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Points of conflict

Why has the Supreme Court given an ultimatum to the Reserve Bank of India on loan defaulters?

PRASHANTH PERUMAL J.

The story so far: On April 26, the Supreme Court directed the Reserve Bank of India (RBI) to disclose to the public the names of wilful defaulters on loans and also other information gathered by the central bank during its annual inspection of commercial banks. The RBI and the Supreme Court have been at loggerheads over this issue for a while now, with the central bank repeatedly refusing to obey the orders of the Supreme Court.

What did the RBI do?
In January 2016, the RBI refused to comply with demands made by activists under the Right to Information Act (RTI) to disclose copies of the annual inspection reports on banks such as the State Bank of India, Axis Bank, and ICICI Bank despite orders from the Supreme Court. The RBI also refused to provide information regarding the derivative losses suffered by banks and the fines imposed on banks by the RBI for violating various norms. The Supreme Court has this time around given the RBI a "last opportunity" to abide by its orders or face serious penal action. The disclosure of information about banks, however, is not the only point of conflict between two of the nation's powerful institutions. In early April, the Supreme Court quashed the RBI's circular issued on February 12, 2018 which directed banks to resolve their troubled loans within a period of 180 days. If banks failed to resolve their bad loans within the given deadline, the bad loan cases would be sent to bankruptcy courts.

> The outcome of the battle between the Reserve Bank of India and the Supreme Court will determine the amount of information on banks that will be made public

Why does it matter?
The outcome of the battle between the RBI and the Supreme Court will determine the amount of information related to banks that will be made available to the public. Supporters of the Supreme Court's position believe that greater transparency will allow the general public and investors in public and private sector banks to make better decisions with their money. In particular, they point to the problem of wilful defaults that has been plaguing banks. According to data gathered by TransUnion CIBIL, the amount of wilful defaults has risen by four times in the last five years from ₹39,504 crore at the end of March 2014 to ₹1,61,213 crore at the end of December 2018. At the same time, the number of wilful defaulters has doubled over the same period. State Bank of India, the largest public sector bank, has suffered the largest amount of wilful defaults among all banks.

The disclosure of the names of wilful defaulters to the public, many believe, will help bring about better credit discipline in the country by exposing problems brewing within banks sooner rather than later. In fact, they find it surprising that the RBI which has been spearheading the fight against bad loans is unwilling to release vital information on wilful defaulters to the public. The RBI, on its part, has argued that the disclosure of auditing information related to banks can lead to the exposure of sensitive information that may not be in the commercial interest of banks or even in the interest of the wider economy. The RBI also seems to believe that releasing information about defaulters can unfairly shame borrowers who may genuinely not be able to pay back their loans due to various financial difficulties. Such shaming could have the unintended consequence of impeding genuine business activity in the economy. The central bank has also put forward the argument that it has the fiduciary duty to protect certain information about banks.

What lies ahead?
It is hard to predict what will happen next in this battle. The Supreme Court may begin contempt proceedings against the RBI if it chooses to disobey its latest order, but the impact this will have on the RBI's freedom remains to be seen. The RBI has chosen not to obey orders coming from the Supreme Court in the past, including previous proceedings of contempt against it. If the RBI is forced to abide by the Supreme Court order, it will certainly increase publicly available information on banks. Greater transparency will also help make the RBI more accountable. If there are legitimate reasons for banks and the RBI to withhold certain information from the public domain, however, the forced disclosure of information following the Supreme Court's order may lead to various unintended consequences both within the financial sector and the broader economy. The RBI, for instance, may choose to not include in its annual inspection reports certain sensitive information about banks that it feels shouldn't be in the public domain.

Steering away from diesel

Leading passenger vehicle markets such as the European Union are opting for other fuels. What is the trend against this heavy polluter fuel in India?

G. ANANTHAKRISHNAN

The story so far: On April 25, Maruti Suzuki, India's top carmaker, announced that it would phase out production of diesel models from April 1, 2020, when stricter Bharat Stage VI emission standards come into force. What does this mean for the auto industry?

Why did Maruti take this decision?
Explaining its rationale, the leading passenger vehicle manufacturer said the enhanced emission standards would make diesel engines costlier by up to ₹1.5 lakh, and the acquisition cost of diesel vehicles for consumers would be markedly higher than petrol equivalents. Given the market dynamics, it would not make business sense for the company to invest in developing new diesel engines to meet the BS VI norms. Compressed Natural Gas could be a replacement for both fuels, according to Maruti.

Diesel cars account for about 23% of Maruti's domestic sales and it sold a total of 4.63 lakh diesel-powered vehicles during 2018-19.

On the consumer side, diesel vehicles are not particularly attractive today. The traditional advantage of lower operating costs due to a wide gap between expensive petrol and lower cost diesel has narrowed significantly. On Saturday, the price of diesel in a city like Chennai was ₹70.48 per litre compared to ₹75.92 per litre for petrol.

Environmentally, diesel is a heavy polluter and is losing ground in leading passenger vehicle markets such as the European Union. The rigging of emissions data by Volkswagen to show lower levels of nitrogen oxides accelerated the move away from diesel. Even in Germany, which is a leading maker of diesel cars, cities want to ban them.

Why is the move significant?
India has a growing vehicle-to-population ratio, although it is still lower than several other big countries. While Maruti's is a business decision, policy decisions on emission norms will steer the industry, and are therefore critical to improving air quality.

Ambient air quality has deteriorated so badly that 15 Indian cities led by Gurugram are among the 20 most polluted cities globally as per the IQAir AirVisual 'World Air Quality Report' for 2018, based on fine particulate matter ($PM_{2.5}$) that penetrates the lungs and bloodstream. Transport emissions, particularly from diesel, are a major contributor.

