# TECHNOLOGY AMBIT

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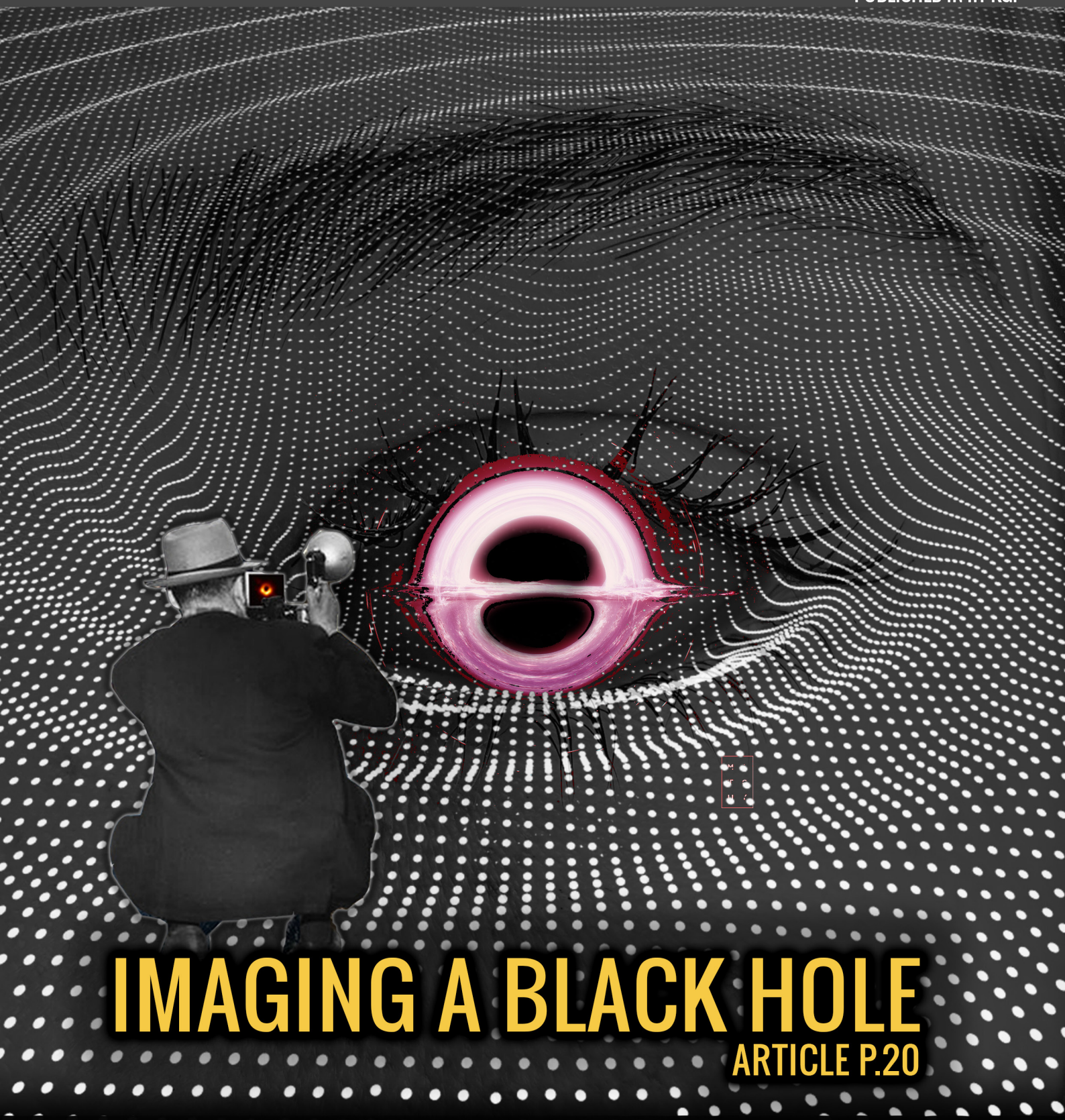

# IMAGING A BLACK HOLE

ARTICLE P.20

# IIT TECHNOLOGY AMBIT

IIT Technology Ambit tries to identify emerging technologies, contemporary research, and start-ups born out of the IIT ecosystem. The analysis of the impact of these developments is done to assist the Tech Sphere of India and beyond to keep pace with the latest.

We actively look forward to contributions from all stakeholders of all IITs.
By stakeholders, we refer to the trinity of alumni, professors, and students of IITs.

# ABOUT THIS EDITION

The April issue focuses on Pure Sciences and their implications in the applied world.

Firstly, we have Suraj Iyyengar, who interviewed Prof. Venky Venkatesan, one of the leading names in the world of NanoTechnology. Prof Venkatesan talks at lengths about where NanoTech is headed and how our beloved Moore's law may finally desert us.

Then we have Samruddhi's interview article with Dr. Bala Bharadvaj, who is currently the MD of Boeing India Engineering and Technology Center. With a mixture of wit and knowledge Dr Bharadvaj talks about where Boeing is headed in the future and how the aviation industry is going to change.

Next, we have Shail's review article on Spoonshot, a startup that is leveraging AI to hand out personalised food recommendations. Given that food is intrinsically something that needs similar tastes to be identified with, Food Data Science becomes quite the need of the hour for companies looking to offer state of the art services.

Next up, we have Utkarsh writing about the details of the Black hole image that recently took the world by storm. The significance of that image and the technology that went behind this process are discussed in detail,

Lastly, we have Aritra's article about a groundbreaking discovery about IIT Kharagpur researchers led by Prof. Pinaki Sar who have discovered signs of life in India that dating back to 2.5 billion years in the form of microbial cells. Surprisingly and interestingly, this discovery of sign of life goes back to an era when the Earth's crust was unstable.

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# From the tech GOSPEL

Aye, I'm the Tech Gospel, a magnanimous preacher of the Philosophy of Technology. Magnanimity is personified in me by the fact that I will ignore your ineptitude towards ruminating on the Philosophy of Technology or rather in the concept of philosophy itself.

In the last issue, we had looked at ancient India's contributions to mathematics. We had specifically looked at the invention of binary numbers and the discovery of Fibonacci numbers. We'll further this exploration towards science and technology.
In the next few issues as well, I would like to let the readers know about some significant science and technology discoveries that ancient Indians have given to this world.

One of the important scientific inventions in the field of problem solving is the chakravala method. It is a cyclic algorithm to solve indeterminate quadratic equations, including the Pell's equation. This method for obtaining integer solutions was developed by Brahmagupta, one of the well known mathematicians of the 7th century CE. Another mathematician, Jayadeva later generalized this method for a wider range of equations, which was further refined by Bhāskara II in his Bijaganita treatise.

Next in line comes the theory of atoms. One of the notable scientists of the ancient India was Kanad who is said to have devised the atomic theory centuries before John Dalton was born. He speculated the existence of anu or a small indestructible particles, much like an atom. He also stated that anu can have two states — absolute rest and a state of motion. He further held that atoms of same substance combined with each other in a specific and synchronized manner to produce dvyanuka (diatomic molecules) and tryanuka(triatomic molecules).

No wonder, Albert Einstein himself said: "We owe a lot to the ancient Indians, teaching us how to count. Without which most modern scientific discoveries would have been impossible."

That's all for this issue. Tune in next month to know more about ancient India's contributions to science and technology.

