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The Science and Politics of Materials

An Interview with Prof DD Sarma, Indian Institute of Science (IISc), Bengaluru.

By Lokendra Sharma and Akriti Sharma

Source: Lokendra Sharma and Akriti Sharma

About STIR

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About the Team

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The Science and Politics of Materials

An Interview with Prof DD Sarma, Indian Institute of Science (IISc), Bengaluru.

From the Bronze Age to the present Silicon Age, we mark different epochs, eras or civilizations by materials. And the importance of materials has only increased in the last few decades owing to the innovations in the field of material sciences. Prof Dipankar Das Sarma, a world-renowned material scientist at the Indian Institute of Science (IISc), Bengaluru, has not just been a witness but also contributed to this growth. In a wide-ranging interview, he responds to questions regarding the efficiency of solar cells, the future of solar energy, challenges of energy storage, the viability of hydrogen fuel, the pervasiveness of nanotechnology, the economic, political and environmental aspect of materials, and the future of material science.

One of the focus areas of your research group is energy science, more specifically, increasing the efficiency of solar cells. What are the challenges involved, and how is your research addressing it?

Prof Sarma: The bottom-line of all energy sources is that they should be cost-effective and accessible to everyone. However, there are many challenges hidden behind this simplistic statement. For example, it has taken 50-60 years and billions of dollars of investment to bring solar cell efficiency to the level where it is now commercially successful. We can produce electricity from solar energy at a rate that is viable when compared against fossil fuel routes. If you look at the historical efficiency curve of solar cells, you will notice how slow and gradual the increase in efficiency has been.

Our everyday life is based on silicon technology. And the importance of silicon cannot be overstated; not only solar cells, but almost every semiconductor device is also based on silicon. We now know how to make highly pure silicon and how to dope it with a desired material at a desired position to create a p–n junction, which forms the basis for all such devices. There are many other semiconductors that can perform as good as (or even better than) silicon, but we have not invested enough time and resources on those materials to replace silicon commercially; hence, we do not know whether they can provide viable technologies of the future. This is the main bottleneck because of which we are not able to move beyond silicon.

The presence of silicon in solar cells, however, poses one challenge. Silicon is an indirect band gap material. It has a band gap of 1.1 electron volts. The band gap of a material decides what the smallest energy photon it can absorb is. If the photon energy is smaller than the band gap, it is not absorbed.

Band gap is defined as the energy difference between the maximum energy of the electron-occupied valence band and

the minimum energy of the electron-empty conduction band of any material; it forbids the free flow of electrons. While in the case of conductors (metals) there is a free flow of electrons due to the presence of overlapping valence and conduction bands making the band gap zero, in insulators this gap cannot be bridged without providing some external energy to the system. However, when a photon is incident on a semiconducting material, a valence electron absorbs the energy of the light particle and gets excited to the conduction band provided the photon energy is high enough to overcome the band gap of the material. There are two types of semiconductors, namely indirect and direct band gap semiconductors. While direct band gap semiconductors have their minimum energy of the conduction band and maximum energy of the valence band at the same electron momentum, indirect band gap semiconductors don't. As a consequence of its indirect bandgap, silicon has relatively poor absorption of solar radiation. The photon absorption can be enhanced with the increase in the thickness of the silicon material, but an increase in the thickness poses other technical challenges that tend to compromise the efficiency. So, we need thin material with very good absorption.

As I mentioned before, multicrystalline silicon-based solar cell efficiency has gradually improved. In 1984, it was around 14 per cent. In 2021, 37 years later, it has increased to more than 23 per cent. However, in the case of relatively new hybrid semiconductor - halide perovskites (HP) - a hybrid of organic and inorganic materials, the efficiency with improvements over only the last ten years has surpassed the efficiency of silicon-based solar cells achieved over nearly 40 years of tremendous efforts.

HP is an excellent material for solar cells in many ways, but it is also at the same time rather unstable. There is much research going on how to stabilize it. It is unlikely that it will be replacing silicon anytime soon. Therefore, scientists are attempting to make tandem cells combining a thin layer of HP on top of silicon because the former absorbs solar energy very well where silicon doesn't. Our group at IISc is working on similar hybrid systems to understand and extend their spectacular properties.

In the near future is it possible to have highly efficient solar cells, say, 70-80 per cent?