As of 2017, India's installed capacity for vehicle production stood at 7 million four-wheelers and 27.56 million two and three-wheelers. Commercial three-wheelers, such as large autorickshaws, sold in the past include heavily polluting diesel models that continue to operate even in densely populated cities.

During 2017-18 the auto industry produced over four million passenger vehicles and just under 900,000 commercial vehicles, according to the Society of Indian Automobile Manufacturers.

After the decontrol of diesel pricing about five years ago, the share of diesel models in car sales has dropped from nearly 43% in 2012-13 to 23% at the end of 2018.

What is diesel's pollution profile?
The Auto Fuel Vision and Policy 2025 published by the erstwhile Planning Commission, which laid out the road map for a transition to less polluting fuels, pointed out that sulphur in diesel is a contributor to particulate matter both in the vehicular exhaust and in the atmosphere. Sulphur is found in petrol too, but for comparison, it was 2,000 parts per million (ppm) in petrol before introduction of standards in 2000, but in diesel it was 10,000 parts per million (ppm) in 1996. Sulphur content was reduced with each phase of upgradation of emission standards to touch 50 ppm under BS IV. In BS VI, which is already dispensed in Delhi, it is 10 ppm.

Sulphur plays a key role since higher concentrations have an impact on technologies for control of other pollutants in the emissions, such as carbon monoxide, particulates, oxides of nitrogen and hydrocarbons.

The importance of cleaner diesel was studied in Karnataka, and data show that adoption of Bharat IV diesel in 2015 had an impact on the sulphur dioxide (SO_2) concentrations. The sulphur content of diesel changed from 350 ppm to 50 ppm. There was a 25% drop in nitrogen dioxide (NO_2) concentrations too, which could also be linked to change in the fuel quality. But such gains were neutralised by traffic growth. The rise in larger PM_{10} concentrations by 50%, was linked to growing numbers of vehicles and dust resuspension, besides construction activity.

> The Auto Fuel Vision and Policy 2025 pointed out that sulphur in diesel is a contributor to particulate matter both in the vehicular exhaust and in the atmosphere

Even with cleaner fuel, increase in vehicle numbers, especially those running on diesel cut into the gains. It was witnessed in Delhi, where, in spite of a shift of buses and autorickshaws to CNG during 1998-2002, the air quality gains were soon lost to explosive motorisation.

Bengaluru also had a similar experience, as a study by the Air Pollution Knowledge Assessment City Program by Urbanemissions.info showed. The city has steadily motorised, and number of vehicles registered per 1,000 population increased from 150 in 1990 to 300 in 2001 and 600 in 2016.

Within the transport sector, more than 70% of $PM_{2.5}$ emissions were found to originate from a small fraction of diesel-powered vehicles. Also an estimated 200 million litres of diesel are used by diesel generator sets in the city annually.

Data for Delhi from 2011 led researchers to conclude that on-road commuters are exposed to 1.5 times the average ambient concentrations. Automotive emissions add to the pollution burden imposed by manufacturing and construction activity, power plants, biomass burning for cooking and heating, and incineration of farm residues and garbage.

How can eliminating diesel improve health?
Air pollution is a leading contributor to non-communicable diseases and accounts for a large number of premature deaths. The World Health Organisation describes diesel exhaust as an occupational cancer-causing agent.

In India, the Global Burden of Disease Study 2017 attributed 8% of the disease burden, and 11% of premature deaths in people below 70 years of age to air pollution.

An assessment by researchers published by *The Lancet Planetary Health* in December 2018 said most Indian States, particularly those in north India, and 77% of the country's population were exposed to an annual population-weighted mean [fine particulate matter], $PM_{2.5}$, greater than the 40 microgrammes per cubic metre of air limit recommended by the National Ambient Air Quality Standards.

Even with a reduction in the sulphur content in BS VI fuels, the health effects of lower emissions would be lost due to a growing number of vehicles. The best scenario to reduce $PM_{2.5}$ exposure in India is, therefore, not just shifting to BS VI fuels but bringing about a reduction in use of private vehicles through augmented public transport and promoting alternative fuels including the use of electric vehicles.

In his book, *The Invisible Killer*, air pollution scientist Gary Fuller says diesel cars were promoted by a variety of actors, such as oil companies, governments, and vehicle manufacturers in the 1990s in order to create a market for the middle fractions of crude oil. Real-world emissions in new cars have not always aligned with expected type-approval tests. While test cycle nitrogen oxide emissions decreased by 80% since 1992, the real driving emissions from diesel cars increased about 20%, says Prof. Fuller in a recent paper.

In Europe, trucks and buses were already running on diesel, and industries and governments promoted its use in cars, giving petrol a lesser profile. Car makers produced newer diesel engines and promoted them citing lower carbon dioxide (CO_2) emissions compared to petrol equivalents.

India has slowly moved towards stricter regulation through mass emission norms for vehicles. The first standards came into force in 1991 for petrol vehicles, and a year later, for diesel vehicles. Based on Supreme Court orders of 1999, the Central government notified the Bharat Stage II norms for the National Capital Region and Bharat Stage I for the rest of India, from 2000. After transitioning over the years to BS III and BS IV, BS VI (the equivalent of Euro VI) standard will cover vehicles manufactured on or after April 1, 2020. (BS V has been skipped altogether.) Its 10 ppm sulphur standard will be less polluting, since the current level is 50 ppm.