# AVIATION-THE SKY AND BEYOND: AN INTERVIEW WITH DR. BALA BHARADVAJ, MD, BOEING INDIA

*"IIT Technology Ambit interviewed Dr. Bala Bharadvaj at Global Entrepreneurship Summit in February, 2019. Dr. Bharadvaj graduated from IIT Madras in Aeronautical Engineering in 1974 and went on to complete his PhD from Georgia Tech in 1979. He currently serves as the MD of Boeing India Engineering and Technology Center in Bangalore. His interviewed was marked with dollops of humour mixed and profound thinking that set us up to understand and enjoy simultaneously."*


## Q. Does Boeing have plans beyond aviation and aerospace?

We plan to go beyond airplanes. We are looking into end-to-end connectivity, like a flying car. We do a lot of innovative things. We want to transcend airport-to-airport transport and venture into home-to-home transport.

## Q. What is Boeing's five-year plan for India?

We basically plan to expand our engineering footprint in India, including things like IT, research etc. There is another section about providing production services to India. For example, the Indian air force, navy etc. We look to support needs of the government of India. We also support what we have already delivered to India. Airplanes have complex machinery and require a lot of maintenance.

## Q. What are the technologies that can cause disruption in the aerospace industry? Are these technologies being worked on in the IITs or in the company's R&D?

Disruption refers to something like serendipity, the positive side of an accident. It is something we had not expected was coming. Digital industry is disrupted by data analytics, block chain, IoT etc. These foundations can affect many fields from washing machines to aircrafts. The ability to store and harness a lot of data requires sensors. This can cause an impact on aerospace as well. It depends on the intelligence of people using the data as well. For example, maintenance of an airplane. Sensors on airplanes help us monitor signals. We can thus figure out if that part of the craft needs attention, is deteriorating or is alright. These things were not so easy to tackle back in the day.

In Boeing R&D, we are looking into all of these things. We are part of a global company so are in touch with colleagues in USA, Australia etc that we collaborate with. Coming to places like the IIT's, universities are very important as there is a lot of fundamental research going on. The more interaction there is between professors of college and people in the industry, the research can be made more relevant. There are faculty members with high levels of expertise in a niche area. They experiment in a particular zone that help us know if we thinking in the right way and so on.

## Q. In your opinion, what can India do to become the global leader of aviation and space exploration? What kind of research will be required for the same?

India can become the global leader. A great example is ISRO. They have extremely reliable and low cost products. They are launching satellites for other countries. It is competing with the rest of the world. Coming to the airplane side, Boeing works with the Tata group. We are making very reliable parts for both Boeing and Airbus. Indian companies have the discipline of setting up these systems of great quality. Airplanes are more complex than even rockets! A great deal of precision goes into the making. One mistake with a rocket wastes it but airplanes are more flexible in that zone. Worldwide, commercial and military airplanes have achieved a lot of reliability. That is India's challenge. We have smart, conceptually strong people but we need disciplined, decimated effort to do it again and again. Collaborations are done keeping in mind mutual benefit. There must be goals that both parties find to be useful. Too many cooks spoil the broth. Collaborations cannot be forced. There must be mutual respect and give-and-take.

## Q. What were the major technologies that were used in your domain during your tenure?

I started more than 30 years ago. Those days, computers were not as powerful. We take for granted the programs we use today. People back then had a lot more intuitive knowledge and understanding of physics. Most of my engineering classes have been useful during my career. The physics stays the same but the dependence of computers has changed. The complexity of the computer technology has advanced a lot. Aerodynamics is a subject very unique to aerospace. It is a fundamental part. We relied a lot more on experiments. It took a lot of time in the lab. My colleagues were doing research in CFT. Today I work a lot more on the computer as the problem space has become bigger. When we develop the shape of an aircraft, we can do it in a much more sophisticated way. Similarly on the structure side. We had rudimentary tools in the past but today we have advanced tools, some of which were developed in NASA and taken over by private industry to make them better. The intuitive nature of design has been replaced by the computational design of computers. Our dependence has increased but it has allowed us to make more sophisticated designs. It has allowed us to make aircrafts with much better fuel efficiency, for example. It has saved us some time but not much because since we can do detail analysis, we explore things we couldn't do before. Air travel has become less expensive over the last 30 years. So have computers. Not necessarily the machinery but the cost of travel has certainly become cheaper.

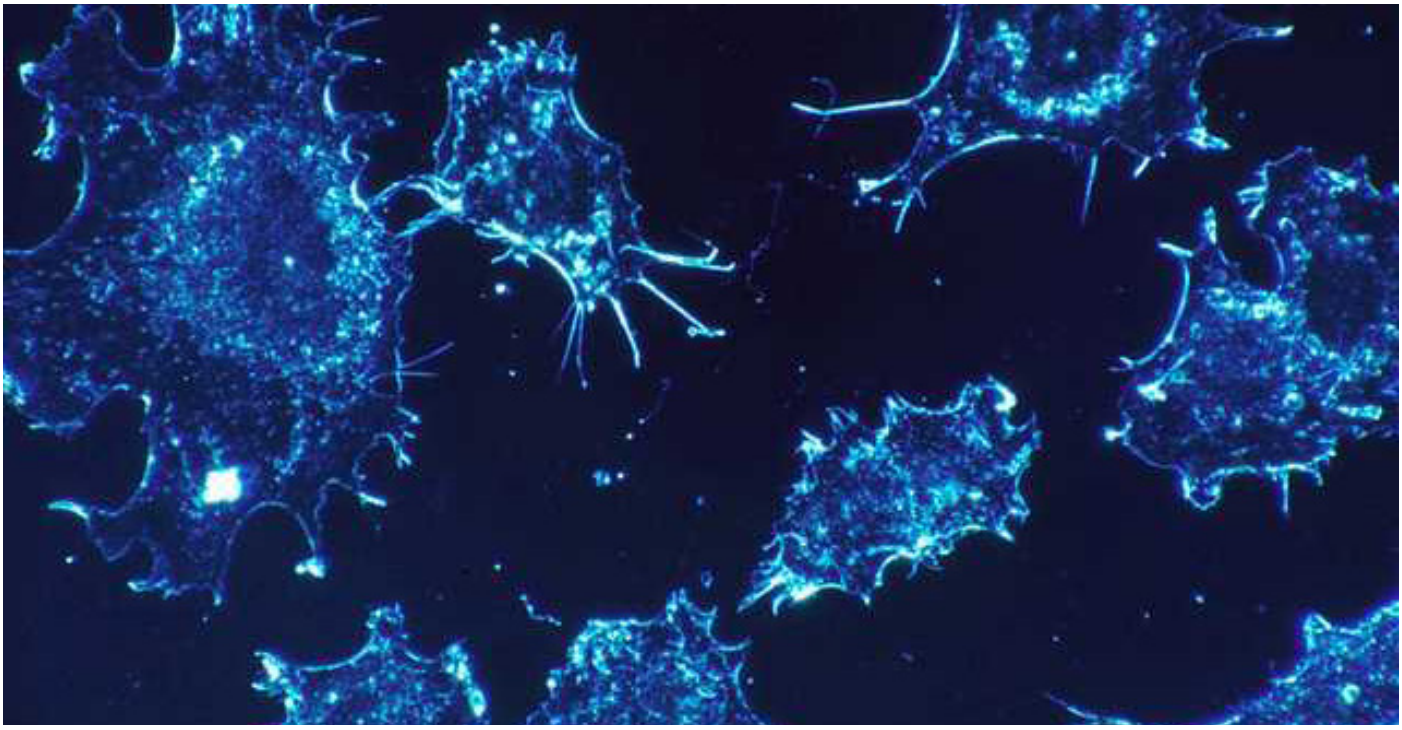
## Q. Can you mention some problems that are still not solved by technology but have a good scope for working on?