Prof Sarma: No; 70-80 per cent efficiency is theoretically impossible just with solar cells, with the theoretical limit for a hypothetically ideal solar cell combining infinite number of cells each with a different bandgap being less than 69 per cent. To achieve the maximum current from the entire solar spectrum through absorption, the semiconducting material should have a smaller band gap. But a lower band gap limits the voltage output of the device. If you try to absorb all the photons, the voltage will decrease towards zero. Maximizing energy conversion from solar cells requires optimizing both the current and the voltage obtained from the device, since the power output is the product of these two. For a single-junction

(single active material) solar cell, the best band gap is a direct one of about 1.4 electron volts, leading to the theoretical limit of about 33 per cent for the efficiency. The tandem technology I discussed previously has the potential to take us to higher efficiencies. For example, a two-junction tandem cell using two ideal materials absorbing two separate parts of the solar spectrum efficiently has a theoretical limit of efficiency about 47 per cent. Tandem cells are commercially available today with about 30 per cent efficiency but the cost-benefit does not permit their wide-spread use.

Would attaining the maximum theoretically possible efficiency make solar a dominant energy of the future?

Prof Sarma: Solar energy, based on silicon technology, is expanding its global footprint rapidly. We are already producing electricity from solar photovoltaic (PV) at a competitive price lower than fossil fuels in many places, and further research in increasing the efficiency will afford us electric energy from the sun at an even lower price. The major bottleneck is not in the development of PV cells anymore.

The most required developments in this area are related to the storage of solar energy. Even if we have highly efficient solar energy production, solar cannot thrive without good energy storage technology. This is related to the fact that the energy production from the sun depends on the intensity of the sunshine on the solar cell and fluctuates widely with the season, time of the day, and weather conditions, leading to highly fluctuating power output from solar cells. Since the energy required for our use cannot depend on such uncertain energy production, it is essential to store the energy from solar cells and then convert it back for our use as and when required and at the rate that is needed. While there has been tremendous progress, we need even more efficient energy storage per unit of mass, volume and price of the storage device. Both energy and power density obtainable from such devices have to become high, and the price has to come down for more rapid penetration of this technology in our society replacing the traditional and harmful methods of energy production based on fossil fuels.

Using renewable energy to generate green hydrogen fuel is also a promising way of storing energy. And hydrogen fuel produces only water vapour when burned and therefore has zero emissions. How viable is hydrogen as fuel?

Prof Sarma: I believe that someday, maybe decades or centuries after, hydrogen will be viable and be a central part of the cyclic energy system. Today's renewable energy sources would not stay renewable for very long. To make solar and wind energy possible, you need many raw materials such as silicon, lithium, cobalt, copper and rare earths. And all of these are finite. Then you also have the geopolitics of resources to deal with. Therefore, we need a cyclic economy, and hydrogen is the best candidate. So, if we can find a way of producing hydrogen from water and then burning hydrogen to produce water without creating any intermediate greenhouse gas, it would solve a lot of problems.

But as of today, hydrogen largely remains commercially unviable. This is because of a number of reasons. First, storage of hydrogen is a challenge. Energy stored per unit of volume is low for hydrogen. Second, hydrogen is very explosive; storing and transporting it requires special care. Third, due to the previous factors, using hydrogen as fuel, say in vehicles, might self-consume a substantial chunk of energy it supplies and also make it expensive. However, we should note that there are a few car models available at present in select markets that are fuelled by hydrogen.

Your research group also works on nanotechnology which, along with AI, robotics, 3D printing and biotechnology, is considered revolutionary and disruptive technologies of our times. But while the latter are highly visible in the global economy and our daily lives, it appears that nanotechnology is yet to become ubiquitous. Do you agree with that?

Prof Sarma: The answer is slightly more complex than a simple yes or no. While we don't realize, there are nanotechnology solutions being implemented in many products that we use. For example, some high-end television sets use indium phosphide nanoparticles because that gives very good colour rendition. The transistors on chips which power our mobile phones and computers have today gone down in size with the latest technology allowing to reach below 10 nanometres. From tennis rackets to bicycles to aeroplanes, we find the usage of carbon nanotubes, which are very light in weight but very strong in terms of strength. Even medical science is looking at nanotechnology for drug delivery. Since certain nanoparticles can absorb targeted molecules with high-specificity, they also find a place in diagnostic and sensor applications. There are many such examples of nanotechnology applications. What the scientists are doing in the nanoscience labs, therefore, has many direct as well as collateral benefits. Nanotechnology has been a very diverse activity, and many of its applications actually change our lives without us realizing it. That's what technology is all about, and that's what human beings are all about: we get so used to technological artifacts around us so quickly that we take for granted everything that wasn't even there until yesterday.

The imperative of economic development has meant that the research being conducted by material scientists is leading to more environmental degradation by demonstrating novel ways of exploiting natural resources. On the other hand, material scientists like you are very conscious of the problem of climate change and are very vocal about it. How do you address that contradiction?