Paying through the nose

The conversion costs involved in upgrading from BS-IV to BS-VI are higher for diesel cars compared to petrol and CNG cars

■ There has been a significant fall in the number of diesel car sales over the past six years. In 2012-13, these accounted for nearly 43% of passenger vehicle sales in the country while in 2018-19, the share of diesel cars is only 23%

Sulphur content in diesel

Diesel	BS I (2000)	BS II	BS III	BS IV	BS VI
Sulphur (ppm max)	2,500	500	350	50	10

Cost of upgrade

Four-wheelers (Passenger cars and LCVs, Less than 3.5T#)

Category	BS IV to BS V (₹)	BS V to BS VI (₹)
Petrol	3,000 to 5,000	4,000 to 6,000
Diesel	30,000 to 50,000	20,000 to 40,000
CNG*	3,000 to 5,000	4,000 to 6,000

Four-wheelers (Heavy duty vehicles, More than 3.5T#)

Category	BS III to BS IV (₹)	BS IV to BS V (₹)	BS V to BS VI (₹)
Diesel	70,000 to 1 lakh	80,000 to 1 lakh	80,000 to 1 lakh
CNG*	30,000 to 40,000	30,000 to 40,000	40,000 to 50,000

*CNG-Compressed natural gas
#T-tonne
Source: Auto Fuel Vision & Policy 2025

■ Pollution levels in major Indian cities have been consistently recorded well above permissible limits. This has prompted the government to leapfrog from BS-IV to BS-VI, skipping BS-V

Compiled by Sumant Sen

Chips at stake in the PepsiCo-farmers fight

Who has infringed on rights under the Protection of Plant Varieties and Farmers' Rights Act, 2001?

PRISCILLA JEBARAJ

The story so far: A David versus Goliath story has played out in Gujarat over the last month, with food and beverages giant PepsiCo dragging potato farmers to court for allegedly growing its registered potato variety used to make 'Lays' chips. Four small farmers from Sabarkantha district were sued ₹1.05 crore each, although they cite a law allowing them to grow and sell even registered plant varieties. Faced with growing social media outrage, boycott calls from farmers groups and condemnation from major political parties, the company finally agreed to withdraw cases after talks with the Gujarat government.

GETTY IMAGES/ISTOCKPHOTO

When was the variety introduced?
PepsiCo introduced, in 2009, the FC5 variety of potato that it uses to make its popular 'Lays' potato chips to India. The potato variety is grown by approximately 12,000 farmers who are a part of the company's collaborative farming programme, wherein the company sells seeds to farmers and has an exclusive contract to buy back their produce. In 2016, the company registered the variety under the Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FRA).

Finding that farmers who were not part of its collaborative farming programme were also growing and selling potatoes of this variety in Gujarat, PepsiCo filed rights infringement cases under the Act against some farmers in Sabarkantha, Banaskantha and Aravalli districts in 2018 and 2019. Farmers allege that the company hired a private detective agency to pose as potential buyers, take secret video footage and collect samples from farmers' fields without disclosing its real intent.

What is the farmers' stand?
The ₹4.2 crore lawsuit against four small farmers in Sabarkantha district was heard by an Ahmedabad commercial court on April 9, and an ex-parte injunction ordered against the farmers. However, farmers' rights groups across the country began a campaign against PepsiCo, requesting the Protection of Plant Varieties and Farmers' Rights Authority to intervene in the case and bear the farmers' legal costs using the National Gene Fund. At the April 26 hearing, the company offered an out-of-court settlement to the farmers on the condition that they give an undertaking not to grow the registered variety and surrender existing stocks or to join its collaborative farming programme.

Demanding an unconditional withdrawal of cases, farmers unions affiliated to the ruling Bharatiya Janata Party (BJP) as well as the Left parties joined in boycott calls against PepsiCo products and stoked outrage on social media as well. In the midst of an election season in which agricultural issues are in the spotlight, senior political leaders from the Congress and BJP added their criticism. On April 27, the Gujarat government announced that it would back the farmers and join the legal case on their behalf, although it later indicated it was working toward an out-of-court settlement. Finally, on May 2, PepsiCo agreed to withdraw all nine cases after discussions with the government.

What is the legal basis for the suit?
Both PepsiCo and the farmers cite the same Act to support their opposing positions. The PPV&FRA was enacted in 2001 to comply with the World Trade Organisation's Agreement on Trade-Related Aspects of Intellectual Property Rights.

PepsiCo based its suits on Section 64 of the Act dealing with infringements of the registered breeder's rights and subsequent penalties. The farmers' legal case depended on Section 39 of the Act, which allows the cultivator to "save, use, sow, resow, exchange, share or sell his farm produce including seed of a variety protected under this Act" with the sole exception of branded seed. As this section begins with the words "Notwithstanding anything contained in this Act...", farmers claim their rights have precedence.

Over the last decade, more than 3,600 plant varieties have been registered under the Act, with more than half of the registration certificates going to farmers themselves. This was the first case of infringement of rights under the Act, according to the central agency set up to implement the Act.

Who are the stakeholders and what are the stakes?
"The company is harassing us. I am not a crorepati, I cannot afford to pay these damages they want," says Haribhai Patel, who owns four acres and was sued for ₹1.05 crore. He claims he bought potato seeds locally, and is within his rights to grow and sell any variety. Even PepsiCo supporters admit that they lost the perception battle by dragging small farmers to court for large sums in election season.

However, some of the farmers sued in 2018 seem to be larger players with bigger stakes in the game. Fulchand Kachchhawa reportedly owns over 150 acres of land, as well as cold storage facilities, and is a potato grower and trader selling much of his produce to 'Balaji Wafers', the major regional competitor of 'Lays' chips. It is alleged that he sells the registered variety of seeds to smaller farmers and buys their produce as well. It is unclear whether his activities would be protected under Section 39 of the PPV&FRA.