There are many ares but it depends on the subject. If you go back to aerodynamics, which is a more mature field, the kind of unsolved problems are really the niche problems. For example, today we use fluid mechanism to disrupt flow to improve aerodynamics of the environment. This is something that doesn't drastically change flow


in normal conditions but in certain conditions, the overall airplane can become more efficient. We talked about the digital technologies which are still evolving. Aerospace is not a science, it is an industry. Our goal is to take people from one place to another. Shouldn't we have something better than trains? Like helicopters going from one point of a city to another point in a different city. Helicopters are also a part of the aerospace industry though it has slightly different technology. The part which gets attention is people publishing a paper about something unheard of and completely new. Technologists should be solving problems. Generating ideas and experimenting are part of science. Engineers should use these ideas and to me are entrepreneurs by definition. Material science or aerodynamics is not good or bad but it is the passion people have for that subject. They can take the knowledge and create a success story of creating something new. More than technology, we must focus on the value and utilisation of ideas. A patent is nice to have but that by itself is useful only when it is applied but it is not as important as someone without a patent who solves a problems and makes a 100 more people smile.

**Q.** HBR and MIT Tech Review are well-established Journalism bodi0es that use the brand name of their institutions and provide benchmark content to the world, in a similar sense IIT Technology Ambit is a PAN IIT initiative that uses the brand name of IITs and provides benchmark reviews and articles on Technology in the Indian context. Do you believe that 'Quality Journalism on research and technology' is crucial? If yes, what suggestions do you have for IIT Technology Ambit on this front?

The many graduates of IIT's have gone on to do extremely well. This has created a strong brand name for the IIT's internationally as well. The IIT 'tag' has become synonymous with excellence. We should leverage it because there is a tremulously great amount of respect for that 'tag'. You can use it to highlight some of the things being done in the system of alumni, professors and so on. You can inspire others. I have met IIT alumni working in the Indian government working on policies and so on. This amazes me because they chose to go back through the IAS exams and become part of a different kind of environment. They are making an impact. That kind of information can inspire the larger audience in terms of what the IIT's have done. In terms of technology, there is no distinction between Indian, Japanese or American technology. Just like science is science, technology is technology. There are some problems that are specific to a country. For example, flowers from the Ganges are being collected to extract perfume. That is a very Indian context. This is where distinctions arise between different countries. What works in Himachal Pradesh may not work in Tamil Nadu. These are things we should think about when we devise technology. You never know, something that you developed for India may help someone in some other country.



# EMERGING AREAS IN NANOTECHNOLOGY: A CONVERSATION WITH PROF. VENKY VENKATESAN

*"IIT Technology Ambit had the pleasure of interviewing Dr Venky Venkatesan, an alumnus of IIT KGP of the 1969 batch. He completed his PhD degree from Bell Laboratories. He currently leads the Singapore Nano Institute at NUS. He talks at lengths about where nanotechnology is headed and how Moore's law might finally get debunked."*

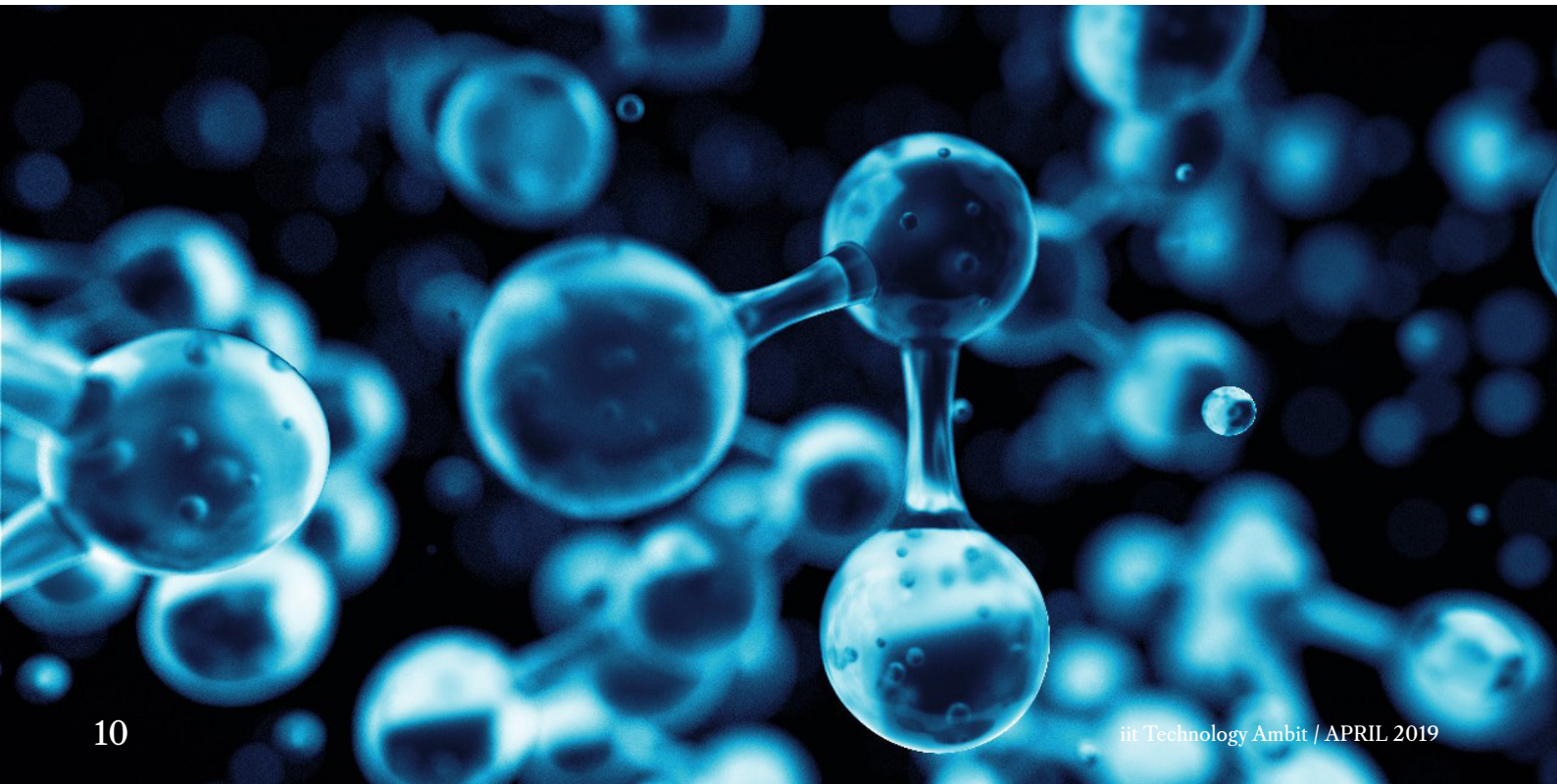
On December 29th, 1959. American Physical Society, California Institute of Technology. Richard Feynman famously gave a talk entitled- 'There's plenty of Room at the Bottom'. "Why cannot we write the entire 24 volumes of the Encyclopaedia Britannica on the head of a pin?"
"Let's see what would be involved. The head of a pin is a sixteenth of an inch across. If you magnify it by 25,000 diameters, the area of the head of the pin is then equal to the area of all the pages of the Encyclopaedia Britannica. Thus, all it is necessary to do is to reduce in size all the writing in the Encyclopaedia by 25,000 times. Is this possible? The resolving power of the eye is about 1/120 of an inch – that is roughly the diameter of one of the little dots on the fine half-tone reproductions in the Encyclopaedia. This, when you demagnify it by 25,000 times, is still 80 angstroms in diameter – 32 atoms across, in an ordinary metal. In other words, one of those dots still would contain in its area 1,000 atoms. So, each dot can be adjusted in size as required by the photoengraving, and there is no question that there is enough room on the head of a pin to put all the Encyclopaedia Britannica."