Prof Sarma: It is a very difficult question; and it is difficult because it points to a serious problem whose solution is extremely complex, if at all there is one. The root cause lies in the dominant paradigm of development. This means that if one wants to find a solution, they have to change that very paradigm. Why should the GDP increase year after year? Isn't it unsustainable? Should GDP rise just because the share market prices have to go up? We are creating demand where there is

none. Every year, you're getting higher-end gadgets, without knowing why you need them. And your need is being created through very careful AI implementation. This drains the resources which are all finite. In the process of manufacturing anything you go to the mines, take the relevant concentrated material from there, make products, and then that product goes all over the world. If you forget once about the intermediary — human beings — what you're doing is taking a concentrated material that nature had created and evenly distributing across the world. Higher-order energy is being converted into lower-order one. Which is exactly the thermodynamic process. The natural processes always go in that direction. It is entropically driven, and you cannot reverse entropy. The problem is we are running ever faster in that direction. That is why I believe we need to think in terms of cyclic order, where the only energy input comes from the sun. If we don't use it, much of it is anyway going to get wasted. Everything must be cyclic. If we don't have a recycling strategy, we are heading for a big problem because all natural resources, as we know them, will someday run out.

We have to ask some very tough questions of ourselves as a species, and not as a country. Climate change is a threat that is forcing people to ask such questions. And that's very important, because climate change has transboundary consequences, and therefore has to be dealt with by the human species as a whole. But if you think about these issues in terms of a country, or like a company, you would not mind growing or taking certain actions that may put others at peril. And this will lead to complete collapse and chaos.

At some level, a new generation of organic chemistry may be the solution to address the contradiction you flagged. Because organic chemistry doesn't depend so much on inorganic material (except some catalysts). Much will depend on whether we can figure out ways to combine mainly carbon dioxide, hydrogen, oxygen and nitrogen to produce most things that we shall need. If these materials are degradable and we can recombine the components again, then to a large extent, we can have a cyclic economy with the input of the energy coming from the sun.

Don't you think material scientists should now start focusing on researching things that actually lead to less exploitation?

Prof Sarma: I agree, and there is no second thought about that. Incidentally, this thought is closely related to a concept that is a buzzword in our community - earth abundant materials. It simply means using those resources which are abundant in nature as opposed to those that are rare. But using such alternate material only postpones the trouble to a later date.

But environmental considerations might not be the only motivating factor. The example of rare earth materials is instructive in this regard. China controls the global rare earth industry. And rare earths form a very important component of magnets which are then used for innumerable applications. Policy makers and scientists are concerned about this situation. Therefore, they are investing heavily in making powerful magnets

without rare earths. What this also shows is that there is a close relationship between geopolitical considerations and science.

Since using earth abundant materials is like delaying the inevitable then maybe the focus should explicitly be in reversing the exploitation trend altogether?

Prof Sarma: As I mentioned previously, recyclability has to be built into our system. However, if we try doing that too early, when the crisis hasn't yet come, there may be some resistance. Human beings are not very good at anticipating and solving problems. We are very good at borrowing and spending, and when the troubling time comes, then try to see what can be done about it. At present, sadly, we are in borrowing mode.

Even in this borrowing mode, the 'exploits' of material science and technology are being distributed unequally in the world. While some societies are very materially affluent, and some are not. What are your thoughts on this?

Prof Sarma: Sometime back, I gave a talk on the energy crisis which exactly addressed this. If we look at the per capita energy consumption in the world, the inequality of energy access and usage becomes very clear. When we know that there is an almost linear relationship between GDP and energy usage, why should not developing countries have a legitimate aspiration to become as affluent as, say, America? But if only two countries, China and India, were to somehow use the same per capita energy as the US, there's no way the current system can be sustained; it will collapse instantaneously. Now there is a realization of the importance of cutting down the emission from traditional energy sources. Being already in possession of advanced technology, the developed countries can afford the transition better. It is not very different from what happened during the 1960s onwards when the technologically advanced countries created a world of nuclear haves and haves-not. If developed countries believe that climate change is bad, then they must also realize that much of it is a consequence of their own development; this should call for committed actions to help and even finance energy transition in the developing countries. Even though we may want the Amazon rainforest to remain pristine, Brazil may very well ask: why should we maintain the Amazon rainforest for the whole world at the cost of our development and economy?

From the stone age of the past, to the silicon age of the present, human civilization has come very far. What would be the key innovations in the field of material science and technology that would define the upcoming epoch?