PepsiCo says its collaborative farming programme and registered variety rights are under threat. While 'Lays' claims to be a leader in the country's ₹5,500 crore potato chips market, regional players are eating into the market share.

> Both PepsiCo and farmers cite the same Act to support opposing positions. The PPV&FRA was enacted in 2001 to comply with the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights

Farmers rights groups such as the Alliance for Sustainable and Holistic Agriculture saw the issue as a test case on farmers rights in India under the WTO regime, and warned that a bad precedent could hurt farmers of other crops and endanger the country's food sovereignty.

What happens next?
While farmers have claimed victory, they also demanded an apology from PepsiCo and plan to sue for compensation for "harassment" by the company. They are also wary of any future government-facilitated negotiations on seed protection and the rights of breeders. Pepsico's decision to withdraw the cases was "backed by an assurance from the government for a long term amicable settlement", according to sources familiar with the development, who added that both the Gujarat government and the Centre were involved in that assurance for further talks.

CAPSULE

Living on poison
Arsenic is known to be poisonous, but recently, researchers have identified micro-organisms in the Pacific ocean that breathe arsenic. In the study, the team analysed DNA from the seawater, noting two pathways to gain energy from arsenic-based molecules. Biologists think this is remnant from Earth's early history. The study was published in *PNAS*.

Violent birth
A violent collision of two neutron stars took place 4.6 billion years ago and may have been the source of several heavy elements on Earth such as gold, platinum and uranium, a new study finds. According to the study, published in *Nature*, nearly 0.3% of such elements were created in this colllision. The study adds to existing knowledge on origin of our solar system

IIT Kanpur identifies novel molecule to control hyper inflammation

Hyper inflammation compromises pathogen-clearing ability, also destroys the tissues surrounding the inflamed area

R. PRASAD

Researchers at the Indian Institute of Technology (IIT) Kanpur have identified and characterised a novel small protein molecule that can effectively control inflammation leading to better treatment outcomes. In contrast, inflammation control by molecules that are undergoing clinical trials may not be optimal due to inherent drawbacks. The work was done in collaboration with the University of Queensland.

Hyper inflammation

While some amount of inflammation at the site of infection is required for effective clearance of pathogens, too much inflammation compromises pathogen-clearing ability. Hyper inflammation also destroys the tissues surrounding the inflamed area leading to inflammation disorders such as sepsis, inflammatory bowel syndrome, rheumatoid arthritis and psoriasis.

A small protein (C5a) that is a part of the innate immunity (immediate defence against pathogens that have never been encountered before) gets activated when a pathogen enters the body. The C5a protein then binds to a particular receptor (C5aR1) found on the surface of certain cells such as macrophages and neutrophils to begin the process of inflammation and pathogen clearance.

Multitasking molecule: Unlike the molecules now being tested, our peptide molecule also reduces the amount of IL-6 being released, say Arun Shukla (right) and Shubhi Pandey.

Neutrophiles are already present in the body and circulate in the blood. Once the small protein binds to the C5aR1 receptor found on neutrophils, there is increased migration towards the site of infection leading to hyper inflammation. At the same time, binding of the small protein to the receptor on macrophages reduces the amount of a pro-inflammatory cytokine called interleukin-6 (IL-6) that is released, which is desirable to overcome inflammatory symptoms.

Therapeutic agents now undergoing clinical testing prevent the C5a protein from binding to the receptor found on neutrophils leading to reduced migration of neutrophils to the site of infection. Hyper inflammation is thus prevented. However, it has the opposite effect on interleukin-6 release. Unlike the C5a protein, the drug candidate molecules do not reduce the amount of IL-6 being released thereby causing more inflammation.

Role of IL-6

"There is more inflammation when the amount of IL-6 at the site of infection is more. So it is desirable to reduce the amount of IL-6 being released to overcome the inflammatory symptoms," says Arun Shukla from the institute's Department of Biological Sciences and Bioengineering. He is one of the corresponding authors of a paper published in the *Journal of Biological Chemistry*.

The small protein molecule identified by IIT Kanpur researchers addresses the shortcomings seen with the drug molecules now undergoing clinical testing. The drug molecule that IIT Kanpur team used for this study is already known to bind to the C5aR1 receptor. But its effects were not characterised in term of IL-6 release and neutrophil migration.

"Our peptide molecule binds to the C5aR1 receptor found on neutrophils and reduces their migration to the site of infection. And unlike the molecules now being tested, our peptide molecule also reduces the amount of IL-6 being released," says Prof. Shukla. Under *in vitro* conditions, the combined effect may lead to reduced inflammation.

"The molecule only reduces and not blocks neutrophil migration. There should be sufficient inflammation at the infection site to clear the pathogens," says Shubhi Pandey from IIT Kanpur and first author of the paper.

The peptide molecule identified by the team is smaller than the C5a protein so the binding to the receptor is weak. "So we have to use higher concentration of our synthetic peptide to achieve better results. Future work would be to increase the strength of binding by improving the molecule so that less concentration is needed," Prof. Shukla says. The team plans to carry out animal studies in future to measure the therapeutic potential of the molecule.

Why is northeast India drying up rapidly?

Decreasing monsoon rainfall is associated with natural changes in the subtropical Pacific Ocean

ASWATHI PACHA

Northeast India, one of the wettest places on the Earth has been experiencing rapid drying, especially in the last 30 years. Some places which used to get as high as 3,000 mm of rain during the monsoon season have seen a drop of about 25-30%.

A team of researchers from the Indian Institute of Tropical Meteorology, Pune, and Assam University set out to understand whether this decline is caused by anthropogenic activity or is it part of natural changes.