The possibility of synthesis via direct manipulation of atoms discussed, laid the seeds for the development of nanotechnology, as we know it today. Over a decade later, in his explorations of ultraprecision machining, Professor Norio Taniguchi coined the term nanotechnology.

Nanotechnology is the manipulation of matter on an atomic, molecular and supramolecular scale. Generally, it is the manipulation of matter with at least one dimension sized from 1-100 nanometer (10-9 m). It is where quantum mechanical effects are important. At such scales, matter can exhibit unusual physical, chemical, and biological properties. These differ from the properties of bulk materials and single atoms or molecules. Properties such as melting point, fluorescence, electrical conductivity, magnetic permeability, and chemical reactivity change as a function of the size of the nanoparticle.

In the 1980s, two major breakthroughs sparked the growth of nanotechnology. First, the invention of the scanning tunnelling microscope in 1981. It provided an unprecedented visualization of individual atoms and bonds, and used to manipulate individual atoms in 1989. The developers, Gerd Benning and Heinrich Rohrer at IBM Zurich Research Laboratory received a Nobel Prize in Physics in 1986. In 1989 Don Eigler of IBM demonstrated this by arranging 35 atoms on a surface made of nickel to spell out IBM.

Second, the discovery of Fullerenes in 1985 by Harry Kroto, Richard Smalley, and Robert Curl. They together won the 1996 Nobel Prize in Chemistry. In 1991, came the discovery of tiny needles of carbon that run anywhere from 1 nm to 100 nm in diameter. These are tubes made of carbon atoms connected in hexagons and pentagons. The discoverer Sumino Iijima, named



them carbon nanotubes. Nanotubes come in two types: single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs).
Manufacturing nanostructures with various degrees of quality, speed and cost has two approaches. The 'bottom-up' and the 'top-down' approach.

Bottom-up manufacturing involves the building of structures, atom-by-atom or molecule-by-molecule. There are three categories of approaches- chemical synthesis, self-assembly, and positional assembly.

- Chemical synthesis is a method of producing molecules or particles, which are used either directly in products in their bulk disordered form, or as the building blocks of more advanced ordered materials.
- Self-assembly is a technique in which atoms or molecules arrange themselves into ordered nanoscale structures by physical or chemical interactions between the units.
- In positional assembly, the atoms, molecules or clusters are manipulated and positioned one-by-one.

Top-down manufacturing involves starting with a larger piece of material and etching, milling or machining a nanostructure from it. Precision engineering and lithography are techniques used to remove material from it. Electron beam lithography is primarily used to fabricate the masks used for optical lithography. Ion beam techniques aid to repair masks and for specialist device applications.

Fields like nanoelectronics, nanomechanics, nanophotonics and nanoionics provide a scientific foundation of nanotechnology. Here's a list of the types of things nanotechnology is making possible today. Nano is being used:

- To make strong lightweight equipment ranging from tennis racquets to windmill blades
- To clean up industrial solvents contaminating groundwater
- To protect clothing with nanoparticles that shed water or stains
- As efficient catalysts in chemical manufacturing by saving energy and minimizing waste products.
- As a coating on countertops that kills bacteria
- In sunscreens to provide protection from UV rays without producing a residue
- In wound dressings to rapidly stop bleeding in trauma patients
- As a film on glass to stop water from beading and dirt from accumulating
- In paints to prevent corrosion and the growth of mould and provide insulation
- To make nano-featured integrated circuits. These allow companies to make computers chips that contain billions of transistors
- In bandages to kill germs
- For coatings in heavy-duty machinery to make it last longer
- In plastic food packaging to keep oxygen out so the food spoils at a much slower rate

Prof T. Venky Venkatesan, Director of NUS Nanoscience and Nanotechnology Initiative and alumnus of Indian Institute of Technology, Kharagpur spoke to IIT Tech Ambit about the future of nanotechnology.

In 1965, Gordon Moore, one of the founders of Intel, observed that the number of transistors was doubling every 24 months and would continue to do so. This is the Moore's Law. For 50 years the chip industry managed to live up to that prediction. The first integrated circuits in 1960 had ~10 transistors. Today the most complex silicon chips have 10 billion. Silicon chips can now hold a billion times more transistors. Moore's Law was an observation about process technology and economics. However, a combination of spiralling cost, technology barriers, power density limits and diminishing returns means Moore's law is dying. The year to year growth in computing power is ending.

Device designers now need to get creative with the 10 billion transistors they have to work with. Companies are going from fabrication technologies to packaging technologies. With new chip architectures coming in like multi-core CPUs, massively parallel CPUs and special purpose silicon for AI/Machine Learning and GPU's like Nvidia, new ways to package the chips and to interconnect memory and even new types of memory are being developed.

"Currently, we are handling these new technologies using CMOS transistor which is inefficient to handle human-like computer", says Venky. "The chess grandmaster's brain uses 20watt of power

whereas the supercomputer uses 20terrawatt of power. That gives you the energy scale at which CMOS is operating. Companies like Intel and IBM are developing 'biochips' which perform biological-like functions. They try to emulate what a neuron does in terms of asynchronous processing and other things. The challenge there is to reduce the power consumption and cost."

Progress in computer technology (and the continuation of Moore's law) is becoming increasingly dependent on faster data transfer between and within microchips. "The next field that nanotechnology will influence is communications interface on multiprocessor systems-on-chip (MPSoCs). A very large electromagnetic delay happens in such chips where distances of propagation are very long. Silicon Photonics is expected to be the technology platform to address next-generation optical interconnect solutions. However, in photonics, there is a slight mismatch between the photonic devices and transistors. A laser- about 100 microns- is about a million times bigger than a transistor. Plasmonics is another answer to this problem where you propagate light in the form of surface plasmon and carry information without the electromagnetic delay. Plasmonics will become the next big thing."

Nanomedicine is the application of nanotechnology in medicine. It draws on the natural scale of biological phenomena to produce precise solutions for disease prevention, diagnosis, and treatment. Nanoparticles are being used to encapsulate and even help deliver medication directly to cancer cells and minimize the risk of damage to healthy tissue. This can change the way cancer is treated. It can also dramatically reduce the toxic effects of chemotherapy. Novel materials are engineered to mimic the crystal mineral structure of the human bone or used as a restorative resin for dental applications. Graphene nanoribbons are being studied with the goal of replacing spinal cord injuries. Nanotechnology enabled imaging and diagnostic tools are reducing diagnosis times, providing personalized treatment options and better therapeutic success rates.

Professor Venky owns a company that is working on correlating the content of breath with diseases. "Every human being is made up of many organic molecules. Disease cells release specific molecules which we release through our breath. By measuring the organic content of the breath we can get all the disease information. Cancer, for example, symptomatically shows up at stage 4 with a 5 per cent survival chance. For stage 1 it has an 80 per cent survival chance. Breath diagnostics coupled with molecular pattern studies can get us a point ranking for each disease. Be it cancer or a disease of the heart, it can be immediately diagnosed."

Technological advancements must keep pace with scientific discoveries. To compete in the global economy, one must learn to quickly leverage new technologies. In his tenure at the Forum on Industrial and Applied Physics (FIAP) Venky stresses on entrepreneurship. He believes that "the enrolment of students in a field correlates with the ability of the student to make a decent living out of the education and the degree finally obtained. Most Physics students enter the field with the view of becoming a faculty or an industrial or National Labs researcher and in some rare cases a teacher. We must somehow change this limited view."