Prof Sarma: If you allow me to dream, I would love to see several innovations in material science that can contribute to bring in new technologies redefining the coming epoch. For example, affordable and viable fusion technology which, if it happens, would solve most of our energy problems. As of now, the energy required to run a fusion reactor is more than what it produces. Then, any material invention that makes quantum computation a common person's tool will lead to changes

in our lives that we cannot even imagine at this stage. There are certain limitations today because we have to do things at very low temperatures and with very carefully prepared objects, posing serious challenges to scale up such systems to practical device levels. If we can have robust objects that support quantum computation at room temperature or higher, it would completely redefine our lives. It will be as defining as the semiconductor revolution, or to go back in history, the discovery of fire. It has been a long-time dream of material scientists to achieve superconductivity at room temperature or higher. This would allow power transmission without any loss. It may also revolutionize transportation as superconductivity will allow for magnetically levitating vehicles along with many other applications. Further, I would place making potable water available and affordable for everyone through material innovation as an urgent need of today. While not as spectacular as other examples above, this will go a long way in addressing the most basic unfulfilled need of millions of people. This would entail developing feasible water desalination technologies as well as efficient ways of converting contaminated water into a potable one. Similarly, another area of innovation that is urgently required is to have highly efficient and cheap storage technologies that will make renewables ubiquitous and reduce emissions substantially. Unlike the first few examples, I hope to see this happen in my lifetime. I am also sure that rapid advances in material science will lead to innumerable better sensors and detectors for applications in every aspect of human existence, including in detection of diseases.

About the interviewers

Lokendra Sharma and Akriti Sharma are PhD Scholars at the School of Conflict and Security Studies, National Institute of Advanced Studies, Bengaluru.

In brief

by Rashmi Ramesh and Avishka Ashok

Merck announces 'Molnupiravir': A breakthrough in COVID-19 treatment

On 1 October, Merck and Ridgeback Biotherapeutics announced a new drug that is tipped to be among the key tool alongside vaccines, to fight COVID-19. The company announced the results of the phase-3 trial of the anti-viral drug named 'Molnupiravir'. The drug was found to nearly halve the probability of hospitalization of patients infected with mild to moderate levels of COVID-19.

The study was conducted on around 775 patients with mild to moderate symptoms of COVID-19. An analysis of the study revealed that 7.3 per cent of people administered a course of Molnupiravir were hospitalized and no deaths were reported. On the other hand, the hospitalization rate of patients which received the placebo stood at 14.1 per cent and eight deaths were recorded.

Molnupiravir can prove to be a game-changer for countries struggling to procure and conduct vaccination drives. At present, 55 countries are yet to vaccinate 10 per cent of their populations. Reports say that more than twenty countries have vaccinated below 2 per cent of people. The vaccination policies have left the low-income and middle-income countries far behind in the vaccine race.

In the words of Prof Peter Horby, University of Oxford, "a safe, affordable, and effective oral antiviral would be a huge advance in the fight against COVID." Currently, the antiviral Remdesivir and generic steroid Dexamethasone are used to treat patients who are hospitalized. A drug that can be administered at home is certainly helpful in fighting the pandemic in a better manner. Merck also stated that the viral sequencing done in the studies conducted shows that the pill is effective against all variants of COVID-19, including the highly transmissible Delta variant.

However, there are certain critical concerns. First, the phase-3 studies have shown that the pill is effective on mild and moderate cases. In fact, tests have been conducted only on such cases as of now. Second, the comparison to vaccines. While the pill is used for treatment, vaccination is a preventive measure. A case of easy availability of the pill may induce complacency in dealing with the pandemic, particularly among the population that is averse to taking vaccines. This will not prevent the cases, and only treat, if COVID-19 is contracted. (Jacob Koshy, "Molnupiravir, Merck's new drug to treat COVID-19", *The Hindu*, 2 October 2021; Deena Beasley and Carl O'donnell, "Merck pill seen as 'huge advance', raises hope of preventing COVID-19 deaths", *Reuters*, 2 October 2021; Cynthia Koons, "No, Merck's Pill Won't End the Pandemic", *Bloomberg*, 2 October 2021; Jim Reed, "Covid antiviral pill can halve risk of hospitalization", *BBC*, 2 October 2021)

China's energy crisis impacts national production and international supply chains

On 30 September, The Guardian reported that the Chinese economy was suffering an economic slowdown due to an energy crisis. This led to rationing out of electricity supplies to industries and residential areas. On 1 October, Xinhua Net reported that the economy was suffering a slowdown for the first time after the Chinese economy picked up post the first wave of the pandemic.

The slowdown is caused by the industrial dependency on coal-powered energy which has been suffering from numerous restrictions due to the international pressure on reducing emissions as well as a shortage of coal supplies. The Chinese government has issued a restriction on the units of energy consumed by industries and businesses to meet the carbon reduction goals set by the country at international conferences. A minimum of 20 provinces are suffering from widespread power cuts while factory outlets of international companies like Apple and Tesla suffer from a production standstill. The factories are forced to stop production in order to not exceed the limit set by the government in order to meet with the international and national demands of controlling carbon emissions.

