hovercraft. At ISRO (Indian Space Research Organization), he worked at SLV-3 rocket. It became a milestone in ISRO's history. Kalam was then asked to head DRDO missile programme and the rest as everyone knows is history. He also became People's President.

12. MICROWAVE ENGINEERING

Rajeshwari Chatterjee—She was a pioneer in more than one way. She was first woman engineer at IISC who earned a PhD and joined institute as a professor. Her microwave technology programme blossomed and DRDO later used her research for building radar antenna among other things. Her husband S.K. Chatterjee who worked in same department started microwave engineering laboratory for the first time in the country.



Rajeshwari Chatterjee

13. PHARMACEUTICAL SCIENCES

(i) **S. Ramachandran**—As CEO of Bengal Immunity Co. (a vaccine pioneer in India) in Kolkata, he steered it through difficult times. Later, he headed National Biotechnology Board under Department of Science & Technology. He conceived the blue print for separate department. As a founder secretary of Department of Biotechnology, he conceived many new programmes for the department by mentoring all employees.

(ii) **Asima Chatterjee**—She was one of the earliest woman in India who got a PhD. Although she remained in



Asima Chatterjee

academics pursued research as chemist despite severe fund shortages. She developed drugs for malaria, epilepsy and cancer and left an indelible mark in the scientific research arena.

(iii) **A. V. Ramachandra Rao**—He had developed a process for the manufacture of Diazepam and transferred it to CIPLA (it was first instance of technology licensing from



A.V.Rama Rao

National Chemical Laboratory). The technology of drug manufacturing was guarded secretly by all pharma majors in the world. However, Indian Patent Act 1970 allowed different process to be used for the manufacture of patented drugs which is still a bone of contention between India and international drug majors. He developed extraction method for anti cancer molecules vincristine and vinblastine

(guarded by Eli Lilly Co.).

Later he assumed the directorship of Regional Research Laboratory. Being heavily unionized, the output was nil. He converted it into Indian Institute of Chemical Technology (IICT)—a vibrant and dynamic institution.

14. REMOTE SENSING

(i) K. Radhakrishnan—He is one of the most unusual leaders of ISRO who had management degree from IIM, Bangalore and received PhD from IIT, Kharagpur on management of earth observation system. He was Director of Indian National Centre for Oceanic Information Services, Hyderabad. Later, he became head of National Remote Sensing Agency in 2005, Director of Vikram Sarabhai Space Centre in 2007 and ISRO chairman in 2009.



K.Radhakrishnan

His major contribution was in professional management rather than in science & technology field. He planned long term succession in ISRO. He meticulously planned and executed Mars Mission and Geosynchronous Satellite Launch Vehicle

(GSLV) with cryogenic (temperature less than 1500 C) upper stage.

15. SPACE SCIENCES

(i) G. Madhavan Nair—He is credited with first successful launch of Polar Satellite Launch Vehicle (PSLV) as project Director. As Director of Liquid Propulsion System Centre, he finalized cryogenic engine deal from Russia. He developed Chandrayan-1. He also developed launch vehicle technology when access to this technology was denied to India.



G. Madhavan Nair

(ii) Vikram Sarabhai—He founded Physical Research Laboratory in his house. He was instrumental in set up of Indian National Committee for Space Research with Homi Bhabha. He set up rocket launching station in Thumba, Kerala. After Bhabha's death, he put thrust to space and atomic energy programmes. Unfortunately, he too died at the age of 52 before realizing his dream.



Vikram Sarabhai

(iii) U.R. Rao—Before coming to India, he worked on Explorer spacecraft at the University of Texas, USA. After sad demise of Vikram Sarabhai, he shifted satellite groups from Ahmedabad and Thiruvanthapuram to Bangalore where the group developed several satellites such as Aryabhata, Bhaskara, Rohini, Apple and INSAT. As ISRO chairman, he imitated several programmes such as PSLV, GSLV, cryogenic engine and remote sensing satellites.



U.R.Rao

EPILOGUE—This summary probably does not do full justice to all pioneers who contributed to building of scientific base in India. Due to paucity of space, many more fields are left out. These stalwarts worked with single minded devotion to make India self reliant even under fund

shortage, minimal or no infrastructure, manpower crunch etc. One needs to salute their indomitable spirit to pursue their goals against all odds.

This study mainly focused on following parameters—

1. Path breaking research which opened up a new field in India.
2. Developed a new technology for industry.
3. Built a scientific institution from grass root level.
4. Created a pool of researchers to carry forward the torch.
5. Opened a new field of study/ programme in a University.