# SPOONSHOT: FEEDING AI TO FOOD

*"Everyone has their own preferences, especially when it comes to food. The only possible way a review and rating makes sense only if it has been reviewed by people who have same food tastes as you, and are not complete strangers to your food preferences! Personalised recommendations based upon your taste preferences, mood and context, are a far better way to receive relevant options for you to make an intelligent meal choice. Spoonshot leverages AI for personalised Food recommendations, and , is well, leading the new field of Food Data Science."*

India's food delivery space is at its hottest right now. In the ecommerce industry, food delivery is a segment that has attracted billions of dollars from foreign investors in recent years. Mammoth increase in smartphone penetration and internet availability have further helped startups to scale into Tier III and Tier IV towns, the latest addition being Kharagpur- where Swiggy and Zomato overwhelmed IIT Kharagpur students by onboarding all the restaurants/cafes in the city.

Restaurant discovery and food delivery firm Zomato claimed to have hit the 21 million monthly order run rate in India in September 2018 implying that the firm saw its highest weekly order volume during the month touch 700,000 orders each day of the week.

A decade ago, dabbawalas criss-crossed the city by train and bicycle, conveying metal tins with hot home-cooked lunches to hungry office workers. Now the city's lunchbox carriers have been replaced with thousands of young men with scooters and smartphones, guided by the algorithms of India's online food delivery services. Indeed, the Indian Food delivery market has come a long way!

Most of the successful startups in the consumer internet segment like Swiggy, Zomato, Ola, Flipkart, etc have something in common that makes them work seamlessly. All of them have aggregator-based models, with no ownership of supply(food, cabs, etc). But the deeper similarity is their reliance on consumer feedback to rapidly iterate and eliminate the bad quality of supply. For instance- In mid 2015, numerous startups were coming up with the concept of providing digital presence to restaurants, which included website development, online ordering, social media presence and online food delivery. But Swiggy, among all of them, was successful because it listed all the restaurants in its app, where the users give feedback about the restaurant. Bad/poor actors are rapidly removed, thereby ensuring quality is managed as they scale.

These aggregators "outsource" quality control to customers, through rapid transactions. Although this particular play goes really well when it comes to cab aggregators and online marketplaces, other mechanisms and review systems should come into place to make the online food ordering a delightful

experience.

## *Dependency on Reviews and Ratings*

Most of us choose what and/or where to eat by reading reviews and ratings of restaurants. Think about all the restaurants you have visited or ordered food from over the last few months. How did you choose that restaurant? Probably by reading ratings and reviews. Did the experience live up to what the reviews told you?

Your taste for food is extremely personal. Everyone has their own preferences, based upon their background and experiences. Most of us even have irrational preferences. We're complex and strange beings. What you want to eat is often based upon your food mood.

Reviews and ratings don't help a person in such scenarios. The only possible way a review and rating makes sense only if it has been reviewed by people who have same food tastes as you, and are not complete strangers to your food preferences! Personalised recommendations based upon your taste preferences, mood and context, are a far better way to receive relevant options for you to make an intelligent meal choice.

This article talks about Spoonshot, a startup co-founded by an IIT Madras alumnus, that leverages food science and machine learning (AI) to understand and predict people's tastes. They are helping the F&B industry with key challenges including recommendations & personalisation, menu & product development and insights & trends.

## *AI in Food: Spoonshot*

Spoonshot (formerly known as dishq) was founded in 2015 aiming to build a personalized food discovery app for the Indian market. It was launched by Kishan Vasani (chief executive) and an IIT Madras alumnus Sai Sreenivas Kodur (technology head), who both previously worked, respectively, at online food ordering ventures Just Eat and Zomato.

Dishq(a combination of dish and ishq) concentrates

towards shifting food while ordering away from ratings and reviews, towards a more visual and emotionally driven decision. The startup further uses food science to extrapolate novel and relevant insights, personalised to every customer. Their methodology is highlighted towards unveiling clouded product innovation opportunities by surfacing early signals for novel and emerging ingredient combinations. To develop and enhance, their analysis gives decision-makers the quantitative confidence they need to motivate them to act faster.

Today, many of us are adventurous eaters, constantly searching for new food experiences. Most of us also make food decisions by prioritizing our health. In this new environment, all restaurants and FMCG companies, whatever their size, have to become as dynamic as possible. Spoonshot provides the freshest analytics to help them stay at the forefront.

The company initially started out with a B2C product that helped people to find the most relevant food for them. While users of their app were able to discover great food for them, they weren't able to order the food directly through the app. So, in the first half of 2017, they made the transition from food discovery app to taste tech provider.

With the help of its major three products v.i.z Genesis, Personalised recommendations and Guest Intelligence, Spoonshot has created an ecosystem that collects data and converts it into actionable insights.

## *Genesis: Going beyond consumer insights*

Professionals in the food industry are constantly looking to understand their consumers so as to be able to sell their products effectively. Analyzing the behavior of consumers in different demographics is the conventional way of gathering consumer insights. Many companies today make big decisions about new products, and their marketing strategy based on this data. Spoonshot has built a food brain that is able to ingest large amounts of data about consumer behavior at a global level and make sense of it.

This would not be possible without the combination of food knowledge and artificial intelligence. Molecular level data about food with scientifically backed principles allows them to provide accurate insights.

A case study provided on the company's website helps us to understand the entire process in a better manner. Spoonshot came up with a suggestion for a juice manufacturer to leverage the popular seasonal pumpkin spice trend by connecting disparate dots. After mining through a countless number of data points, they came up with the concoction of a 'Papaya Turmeric Pumpkin Spice Smoothie'. Why?

At the molecular level, pumpkin and papaya share about 75% of their aroma compounds, which suggests that they go well together. The same is true for pumpkin and turmeric. The fact that papaya, like many other tropical fruits, has gained popularity among consumers over the last few years makes this a sensible choice.

In the last 7-8 years, the interest in turmeric as an ingredient has almost doubled. Curcumin, the main active in turmeric has many proven anti-inflammatory benefits and because it comes from a natural source, the use of turmeric is only growing. This beverage makes a great choice for consumers who are health conscious but still want to enjoy the flavor of pumpkin spice.

## *Personalised recommendations:- Creating a personal menu for everyone*

This feature creates a digital platform with personalized recommendations that delight consumers and drive incremental revenue for the restaurants. Spoonshot recently conducted a pilot with HungerBox, a B2B F&B technology platform, where businesses, e.g. Accenture, are given their own food ordering platform for their employees to use.

As a closed platform, they naturally have high user retention. Employees were frequently using HungerBox's platform, often more than once per day. The issue was that employees wanted to try different food to avoid eating the same dish everyday but had no way to intelligently select other food, given they had so many options. Also, employees would often order a single item, e.g. a coffee, meaning that the basket size was small.

Using the Spoonshot Recommendation API, HungerBox integrated personalised recommendations at 2 key points in their core order funnel. The first was a "Recommended Just For You" box at the start of the funnel. This allowed users to select relevant dishes before choosing a restaurant/cafeteria. Effectively this removed a step in the conversion funnel. The second was a "Why Not Add a X" upsell recommendation, where X would be a drink or snack, just before the checkout and payment screen.

## *Guest Intelligence:- The real key of consumer loyalty*

It's almost impossible to manually track every customer and interact keeping in mind their past experiences. Guest Intelligence makes it possible. It creates a consolidated customer profile based on past interactions that helps the restaurant staff to provide a delightful experience. Real-time tracking of the customer experience during service helps the restaurant to take proactive actions and prevent bad feedback.

Intelligent engagement with Guest Intelligence smart CRM ensures brands to stay connected with their customers. This helps businesses increase repeat guests, build loyalty and spend low on acquiring new customers. By providing a 'consumer score', Guest Intelligence helps in identifying high-value and regular customers upfront.