The frequent stoppages in production have adversely affected the economy as businesses fail to meet the demands of consumers. The slowdown in production also threatens the international supply chains and the global economy. Another factor of the economic slowdown is the acute coal shortage faced in most industrial cities and factories. The Chinese economy has picked up substantially from the pandemic but the coal mining output has failed to match the pace of the industrial comeback. China is also faced with the obstacle of not acquiring enough coal for its economy due to the fallout with Australia, which supplied the country with 40 per cent of its coking coal imports. Even though Mongolia and Russia have been filling the void left by Australia, the current shortage is caused by the gap in supplies to the biggest coal importer of the world. The shortage of coal has also driven up prices in the country.

The crisis in China will impact international supply chains as the country prepares to buy coal at higher prices from coal mining countries. The incoming winter and the rising natural gas prices only add to the urgency of securing coal throughout the world as countries try to ensure sufficient coal supply to warm up the heating systems at home. As global suppliers of coal also suffer from unforeseen circumstances, procuring coal has become more difficult even for countries who are willing to pay a heftier price. The buying capacity of rich countries however, poses a threat to countries who do not have the capacity to pay higher prices. ("Economic Watch: Pressure and perseverance: China's economy maintains resilience," *Xinhua Net*, 1 October 2021; "China hit by massive power cuts due to shortage of coal supplies," *The Week,* 29 September 2021; Martin Farrer, "China's factory activity in shock slowdown as energy crisis hits home," *The Guardian,* 30 September

2021;"China faces electricity crisis due to coal shortage," *NS Energy,* 29 September 2021; Stephen Stapczynski, Ann Koh and Isis Almeida, "China's coal shortage could leave other countries in the dust," *Al Jazeera,* 28 September 2021)

S&T Nuggets

by Akriti Sharma and Lokendra Sharma

CLIMATE AND ENVIORNMENT

India: Researchers find microalga that breaks low-density plastic

On 3 October, researchers from the University of Madras and Presidency College, Chennai, discovered a microalga that can break down low density plastic sheets. Plastic waste is usually disposed of using landfills, recycling and incineration, all of which have negative fallouts. The study looks at the role of microalga "Uronema africanum Borge". The researchers used a polythene bag that was covered by thick green algae, and after thorough study three species of microalgae were discovered after different scales of magnification. The study can help discover ways to degrade plastic in a sustainable manner. However, the study needs research and development before it can be commercially used. A researcher involved in the study was quoted by The Hindu as saying: "The microalgae produce different kinds of extracellular polysaccharides, enzymes, toxins such as cyanotoxins, hormones which react with the polymer sheets (polymer bonds) and break them up into the simpler monomers which will not have harmful effect in the atmosphere". In Africa, Asia and Europe there have been studies on bacteria that can degrade plastic. (Shubashree Desikan, "A tiny plant that can 'digest' low density plastic sheets" *The Hindu*, 3 October 2021; Elumalai Sanniyasi et al, "Biodegradation of low-density polyethylene (LDPE) sheet by microalga, Uronema africanum Borge", *Scientific Report*, 26 August 2021)

The US: Oil spill results in massive environmental degradation

On 3 October, a major oil spill in California Coast resulted in massive loss of marine life and contamination of the wetland. According to the estimates, 3,000 barrels of oil was spilled in the Pacific Ocean covering 13 square miles of area. According to Reuters, the mayor of Huntington Beach said: "Our wetlands are being degraded and portions of our coastline are now covered in oil." She added: "In the coming days and weeks we challenge the responsible parties to do everything possible to rectify this environmental catastrophe." The California Department of Fish and Wildlife restricted fishing in the coastal areas affected by the spill. (Gene Blevins and Jonathan Allen, "'Catastrophic' California oil spill kills fish, damages wetlands", *Reuters*, 4 October 2021; Alta Spells, Holly Yan and Amir Vera, "An oil spill off the California coast destroyed a wildlife habitat and caused dead birds and fish to wash up on Huntington Beach, officials say", *CNN*, 4 October 2021)

The US: Drought in California continue due to changing climate

On 1 October 2021, the historical drought in California reached its second year and the authorities of the region have spent billions of dollars to address the catastrophic effects of climate change. It is

roughly equivalent to the driest year ever recorded in California, 1976-1977. The officials have said that the drought can directly be linked to climate change. State Natural Resources Secretary was quoted by the Scientific American as saying: "Drought is part of California's natural environment, but is now supercharged by accelerating climate change". He added: "Record high temperatures both this winter and spring meant about an 80 percent reduction in the amount of snow and water that flows into our reservoirs, from what we anticipated based on a century of historic records." (Anne C. Mulkern, "California Battles Historic Drought with $5.2 Billion", *Scientific American*, 1 October 2021)