Prof. (Dr.) **Tanmoy Deb** is Professor and head of department of Electronics and Communication Engineering in an engineering college. He has 34 years of teaching and corporate experience. He has authored 47 research papers, 6 textbooks, 11 popular science articles and holds one Indian patent.

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Form IV (see rule 8)

Details of the ownership and other facts relating to monthly newsletter 'DREAM 2047'.

Place of Publication	Noida
Periodicity of Publication	Monthly
Name of the Publisher & the Printer	Nakul Parashar (on behalf of Vigyan Prasar)
Nationality	Indian
Address	Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 309, U.P., India
Name of the Editor	Nimish Kapoor
Nationality	Indian
Address	Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 309, U.P., India
Name & Address of the owner	Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 309, U.P., India

I, Nakul Parashar do hereby declare that to the best of my knowledge and belief, facts mentioned above are true.

Sd/-
Nakul Parashar

Diatoms: hidden ecological sensors inside the *Myristica* swamps

Mital Thacker and Balasubramanian Karthick

ENVIRONMENTAL CHALLENGES:

Pollution and global crisis like climate change, rising temperature, melting glaciers, and changing weather patterns are significant environmental challenges we face today, altering the stability of the ecosystem and leading to an imbalance in biota and biodiversity loss! The present story is about how *Myristica* swamps were widespread across the vast area of the Western Ghats but are rapidly disappearing now due to unfavourable climatic conditions and changes caused by anthropogenic activities. Let us listen to the story of the mesmerizing ecosystem struggling for its survival today.



A glimpse of the *Myristica* swamp ecosystem in the Western Ghats

MYRISTICA SWAMPS:

Hi! You all might be aware of the word 'Wetland.' Wetlands are a particular type of ecosystem that remains flooded permanently or seasonally. I am one such tropical forested wetland known as '*Myristica* swamp,' living in the deep forested valleys of the Western Ghats.

MY HOME: WESTERN GHATS

My home is "The Western Ghats" of India, one of the world's **36 "Global Biodiversity hotspots."** I live here with my siblings. As such, there is no boundary of my home, but to simply put, the Western Ghats is the chain of mountains that runs along the west coast of peninsular India, passing through the states of Kerala, Tamil Nadu, Karnataka, Goa, and Maharashtra. The Western Ghats have been preserving many distinctive ecosystems in its fertile lap for centuries; one among them is "**Myristica swamps.**"- **that's me!**

ABOUT ME:

You might be thinking about what *Myristica* swamps are. What kind of name is it? What type of ecosystem is this that is unique to others? Well, let me introduce myself in detail. Unlike lakes and rivers, few water bodies are swampy, submerging plants and trees within the waters. In simple words, we are a specific type of wetlands that form along waterbodies, consisting of saturated soils and slow-moving waters. Amongst different kinds of swamps, we are a group of swamps dominated by trees belonging to the world's most primitive plant family, commonly known as the Nutmeg family and scientifically called "**Myristicaceae.**" So, we were given the name *Myristica* swamps. Life has to adapt to a submerged environment to flourish inside us because we remain underwater for most of the year. Unlike in a typical aquatic ecosystem, you will be

amazed to see the plant's underground roots outside the soil in *Myristica* swamps. To survive in our swampy environment, trees over here form "U" shaped unusual-looking roots which pop out of the ground, known as '**knee roots**' or '**breathing roots,**' which help plants breathe and take oxygen from the air. The waterlogged condition leads to partial decay of organic matter, resulting in high humus decomposition, making the water inside us more acidic. Isn't it most astonishing to know about acidic waters? With all these unique features, we are the **live museum** of ancient, rich, and endemic floral and faunal diversity, providing information about the biological history of life from the past.

A GLIMPSE OF MY PAST:

"Which flora and fauna will survive in such an extreme ecosystem?"

There might be a few! Why is it essential to study *Myristica* swamps?" If these are your thoughts now,

you would be surprised to know that we are one of the most biodiversity-rich ecosystems! I will take you in my past to satiate your inquisitiveness. Millions of years ago, when humans had not practised cultivation yet, we, the *Myristica* swamps, were nicely spread across the entire stretch of the low elevation parts of the Western Ghats. But gradually, we experienced unfamiliar disturbances primarily due to natural and anthropogenic alterations. A gradual decline in rainfall was observed over the last 10,000 years as well. However, since the change was slow enough, we could adapt and survive. However, the change and damage brought up by the humans/ anthropogenic activities have been so drastic and severe over the short span of 200-250 years that we started disappearing at an alarming rate. Our home is converting for human needs so rapidly that we cannot adapt anymore. If we become extinct, not only will the ecological balance be impaired, but the rich biodiversity will also vanish, which is entirely dependent on our existence. Because of this climate change and disturbances created by some of you, we are now fragmented and shrunken to only a few patches, with Kerala holding a major share of us and a few more in Karnataka and Goa, a single swamp in Maharashtra. We like a sponge, absorbing and retaining water inside us during the monsoon. By holding water inside, we prevent flood, and later by slowly releasing it during the dry season, we prevent draught. Unfortunately, human exploitation has increased because of this exceptional quality; indeed, we are now less than 200 hectares in the whole country.