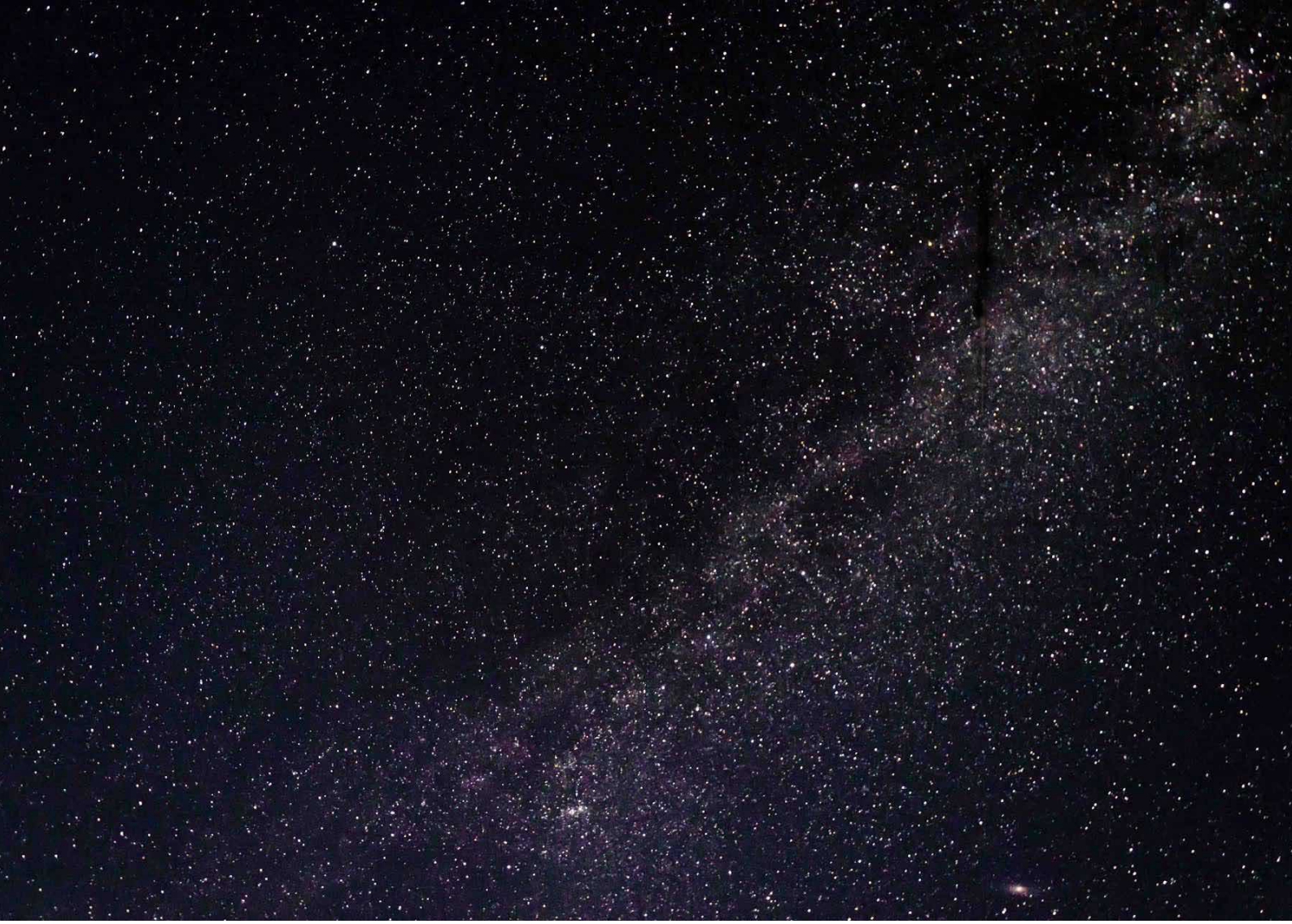
## *Traction and Growt*

The company claims to have more than 100 brands onboard so far, and it recently acquired Hyderabad-headquartered restaurant analytics startup Brisky. Brisky, operated by Bullpup Technologies Pvt. Ltd, advises restaurants on how to target clients and increase guest loyalty based on the data it collects on customers.

Spoonshot is hiring for multiple full-time profiles. Please visit this link for more details.

# THE BEGINNING OF OUR EXISTENCE: A PATH BREAKING DISCOVERY

*"IIT Kharagpur researchers led by Prof. Pinaki Sar have discovered signs of life in India that dating back to 2.5 billion years in the form of microbial cells. Surprisingly and interestingly, this discovery of sign of life goes back to an era when the Earth's crust was unstable."*



Microbial life that resides within the deep continental subsurface represents one of the largest and most diverse biospheres on this planet. This vast expanse of historical secrets has spilled gold in recent times. A team of researchers from IIT Kharagpur found evidence of life in India dating back at least 2.5 billion years, to the beginning of time known to scientists as "The Great Oxidation Event" which marked the entry of oxygen in earth's atmosphere, making life as we know it, possible.

The first sign of life have been found in the form of microbial cells in the Deccan, and it took the team four years of hard work. The microbes were found at a depth of three kilometers from the Earth's surface.

The depths of these ancient rocks do not have oxygen, water, organics, or light to support life. Rock cores dug out from the boreholes were investigated and have been studied to prove the existence of microbes. Dr Pinaki Sar explicitly points out to the fact that these microbes must have survived extreme conditions to live and multiply.

## *The Search:*

The search started in 2014, when ministry asked IIT biotechnologists to join a team of geologists at Koyna in Maharashtra, where a devastating earthquake had occurred in 1964. These geologists were trying to establish the cause of the quake. Since this part of Deccan is made of the oldest igneous rocks, the ministry asked IIT scientists to explore the possibility of life deep inside the rock belly. These are hard, near impermeable rocks where very little water or nutrients had percolated to make life possible.