The results published recently in *JGR-Atmospheres* show that the decreasing monsoon rainfall is associated with natural changes in the subtropical Pacific Ocean.

Root cause: Rainfall reduction over the last 36 years is associated with natural phenomena. ▪ S.S. KUMAR

Pattern of fluctuations

"We found that changes in the Pacific decadal oscillation (PDO) – a pattern of fluctuations in the ocean, particularly over the north Pacific basin – are mainly associated with this declined rainfall," explains Abida Choudhury, a Ph.D. scholar at Assam University and the first author of the paper. "Just like El Nino/La Nina in the tropical Pacific, PDO has a signature for a longer time (on the decadal scale) in the sea surface temperatures and its interaction with the atmosphere, which in turn affects the northeast Indian summer monsoon."

Natural and manmade

The team used observed rainfall and sea surface temperature data for the period 1901-2014 for the study. The results show out that the reduction in rainfall during a major part of the last 114 years may be associated with global man-made factors, while the trend during the last 36 years is associated with natural phenomena.

"Only about 7% of the rainfall in this region is associated with local moisture recycling, which means that anthropogenic activities can affect only this small percentage. So we concluded that the recent rapid drying is a part of interdecadal variability of monsoonal rainfall which is strongly associated with the PDO," says Subodh Kumar Saha from IITM, Pune.

The researchers note that this study can be used to predict the monsoon rainfall over the northeast region on a decadal time scale using Pacific Ocean region data.

Previous studies have found that a dry spell may be preceded by a wet spell, so the researchers warn that "change in land cover and deforestation could potentially result in more natural disasters, for example, flash flood, landslides from torrential rains, and damage to crops and biodiversity".

"Policymakers should take these long-term predictions into account while planning construction of dams, power plants, etc. to prevent loss of property," adds Mahen Konwar, the corresponding author of the study from IITM, Pune.

IIT Delhi 3D prints human skin

The model can reduce and even replace testing cosmetics on animals

R. PRASAD

Researchers at the Indian Institute of Technology (IIT) Delhi have successfully 3D bioprinted human skin models that have certain anatomically relevant structural, mechanical and biochemical features similar to native human skin. The bioprinted skin produced in the lab by the team is already being used by ITC Ltd for experiments.

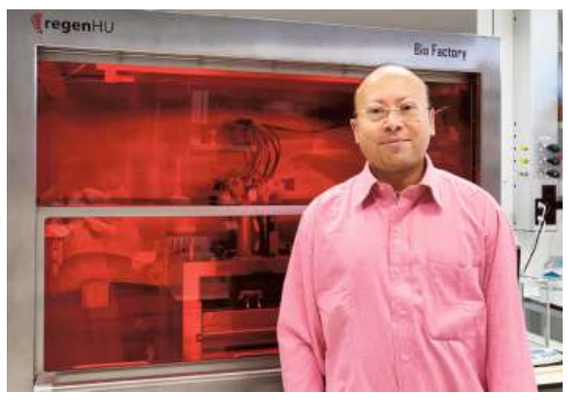
The bioprinted skin model will have wide applications in testing cosmetics. It can also reduce and probably even replace testing on animals.

It can also be used for testing dermatology drugs on human skin and at a future date even help in testing drugs for personalised medicine.

Testing on animals

The European Commission has prohibited testing finished cosmetic products and cosmetic ingredients on animals. It even prohibits marketing of finished cosmetic products and ingredients in the European Union.

The skin is composed of two important layers – the inner dermis (made of fibroblasts) and the outer epidermis (keratinocytes, melanocytes). The junction between the two layers is not flat but is undulatory or wavy. The undulatory morphology is important as it provides biochemical cues and mechanical support to the epidermis layer, provides structural stability to the skin by making the two layers adhere to each other, and not allow cells to cross the junction.



Commercialised: The bioprinted skin produced in the lab by the team is already being used by ITC Ltd for experiments, says Sourabh Ghosh

Unlike the currently available tissue-engineered skin equivalents, the team led by Sourabh Ghosh from the institute's Department of Textile Technology was successful in creating this wavy junction in the bioprinted skin model. The results were published in the journal *Bioprinting*. The study was funded by ITC Ltd.

The undulatory junction was designed using 3D CAD and 10 layers of dermis were constructed through bioprinting followed by eight layers of epidermis. "We designed the pattern so that both layers fit and the interface had a wavy pattern," says Prof. Ghosh. Silk bioink mixed with fibroblasts was used for growing the dermis, while bioink mixed with keratinocytes and melanocytes was used for growing the epidermis.

No shrinkage

The bioprinted skin also retained the original dimension without any shrinkage for up to three weeks. Traditionally, collagen used for developing skin constructs start shrinking within a few weeks thus affecting the morphology. Testing on such skin constructs therefore cannot be carried out beyond one week.

The bioink containing the cells are deposited in a criss-cross pattern leaving gaps in between. "The keratinocytes in the epidermis were seen migrating and filling the pores. This type of migration, which was very clear and striking, and cellular self-assembly recapitulate wound healing-like situation in native skin," says Prasad Admane from IIT Delhi and first author of the paper.

The keratinocytes in the epidermis differentiate and form into four distinct layers. "We studied three proteins – fibronectin, cytokeratin 1 and 14 – that are biomarkers of keratinocyte differentiation. They are produced in the bioprinted skin though the amount was comparatively less than native skin," he says.

Most importantly, gene and protein expression analysis showed 60% similarity in gene expression between bioprinted and native skin. "We identified 56 proteins expressed in bioprinted skin which play an important role in skin development, extracellular matrix organisation and keratinocyte differentiation," says Abhishak C. Gupta from IIT Delhi and co-author of the paper.