China: Anniversary of China's proposal to achieve carbon neutrality

On 23 September, marking the one-year anniversary of China's proposal to achieve carbon neutrality before 2060, Global Times quoted China's Special Representative on Climate Change as saying: "China is the largest developing country in the world. The goal of carbon peaking and carbon neutrality means that China will achieve the highest reduction in carbon emissions in the world and achieve carbon neutrality in the shortest time in history. At that time, it's per capita GDP and carbon emissions will be lower than in the US, Europe, Japan and other developed countries when they peak". At all levels, the government, provinces and municipalities have been working towards the implementation of the "dual carbon" goal. ("China will be the most efficient country in the world in reducing carbon emissions: official", *Global Times*, 23 September 2021)

HEALTH

Uganda: First drug-resistant malaria detected in Africa

On 22 September, researchers in Uganda found out that malaria was resistant to the top drug, Artemisinin, used to contain the parasitic disease. According to the analysis of the blood samples, 20 per cent of samples had genetic mutations highlighting that the drug was ineffective. First drug resistant malaria was found in Cambodia years ago which spread across Asia. The scientists have been keeping a watch on Africa as it accounts for 90 per cent of the malaria cases worldwide. The researchers claim that they are afraid of cross border spread across the African subcontinent. They believe that more action is needed to contain the spread. (Maria Cheng, "Researchers detect malaria resistant to key drug in Africa", *AP News*, 22 September 2021; Betty Balikagala et al, "Evidence of Artemisinin-Resistant Malaria in Africa", *The New England Journal of Medicine*, 23 September 2021)

China: World's first inhalable COVID-19 vaccine heading towards emergency approval

On 22 September, according to Global Times, "world's first aerosolized inhalable adenovirus type-5 vector-based COVID-19 vaccine (Ad5-nCoV) is progressing well toward obtaining emergency-use approval". The vaccine is jointly developed by CanSinoBIO and researchers

from the Institute of Military Medicine under the Academy of Military Sciences. Aerosolized inhalable Ad5-nCoV can help in strong cellular immune response maintaining the same level as that of traditional intramuscular injections in 14 days. The vaccine is said to be promising in place of booster shots. Inhaling Ad5-nCoV as a booster shot can lead to the increase of IgG antibodies that could be seven to eight times that of an inactivated vaccine as a booster. (Hu Yuwei, "World's first aerosolized inhalable COVID-19 vaccine moves toward approval, 'better effects as booster'" *Global Times,*22 September 2021)

The US: Brain implant treats severe depression

On 5 October, a woman with depression was treated through an experimental implant in the brain. The device detects the brain activity of the depression patients and interrupts it with tiny pulses inside the brain. However, this was the first implant and its success would light hope for people with severe depression. Out of the total depression patients, 10-20 percent do not respond to two-drug treatment; the implant can significantly help in these cases. The device costs around USD 35,000 and it is an adapted version of NeuroPace RNS System, used widely in treating epilepsy. (Katherine W. Scangos et al, "Closed-loop neuromodulation in an individual with treatment-resistant depression", *Nature Medicine*, 4 October 2021; Hannah Devlin, "Woman successfully treated for depression with electrical brain implant", *The Guardian*, 4 October 2021)

COVID-19: Pfizer and BioNTech vaccine data for 5-11 years old

On 28 September, Pfizer and BioNTech submitted data to the Food and Drug Administration for approval of their vaccine for children aged 5-11 years. The companies are claiming that their vaccine is a fit for children below 12 years and above 4 years of age. In the last week, they released results of the clinical trials which were conducted on 2,200 participants in that age group. The announcement of resumption of schools might force parents to look out for options to safeguard their children in coming weeks. However, the companies are awaiting authorization for the paediatric use. (Sharon LaFraniere, Shashank Bengali and Noah Weiland, "Pfizer and BioNTech Submit Data Backing Vaccine for Children 5 to 11", *The New York Times*, 28 September 2021)

SPACE

Europe and Japan: Joint mission captures first images of Mercury

On 1 October, BepiColombo, a joint mission by the European Space Agency and the Japan Aerospace Exploration Agency (ESA), captured the first images of Mercury, which is the innermost planet in the solar system. This mission was launched in 2018 and has flown past Venus. The mission's objective is to deliver two payloads: Mercury Planetary Orbiter and Mercury Magnetospheric Orbiter. The former has been developed by ESA, and the latter by JAXA. According to the Associated Press, "probes will study Mercury's core and processes on its surface, as well as its magnetic sphere".