## *The Results:*

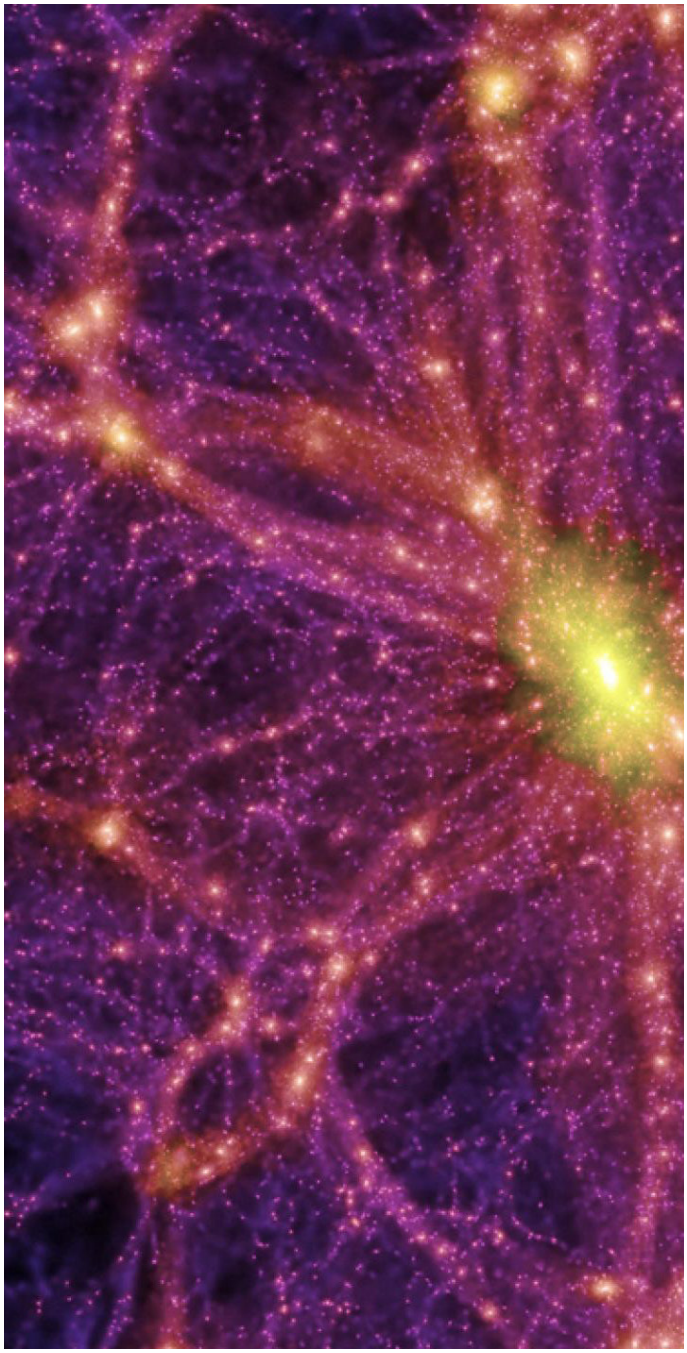
The subsurface rock samples from the Koyna-Warna region in western India span a substantial geological timescale, varying from ~65 Ma (Deccan flood basalt) to Archaean (basement granitoids) and including a small zone of weathered basement rocks that experienced the first rounds of lava flows during the emplacement of the Deccan traps. Geochemical attributes of the subsurface rock samples suggest distinct partitioning of the three major crustal provinces (BS, TZ and GR) deep

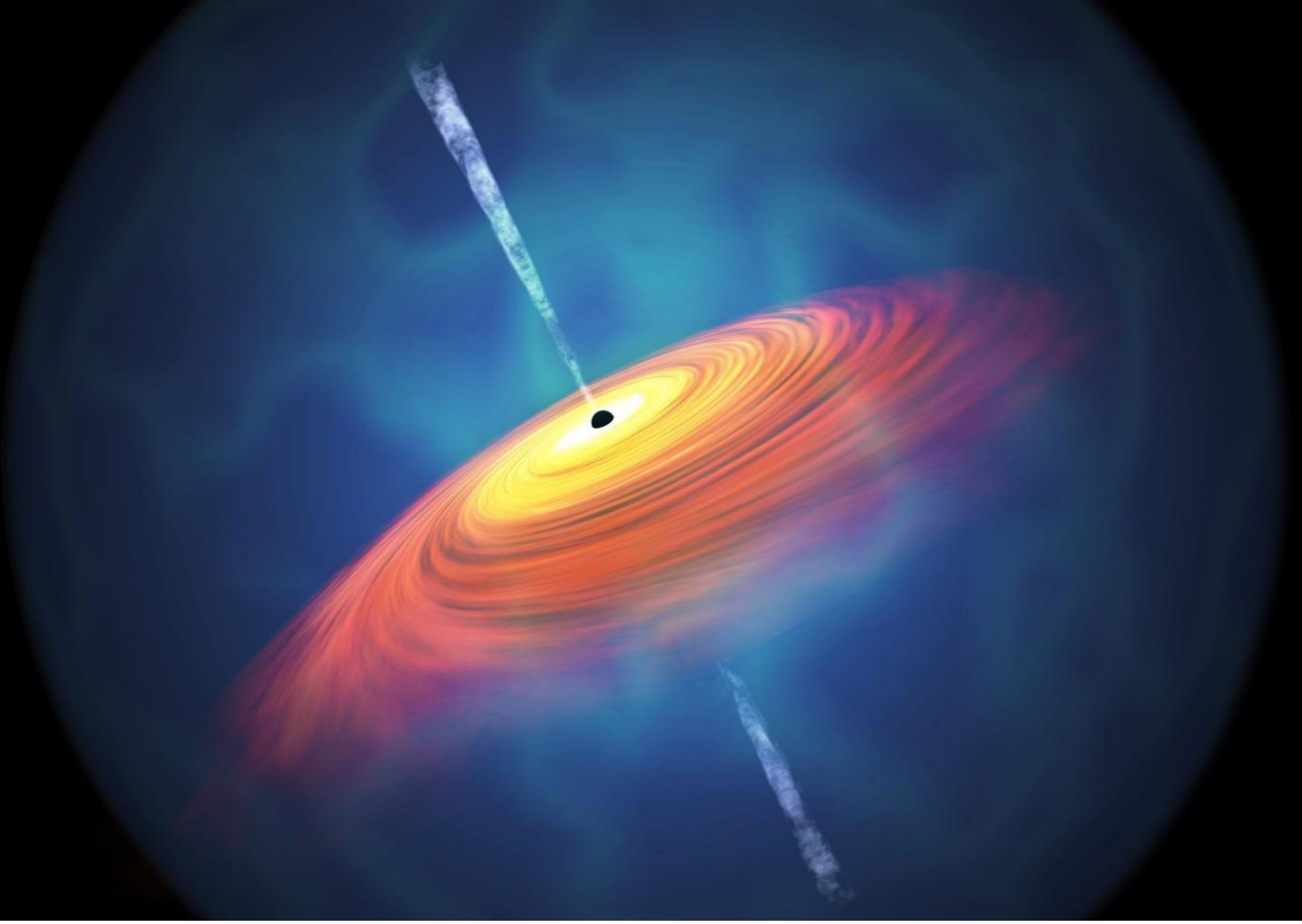
underneath the Deccan traps. During last five decades, the Koyna-Warna region has experienced recurrent seismicity attributable to the changing water levels in the Koyna reservoir, potentially causing structural deformation and associated fault and fracture zones in the adjoining regions. The samples from all three zones used in this study portray characteristic geochemical signatures with respect to minerals present, alkalinity, and low organic carbon along with distinct pattern of abundance for oxides. Nevertheless, variations as evident in a few samples could be attributed to geological phenomena. The variations are mostly in terms of relative abundance of oxides, in particular, higher weight percentage of $Fe_2O_3$ and lower weight percentage of $SiO_2$ than the standard basalts and granites. Some samples contain metasomatic minerals (like berlinite, dravite, pyrochlore and phlogopite). Presence of these metasomatic minerals indicates secondary alterations and possible movement of fluids through different faults and fractures.

Microbial life within the nearly impermeable, highly oligotrophic basalts and granitic bedrock is presumed to be constrained by prevailing physical and chemical factors. The igneous rocks in the deep subsurface have very low porosity and moderate-to-high temperature and pressure, 25 °C increase per km in basalt and 15 °C increase per km in granite; 26.7 MPa increase in lithostatic pressure per km.Deep subsurface igneous provinces are often devoid of photosynthetically derived organic carbon. Nevertheless, the geogenic carbon, in the form of dissolved inorganic carbon, organic acid, abiogenic $CH_4$, $C_{2-4}$ hydrocarbons, electron donors ($CO_2$, $CH_4$, $H_2$, reduced -S and -N) and electron acceptors ($NO_3^-$, $NO_2^-$, $SO_4^{2-}$, $Fe^{3+}$, $Mn^{4+}$, etc.) can act as essential metabolic resources and facilitate microbial life. From the overall geochemical data, scientists could elucidate the nutritional status of this igneous realm which suggests its potential to support microorganisms that prefer chemolithotrophic lifestyle. The chemolithotrophic/chemolithoautotrophic mode could be linked to heterotrophic metabolism through metabolic products of lithotrophic organisms, thus driving the community's overall function.