"We will now explore the possibility of growing hairs on the bioprinted skin," says Dr. Gupta.

Prof. Ghosh's team has already developed a 3D construct for hair follicle structure in collaboration with ITC Ltd.

"Our goal is set up a start-up to focus on developing different diseased skin conditions to test different drug molecules in patient-specific manner," he says.

Robot from IIT Madras checks pipelines for leakage

Endobot is a low-cost solution to identify faults and stealthy connections

SHUBASHREE DESIKAN

At a time when water scarcity pervades many urban centres, it is important to ensure that water being transported through pipes is not lost through leakages. In an attempt to address this issue, researchers from IIT Madras have developed a robot to check pipelines for leaks and other faults. Named Endobot, this robot is to be marketed by an IIT Madras incubated startup, Solinas Integrity, founded by the researchers.

Quite often, pipes that transport water suffer from low maintenance and neglect which causes them to develop leakages. These often go unnoticed except when the water seeps to the surface. Periodically, water pipelines are dug up, and this may bring leaks to notice, but this is left to chance and is a costly process at best. Water is also lost through connections that have not been sanctioned officially. Endobot is presented as a solution that can identify these faults and stealthy connections, at a low cost.

Mobile eye: The electrically-powered robot runs on four wheels connected using a conveyor belt and is tethered at one end.

The electrically-powered robot looks like a small tank, runs within the pipe on four wheels connected using a conveyor belt. It is tethered to the entry point outside the pipe. This construction allows it to run over tough terrain within the pipe without stalling. "Endobot is about 6 inches high and can study any pipe having a diameter more than 8 inches. Since water pipes typically have an inner diameter of at least 15 inches, it suits the purpose well," says Prabhu Rajagopal from the Centre for Nondestructive Evaluation in IIT Madras, where the robot was developed. He is also a non-executive director of the company.

> **The robot captures videos and transmits a live feed to the base at the entry point. It also uses laser-based techniques to examine the pipes as it moves.**
>
> VISHWA SAI PRATHYUSHA
> CTO, Solinas Integrity

"As the robot, which is electrically powered, runs through the pipes at about 15 cm per second, it captures videos and transmits a live feed to the base at the entry point. It also uses laser-based techniques to examine the pipes as it moves," explains Vishwa Sai Prathyusha, who is the Chief Technology Officer of the company and alumna of IIT Madras. These feeds are conveyed to the user's computer and may be analysed later using software developed by the team.

"Of course, the robot has noteworthy features, but also the software and tools for analysis developed by our team give us a major advantage over competition," adds Ms Prathyusha.

Additional sensors

Any technology goes through phases of development and Endobot is no exception. "As a next step, we plan to add more sensors - ultrasonic and electromagnetic - which can help us find out whether the pipes develop corrosion or cracks on the outer side," says Krishnan Balasubramanian, a director of the company. He is a chair professor in the Mechanical Engineering department of IIT Madras and head of the Centre for Nondestructive Evaluation.

"As of now, not many people are working on such small robots," says Prof. Rajagopal. He acknowledges, however, that there is competition at an international level. "Having small robots is a novelty even there, and open source electronics is driving this here," he adds. So while such robots may not be out of reach of international companies, they still have not focused on such solutions. "Recently, the Indian government and corporations and municipalities are increasingly looking at outsourcing operation and management of water resources to private players, and we are in a sort of Goldilocks zone," says Prof. Rajagopal.

The team has already completed one set of trials within IIT Madras campus, where many pipes and installations are nearly 40 years old. They are now in talks with various urban corporations to allow them to try out the robot. Some municipalities have expressed interest in pilot studies using the robot.

To follow a code of life

Dealing with oneself, and those around you

MINI KRISHNAN

Life is full of lessons and ringing messages.

Recently, in order to take a flight back home, I travelled by road from Palakkad to Coimbatore. Driver Mani deposited me at my elegant cousin's flat. For a considerable length of time after I stepped in with my suitcase, my cousin did not close and lock her door. It remained ajar. So I myself got up and locked it.

"Do you often forget to close your door?" I asked jocularly. "Ah... no," she said, "It's just that I didn't want to close the door in Mani's face." She further regretted that she hadn't yet offered him something to drink.

I was so struck by her acute empathy and courteous thought that I felt I had to share it. We teach children so many things to socialise them into our families and larger social circles. Sit up straight, don't cross your legs, don't grab things at meal-time, stand up when an older person enters the room... The list depends on how particular families are and how often a parent is around to advise children on cultured behaviour. Indeed, recognising that parents do not spend the kind of time they once did with their children (given the contemporary work timings) some of the caretaking has been outsourced to schools.

The educationists have put much thought into designing lessons and classes on Ethics Education and Life Skills in schools. At one time the phrase meant learning how to fix light bulbs, how to iron a shirt or mend fuses, but today it encompasses a whole philosophy that trains children in attitudes and value-enhanced patterns of dealing with oneself, the people around you and the environment.

Speaking of which... a few hours later at the airport, I was seated next to a middle-aged *sardar* who was deep in a book. As I was the only other traveller who settled down to wait with a book rather than with a phone, I asked him what he was reading. He flipped the cover in my direction: *Japji*, from the Guru Granth Sahib. He had discovered his religion rather recently because he enthusiastically explained the tenets and said how much he regretted not having paid attention to his father.

"He was a very religious man and I never bothered to ask him what comfort it gave him. His death a year ago struck a spark in me and I am now slowly learning about my religion," he said. More than missing his father, the gentleman regretted not having absorbed his religiosity. "I have so many questions which I know he would have answered, but it is too late."