The mission captured Mercury's Northern Hemisphere and the Lermontov crater. ("European-Japanese space mission gets 1st glimpse of Mercury", *Associated Press*, 2 October 2021)

International: World Space Week celebration begins

On 4 October, World Space Week (WSW) celebrations kicked off. This year's theme would be celebrating the women who went to space. The WSW has been observed annually ever since the UN General Assembly declared its commencement in 1999. It is held every year from 4-10 October, with 4 October signifying the launch of Sputnik (the first human-launched satellite in space) in 1957 and 10 October signifying the signing of the Outer Space treaty. According to the WSW official portal, it is the "largest space event on Earth" with thousands of events held in several countries and are "organized by thousands of organizations, including space agencies, aerospace companies, astronomy clubs and museums". ("World Space Week Highlights 2021", *World Space Week,* accessed on 5 October 2021)

TECHNOLOGY

The US: YouTube announces ban on anti-vaccine content

On 29 September, YouTube announced a ban on all anti-vaccine content on its video-sharing platform. While it was already targeting misinformation about COVID-19, the new guidelines have expanded the ambit to include false claims about any vaccine that has been approved by "local health authorities and the WHO". This includes vaccines for influenza, measles and Hepatitis B, among others. YouTube has also suspended some popular accounts which were promoting anti-vaccine views. Showcasing its record in targeting misinformation, YouTube claimed that it removed "over 130,000 videos for violating our COVID-19 vaccine policies" since last year. This development closely followed YouTube's decision of removing two German-language accounts of a Russian media outlet. ("Managing harmful vaccine content on YouTube", *YouTube Official Blog*, 29 September 2021; "YouTube expands COVID move to block all anti-vaccine content", *Al Jazeera,* 30 September 2021)

Global Finance: In a major breach, data of 6,000 Coinbase customers stolen

On 1 October, Bleeping Computer, reported that Coinbase, a company providing global cryptocurrency exchange services, was hit by a major security breach as hackers stole the data of about 6,000 customers. The incident is only coming to light recently but the hacks took place earlier between March and May this year. Hackers were able to bypass SMS multi-factor authentication by exploiting a vulnerability. Reuters quoted a Coinbase spokesperson as saying: "We immediately fixed the flaw and have worked with these customers to regain control of their accounts and reimburse them for the funds they lost". While the anonymity and security of cryptocurrencies have been often touted by crypto-exchanges, they

have faced breaches over the years, denting their claims. (Lawrence Abrams, "Hackers rob thousands of Coinbase customers using MFA flaw", *Bleeding Computer*, 1 October 2021; "Coinbase says hackers stole cryptocurrency from at least 6,000 customers", *Reuters*, 1 October 2021)

China: New draft measures published to clarify data security law

On 30 September, China published new draft measures to clear the ambiguities posed by the data security law that was implemented earlier on 1 September. This law regulated the collection, storage and flow of data that companies harvested from Chinese citizens. As there was a lack of clarity regarding the different categories of data in the law, the new draft measures attempt to clear them. Three categories of data have been defined, that is, ordinary, important and core. While the ordinary category includes data collected from a smaller cohort and having a low-level societal impact, the important category includes the data that poses threats to the economic and national interests of the country and impacts individuals and enterprises significantly. The core category includes data which poses the most serious threats to China and could lead to major damages. (Josh Horwitz, "China drafts new data measures, defines "core data"", *Reuters*, 30 September 2021)

The US: President Biden announces meeting of 30 countries on ransomware

On 1 October, the US President Joe Biden announced plans to hold a meeting of national security advisors from 30 countries to address the issue of rising ransomware attacks and other cyber attacks. Except that the meeting would be held virtually in October, no other details of the meetings were revealed, including which countries would participate in the event. This announcement comes in the wake of increasing ransomware attacks on the US companies, including the recent one on Colonial Pipeline. Meeting's agenda would be to stop the misuse of cryptocurrencies which are usually used by hackers in demanding ransom payment. It has been called a "Counter-Ransomware Initiative" by the Biden administration. (Trevor Hunnicutt and Nandita Bose, "White House plans 30-country meeting on cyber crime and ransomware -official", *Reuters*, 1 October 2021)

The US: Facebook, WhatsApp and Instagram inaccessible for hours

On 4 October, social media giant Facebook and Facebook-owned companies — WhatsApp and Instagram — went down for a few hours, disrupting access to platforms used by billions of people worldwide. As the servers went down, a number of companies and enterprising individuals which depend on Facebook, WhatsApp and Instagram to do business and reach their customers got adversely affected. Santosh Janardhan, Facebook's Vice President (Engineering and Infrastructure), wrote about the cause of the outage: "Our engineering teams have learned that configuration changes on the backbone routers that coordinate network traffic between our data centers caused issues that interrupted this communication. This disruption to network traffic had a cascading effect on the way our data