These microorganisms mostly bacteria, date back to a time when Earth's crust was still unstable and earthquakes punctuated with volcanoes. Between 2.5 billions and 65 millions years ago the crust would intermittently cool but would be shaken up again by fresh eruptions. These cool interludes were the time when the first life formed, in the form of microbes, started making appearances. The Deccan traps where the country's oldest rocks are located, were home to these first life forms. Geologists across the world are trying to reveal life antiquities on Earth and discovery by IIT scientists could well be a landmark.

Dr Pinaki Sar adds to this discovery: "They are extremely intelligent bacteria and they could teach us a lesson or two about how carbon and inorganic sources can be used for our survival!"





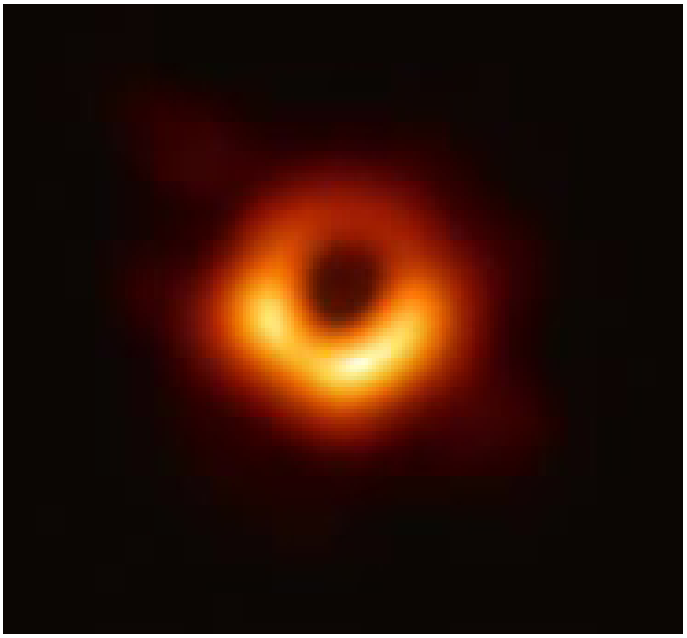
# SUPERMASSIVE BLACK HOLE: BUT WHAT DOES THE IMAGE REALLY SIGNIFY?

*"Ever wondered how a black hole, that was supposed to be black because it could not be seen, possibly get imaged, and create a whole round-the-world ruckus with its imaging as well? Even if it supposedly got imaged, what significance does it create for our Earthly lives? This article aims to explore these questions"*

A picture of a black hole is one of those great, self-negating concepts, like the sound of silence, the presence of absence or the lives of the dead. The nature of one refutes the other. But a picture of a black hole has arrived nonetheless — revealed more than a month back in simultaneous press conferences held in six different locations around the world.

At those events—in Washington, Brussels, Santiago, Shanghai, Taipei and Tokyo — astronomers gave humanity its first look at the black hole at the heart of the Messier 87 (M87) galaxy, nearly 54 million light years from Earth. With that, astrophysics opened one more tiny crack in the wall of secrets that is the universe.

"We are delighted to report to you that we have seen what was thought to be unseeable," said a Harvard University senior research fellow and director of the Event Horizon Telescope (EHT), at the announcement at Washington's National Press Club. "We now have visual evidence. We know that a black hole sits at the center of the M87 galaxy."
True to the nature of the science, the picture does not show the black hole itself. The defining feature of all black holes is that they are so dense, generating a gravity field so powerful, that nothing, not even electromagnetic energy — which, of course, includes visible light — can escape their pull. What the picture reveals instead is the black hole's so-called event horizon, the swirl of gas and dust and stars and light itself, circling the gravitational drain, before they're sucked inside never, ever to reemerge.



The light from the M87 black hole has to travel for 60,000 years through its own galaxy, then for 55 million years across interstellar space. Then it had to make it through our atmosphere, where the greatest enemy of the photons is water vapor. For that reason, all of the telescopes are deployed in places where the air is generally dry and generally clear — though not always. Simple bad weather could stymie even the most sophisticated plans, but the EHT team caught a break.

The black hole at the center of our galaxy goes by the name Sagittarius A*. It has a mass equivalent to about 4.1 million of our suns. While that earns it the sobriquet "supermassive black hole" (more common black holes can be as small as five solar masses), it's actually something of a pipsqueak as these things go. It measures perhaps 24 million miles across, or about a 50 billionth the size of the galaxy. Trying to take an image of that from the 26,000 light year distance at which the Earth sits from the center of the Milky Way is like trying to spot an orange on the surface of the moon—with the naked eye.

The black hole at the center of M87, by contrast, has a mass equivalent to 6.5 billion suns, or 1,585 times bigger than our own black hole. But at 2,700 times the distance, it was even harder to see.

One thing that made the work possible was not just the number of telescopes collaborating in the search, but their geographic distribution. The distance among the detectors — especially the 9,000-mi. north-south stretch from Spain to Antarctica — effectively means a collection dish nearly as big as the Earth itself. More than five decades ago, this concept, called very long baseline interferometry was developed that was deployed in this imaging.

The collection of the data was completed in barely a week, but the collation and analysis of it took the better part of the past two years. The researchers from the different observatories divided into four teams and worked independently, sharing no information among themselves about preliminary results, lest they influence or contaminate one another's data. Each team generated its own image of the M87 black hole from the data it had collected — and then they regrouped.

Integrating all of that imagery into the single picture that was revealed Wednesday presented a logistical challenge all by itself, since the teams had amassed five petabytes of data on half a ton of hard drives. No web-based system could handle all that, and instead, the data was transferred in a decidedly old-school way, with the hard drives physically flown to a Harvard lab, where the image integration was done.

The true wonder of the big unveiling, of course, is not how the images were created, but what they will eventually reveal. For one thing, the mere fact that two black holes of such radically different scales were within reach of the EHT detectors will provide a much richer mix of data. Sagittarius A* is a relatively quiet black hole, with an accretion disk — the ring of matter and energy that orbits the event horizon — that is relatively dim. The black hole still has the power to swallow stars, it's just not swallowing many.

The black hole at the center of M87, meantime, is ravenous, sucking in matter and blowing out jets of supercharged particles that approach light speed and extend for 5,000 light years. The EHT is by no means finished with its black hole work. Three new telescopes are being brought online—in Greenland, France and another in Arizona—and a second observing run was already conducted in April 2018. That data is now being analyzed, too, with much more surely to come. Virtually all large galaxies are thought to be organized around a central black hole. The known universe contains anywhere from 200 billion to 2 trillion galaxies, and while there's a great deal of debate on the exact number, there's no denying that the sample group is huge. We will never survey them all; we will surely survey more. And now, at last, we know how to do it.

# OUR TEAM!

## DESIGN TEAM

KARTIK TYAGI

MANSI SHIVHARE

## MANAGING EDITOR

UTKARSH SINHA

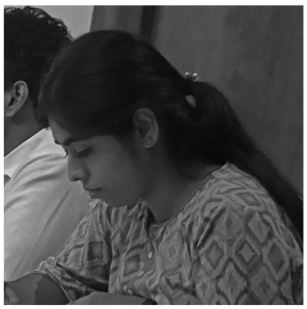
## EDITORIAL TEAM

ARITRA BISWAS

SURAJ IYYENGAR

## ALUMNI ADVISOR

ATAL ASHUTOSH AGARWAL



ASTHA JHAKER

SHREYA SANTRA

SAMRUDDHI PATASKAR

SHAIL DASWANI