I merely consoled him saying that the greatest gift a parent can give a child was what he had received from his father: a code of life.

Because, really, that's what 'life' skills are.

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The pigeon LIFE CYCLE

A fascinating family drama, sans emotions, unfolds on the balcony of a home

SUJIT KUMAR CHAKRABARTI

For some 20 to 25 days, a pigeon pair was nesting in our balcony. It all began when we found them fidgeting around on the plant tub in our balcony that had a tulsi plant in it. We guessed they were trying to make a nest. Our initial reaction was to try to shoo them away. But nature preempted this: within a day we found they had laid two eggs. We stopped trying to get them to fly away.

Endless series of hatching sessions began. One of the two birds would always be found hatching the eggs. And yes! They would take turns lasting eight to 10 hours, in our estimate. Initially it was hard to know which of the two was sitting at any given point. To solve that confusion, my mom came up with a (somewhat kind but effective) solution. One day, she smeared one of them with oiled vermilion on the head. Also, we arbitrarily decided that one of them - the one without vermilion smeared on its head - must be the father; probably because it was the more restless and less trusting of the two.

The funniest moments during the hatching period was when the pigeons would change shifts. The one coming in would fly in from one side of the balcony. The one finishing its duty would fly out from the other end. In between there would be some minimal exchange between the two. However, they wouldn't take enough time even to face or touch each other. The change-over would happen ritualistically, diligently, promptly. No show of romance or affection that the poets so love to associate with love-birds.

We would enjoy thoroughly making guesses about what information they passed between them while changing shift, what the other parent pigeon would do during its absence, and what would even make it come back to relieve its partner.

Of course, there's no way to answer these questions. Scientists wash their hands of all such questions with a single word: evolution. I believe in evolution. But I find it hard to believe that it provides the complete explanation for such spectacles. Considered casually, they appear funny, even comic. But on a second look, all this looks nothing less than a miracle.

On Sunday, it was already a few days since we had started feeling that it was taking the eggs too long to hatch. Probably the eggs would go bad; probably they already had. Why wasn't the pigeon couple just giving up this futile routine?

ILLUSTRATION: J.A. PREMKUMAR

But that afternoon, I casually strolled into the balcony. And what did I see? Two tiny creepy crawly creatures had replaced the two eggs. It was the father who was watching over them. I shouted out in excitement. The others at home rushed out into the balcony to have a look. Each one of us was equally excited, as if it was a childbirth in our own family.

The presumed mother, however, didn't turn up for several hours. We were eagerly waiting for that moment when she would come and find that her chicks were out. We waited for what would be a memorable moment.

Finally, by dusk it arrived. The father was hatching the chicks pretty much the same way he would hatch the eggs. The changeover routine began. The father shifted himself. The chicks got revealed from under him. Now was the moment!

The mom quietly took position, nudged the chicks under her wings, and started hatching. No fluttering of wings. No cooing. No dance of joy. No 'emotion'. Nothing! Come on lady, you've got to be kidding me!

This anti-climax was kind of really sad. It did appear that after all these are probably not conscious creatures, but puppets being controlled through invisible strings. Who is pulling the strings? God? Evolution?

Childbirth is a matter of joy and excitement! They ought to have felt joyous as we would have; and should have expressed it the way we would. Maybe it's this emotion and its expression that distinguishes people from them.

Or does it? Why is childbirth supposed to make us feel happy? Do we know? Or are these all strings too – coloured and strengthened differently – with which some invisible hand is making us play the drama of life, both humans and pigeons alike?

It's been two days. The chicks are growing. The parents feed them out of their own mouth with regurgitated food. We watch. The whole mystery, miracle, science, God, evolution, life... unfold before our eyes on the plant tub. It makes us wonder and smile. It overwhelms and makes eyes well up.

Meanwhile, the tulsi plant has withered. My mom says its offspring will come back to life once this family vacates; there are plenty of seeds dropped by the drying tulsi. Hopefully, the pigeons haven't devoured them.

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Mothering across generations

Striving to earn and deserve the advantages of nurturing received as a young one

NANDINI PATWARDHAN

I grew up in the 1960s in Mumbai. My family comprised my parents and two siblings, and my mother's parents. Our home was small – four rooms, each ten feet square, in a chawl tenement. The living room doubled as bedroom at night. The home was too small for everyone to even eat together. Dinners were consumed in waves – first the children, then the men, and finally the women.

Aji, my grandmother, had studied till fourth grade. She spent almost all her time at home, cooking and performing the many tasks related to that, such as cleaning the grain, cutting vegetables, and boiling the milk twice daily to keep it from spoiling (we did not have a refrigerator). The cooking took place in multiple waves too – first the lunches to be packed for the ones who left home for school or work, then the lunches for those who stayed back home, then the afternoon snack for children who are home from school, and then the dinner.

After lunch, Aji would have a few hours of unscheduled time and she would use it to read the Marathi newspaper, darn clothes, and re-purpose clothes that we children had outgrown, into shopping bags and other useful things.

Aji was born in Myanmar (Burma then), where her father worked for the British Customs. The only thing I recall she ever mentioning about him was that he was known for his honesty. The only thing I know about her mother was that she died during, or soon after, childbirth. How I wish I had asked Aji more questions when I had the time. Aji was the oldest of several children and was married at 14. So, there was not much mothering for her.

Since we were a joint family, Aji was more like a co-mother to me and my siblings. She told us stories from Hindu mythology and taught us the Marathi alphabet. Her greatest skill was in comforting us when our mother disciplined us. She managed to do this in a loving and gentle way, while also reinforcing rather than undermining our mother's authority.