INSIDE MY EMPIRE:

Do you want to explore me? Now, if you're going to get into my empire, you have to reach a deep forest section of Western Ghats. Hold on, Walk slowly! You have to make your way through the tangled



Popping out roots outside the soil that helps plants to breathe in swampy environment.

roots. While you walk, suddenly, if your nose catches a stench of desiccating organic matter, then welcome! You have entered into my empire. I am here to welcome you with the melodious music of the streams, chirping of birds, colourful butterflies, leaping topsy-turvy Malabar giant squirrels, and bouncing Nilgiri langurs. Doesn't this sound like a story of fairy tales? Oh, I forgot to mention the troop of leeches, Malabar pit viper, and King Cobra, who are also eager to greet you! If my mesmerizing beauty hypnotizes you, I want to tell you something with pain: **my siblings and I will vanish soon!** What is pinching me deep inside my heart is that I am nurturing rich and rare biodiversity inside me, yet you have not heard about me! I am afraid that I might die before you could ever know about me. You read it correctly; you don't even know what I am preserving inside! Because of the things you see with the naked eye, you get easily fascinated by them. For instance, the forest department conserved the Mudumalai forest's elephant corridor.

In the same way, larger organisms inside us have been studied extensively. Scientists have discovered several new plant and animal species on the verge of extinction and endemic to us. We are home to 16+ endemic fishes such as *Mystus malabaricus*, *Salmostoma boopis*, *Aplocheilus lineatus* (striped killifish), and frogs like *Mercurana myristicapalustris*, *Nyctibatrachus jog*, *N. kempholensis*, and *N. kumbhara* too. However, you will be surprised to know that the rich diversity of microorganisms

has not caught much attention inside us to date despite our ancient history.

THE MAGIC:

The world is not always full of destroyers; some are savers too! Some days before, I met someone who visited me and scraped some parts of brown, green growth adhering to my roots and stems and on adjoining stones and sediments too! She said, "I think these are tiny algae colonized." She said she would take this shiny and slimy brown growth to her study laboratory and observe it under the microscope. "What was she about to do with my scrapings? I got furious." She smiled and replied that she was looking at the hidden world of microbial diversity growing on me. At first, I didn't get it; later, I realized she was talking about the microalgae known as "**Diatoms**" growing all over me. She said she wants to look at those creatures and their taxonomy and understand what they indicate about the water quality in swamps. Can they be the indicators to evaluate the environmental conditions and anthropogenic interferences inside us so we can be conserved? She said, "YES, like how the 'Catfish' fish reflects high organic polluted waters and Mahseer fish indicates clean waters of western ghats, the same way, diatoms in you are unique than the diatoms from any other city lakes.

DIGGING INTO THE HUGE WORLD OF TINY DIATOMS

(Scene explained)

When she started explaining more about this, I impatiently cut into her talk as I was aware of these tiny diatoms inside me. She continued!

SHE: Diatoms are single-celled algae, so tiny that they are not visible to the naked eye, and so giant colonies that they supply nearly 20-25% oxygen to the entire planet! You can expect them in huge numbers and diverse species (diversity) of various shapes and sizes in all aquatic environments. Like trees, diatoms are

plants; they also do photosynthesis and supply food and oxygen for all the organisms living inside me. They are the primary producers. Their cell wall is made up of glass (silica), so even if diatoms die, their silica cell wall remains in the soil forever and can still be studied.

ME: How are diatoms going to save us?

SHE: Buddy, Be calm! (She elucidated further)

ME: I know about little creatures known as diatoms living inside me, but I don't know how huge in numbers they are.

SHE: Approximately 2 million worldwide. Such a high abundance and species diversity, distribution among most aquatic environments, and sensitivity to different environmental conditions make diatoms reliable and useful environmental indicators.

They are very particular about the quality of water in which they live.

ME: But again, why are few species surviving only here, not in any other water bodies?

SHE: One appealing thing about diatoms is that each species has its own

ranges and tolerances for different environmental variables. It would not be surprising to know that a minute change in my surroundings would cause a complete replacement of the diatoms living inside, and new diatoms will come to live on your roots and any surface with moisture.

ME: Why have you learned about them so much?

SHE: By catching this unique behaviour of diatoms, I will explore how diatoms respond to the changing environment. (Saying so, she peeped into her handy microscope).

A JCB sound disturbed our conversation; she asked what that sound was.

ME: Those are the humans. (Complaining tone). They are converting my area into a plantation, dumping so much unwanted stuff inside me, and degrading my nature and beauty.

SHE: That's problematic for everyone staying nearby.

ME: Indeed! Are you aware that I hold water during a flood and provide water during summer? Some villages are

entirely dependent on me for drinking water. But sadly, you humans are diverting my water for agricultural use and constructing dams. The cascade effect and the water flow might change and can cause floods, the water of which I can't hold anymore as you have already cut some sections of my swamps. How will I survive if you break my flow in between like this?

SHE: Don't worry now; diatoms can provide a solution for this! As soon as someone tries to degrade you, the tiny doctors (diatoms) will alert us about the pollution caused by the disturbance. If you are receiving more pollutants, a different group of species of diatoms will grow.

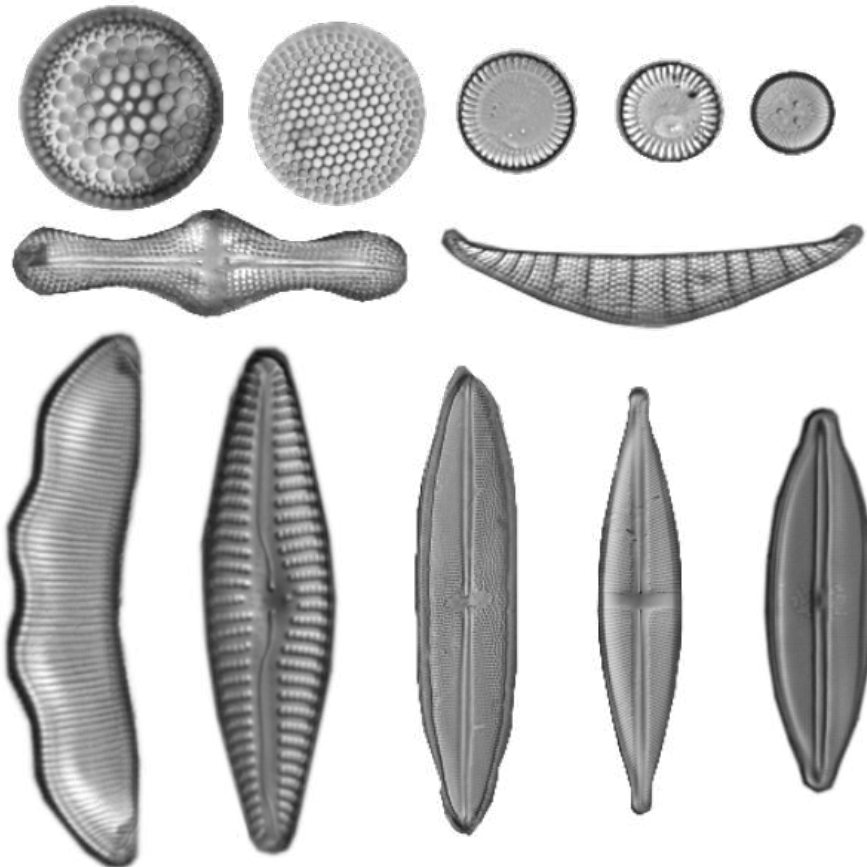
ME: You mean diatoms that love a good environment will vanish off?

SHE: Apparently, a kind of! For example, if the pH and temperature of your water are changing, then diatoms will also alter. Thus, we will learn about your ecological health by looking at the diatoms inside you. This knowledge will help us to pause all the destruction and conserve you.

WHY SHOULD HUMANS CONSERVE US?

We not only provide water for drinking and irrigation but also absorb carbon dioxide from the surrounding atmosphere acting as 'carbon sinks' and helping the world fight against global warming. We slow down the force of rainwater and help prevent sudden, damaging floods in the nearby area, as we did in Kerala recently! We absorb excess nutrients (nitrate, phosphorous) and filter out various pollutants serving as 'nature's wastewater treatment plants.' We preserve rich biodiversity and have been declared 'Biodiversity Heritage Sites.'

Before leaving, the kind researcher assured me that she would also tell the world about our benefits so that others would come forward to conserve us! I got significant relief after listening to her.



Diatom diversity inside the Myristica swamps.

Mital Thacker and Dr Balasubramanian Karthick
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