Aji had come of age at a time when women were "lesser". Hobbled as they were by insufficient education, it was common to also see women of her generation as having judgment, authority and agency of a lower order. In my family, this translated into Aji being shielded from the larger world and being taken care of by her husband, as well as by her daughter (my mother). In turn, she performed her assigned role by offering care and comfort unreservedly to all who crossed her path.

A side-effect of this particular kind of socialisation was that Aji had grown up in a time when women were taught that their virtue lay in sacrifice and service. As a result, they were self-effacing – discouraged from having preferences and, if they had any, dissuaded from asserting those preferences.

Aji would often ask my sister or me, when we returned home from school, if we felt like eating *pohe*, or *chiwda* or some other home-made snack. Considering the question literally, we would answer yes or no, purely on the basis of our own interest in that particular item of food and our level of hunger.

One day our mother overheard this conversation and called us aside. "Whenever Aji asks about preparing something for you, you should just say yes. Usually she asks you when she feels like eating that snack." We nodded yes, and returned to our play. And from that day onwards, we answered in the affirmative regardless of which snack Aji offered to make for us.

As a happy and secure child, I accepted things as they happened. Living in the garden of childhood, for those like me who are fortunate enough to have such a garden, means enjoying the flowers, without having to give a thought to the gardeners who plant the seeds, water them regularly and trim the weeds. But this also means that the task of the rest of life is to live up to the privileges granted, to pay them forward to my children and to others who cross my path. Most important, it means striving to earn and deserve the nurturing received.

I celebrate the fact that the society of my childhood had changed sufficiently that granddaughters were not expected to live lives of denial, by self or others, that had been the lot of grandmothers. I appreciate the emotional intelligence of my mother who understood her mother and found a way to support her without drawing attention to it.

Who was mothering whom? Was Aji mothering her daughter and her daughter's daughters? Was my mother mothering her mother? Or were the granddaughters mothering their grandmother?

I think it was all of the above. My life was the richer, though I did not know it then, because of mothering so thoughtfully and generously offered and so easily, and now, gratefully, received.

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A new era

AMRASHAA SINGH

I remember coordinating with other families and friends to go to the movies. Then we had to be there well in time to buy the ticket and not miss the beginning of the movie. During the intermission, my father used to buy a popcorn tub, which we would all share. If it was a night show then we used to head back home and sleep. If it was a morning show then we would eat at fast food outlets and then go back home. The time we spent eating together when we went out or at the shopping malls would help us bond with the family or the other relatives.

Fast forward ten years, no one bothers to leave the house. A weekend or a Sunday goes past in resting, and if there is a movie we want to watch, just log into your account at Netflix, Amazon Prime or Hotstar, lie down in your bed and watch the film. If you're sleepy while watching it, just pause it. If you dislike the movie, stop it and watch something else. If you want food, open a delivery app and order what you want.

All this has only reduced the time we spend with our families or socialising with our friends. I still remember how we used to watch the entire movie in the cinema even if we did not like it, because we had paid to buy a ticket. Mother used to accompany us to the mall and help us try clothes, now, we WhatsApp her what we like and order it.

The restaurant with dynamic costing

When the cost accountants tried an inter-disciplinary approach at their business venture

GADEPALLI SUBRAHMANYAM

A couple of cost accountants came together to start a restaurant. They made quite a few enquiries about the possible clientele, number of eateries around that area, offices nearby that would have both floating and regular customers. They then started it with as little fanfare as possible, to reduce overheads on advertisement costs. They decided that people who are hungry would themselves look for the signboard of an eatery and that would be sufficient advertisement.

They expected that given their reasonable and transparent pricing policy, they would have the advantage of word-of-mouth publicity, which does not cost the establishment anything.

For each dish on the menu, the quantity and the price, based on raw material costs, overheads such as rent, electricity, wages, possible leakages of revenue, breakage of china, loss of small cutlery, profit margin, leftovers and so on, were factored in. In fact, they took pride in making every possible expense being taken into account, making the costing of the merchandise strictly as per cost accountancy norms.

The first week was dull, except on opening day. They had made provision for a dull first week, and took it in their stride. Slowly, the clientele grew. One of the partners used to go to the market each day to buy perishables, of course from a wholesale market. But it was found that buying in quantity led to high levels of spoilage, so resorted to buying as per immediate requirement from the retail market.

ILLUSTRATION: SREEJITH R KUMAR

But then they found that the prices in the market fluctuated on a daily basis. But they were supposed to offer a certain quantum of each item they sell in terms of size, thickness and quantity. Initially they resorted to asking the chef to reduce the diameter of the dosa and the thickness of the idli when the price of blackgram went up. Some regular customers started grumbling about the reduced size at the cash counter, while paying the bill.

They discussed this at their meeting that night before the eatery closed for the day. Instead of reducing the size, they thought that they could have dynamic pricing, as the airlines, even the railways, now do. They put up a notice that the prices of individual items would be set on a dynamic basis, and would vary according to the wholesale price index, and adjusted to the nearest rupee in view of the problem with small change. Each day the customer was given a menu that showed the dynamic rates for the day. There was a proviso that these were subject to change without notice even on intra-day transactions if there was any change in the circumstances.

One day there was an autorickshaw strike, which necessitated taking a cab to bring vegetables, fish, meat and eggs. Correspondingly, the menu was displaying the changed, higher prices.

As far as cost accountancy norms went this system was very satisfactory, but the clientele was equally dynamic, and soon enough they looked for other eateries that had static prices, at least on a longer-term basis.

The cost accountants were left breaking their heads as to what went wrong, before their establishment closed its doors permanently.

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SUSHIL PRASAD

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