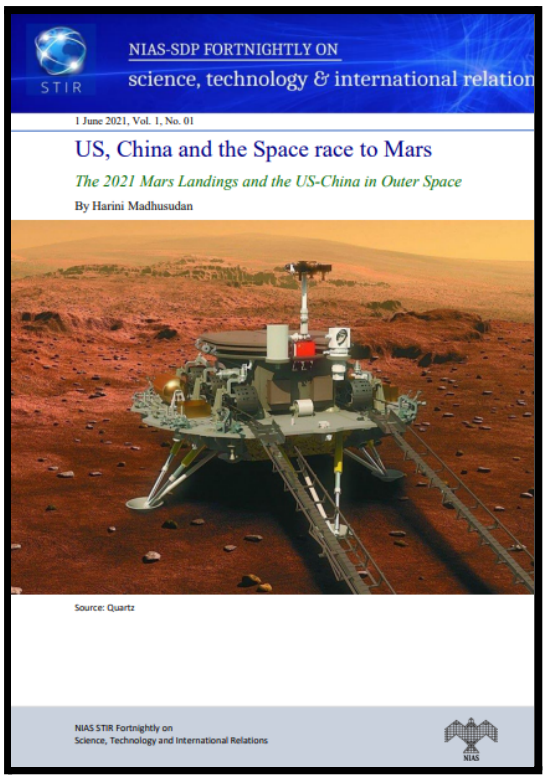
centers communicate, bringing our services to a halt". (Santosh Janardhan, "Update about the October 4th outage", *Facebook Engineering,* 4 October 2021; Mike Isaac and Sheera Frenkel, "Gone in Minutes, Out for Hours: Outage Shakes Facebook", *The New York Times*, 4 October 2021)

The US and EU: Trade and Technology Council launched

On 29 September, the US and EU launched a new transatlantic initiative called Trade and Technology Council (TTC) with the aim of creating synergies and expanding cooperation in development of artificial intelligence, regulating the export of sensitive technologies, and building resilient semiconductor supply chains. It presents a unified front to both big tech companies as well as to China. The US included Secretary of State Blinken, Commerce Secretary and the US Trade Representative. The EU delegation included the EU trade representative and European Commissioner for Competition. According to Reuters, the joint statement said: "We stand together in continuing to protect our businesses, consumers, and workers from unfair trade practices, in particular those posed by non-market economies, that are undermining the world trading system". (David Lawder and Nandita Bose, "U.S., EU agree to work on chip supplies, tech rules, China trade", *Reuters*, 29 September 2021)

About the Authors

Rashmi Ramesh, Akriti Sharma and Lokendra Sharma are PhD scholars in the School of Conflict and Security Studies at the National Institute of Advanced Studies. Avishka Ashok is a Research Associate at NIAS.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US, China and the Space race to Mars
The 2021 Mars Landings and the US-China in Outer Space
By Harini Madhusudan
Source: Quartz
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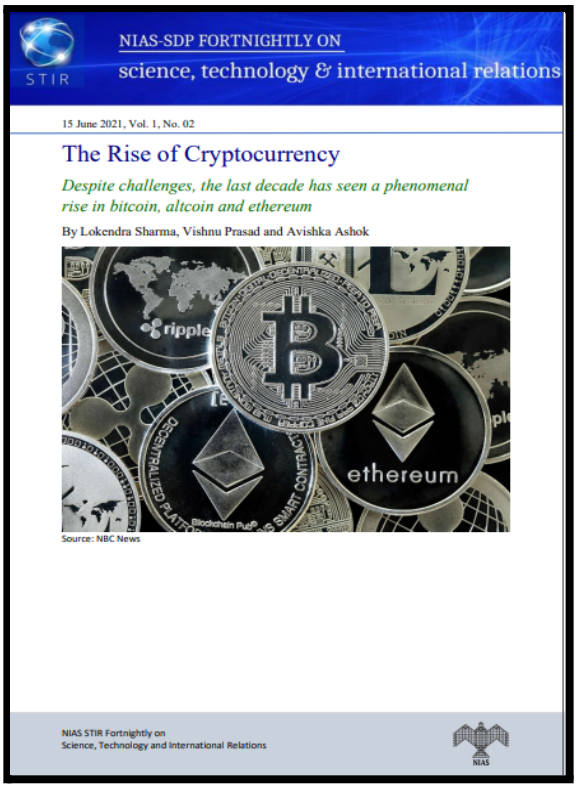
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The Rise of Cryptocurrency
Despite challenges, the last decade has seen a phenomenal rise in bitcoin, altcoin and ethereum
By Lokendra Sharma, Vishnu Prasad and Avishka Ashok
ripple
ethereum
Source: NBC News
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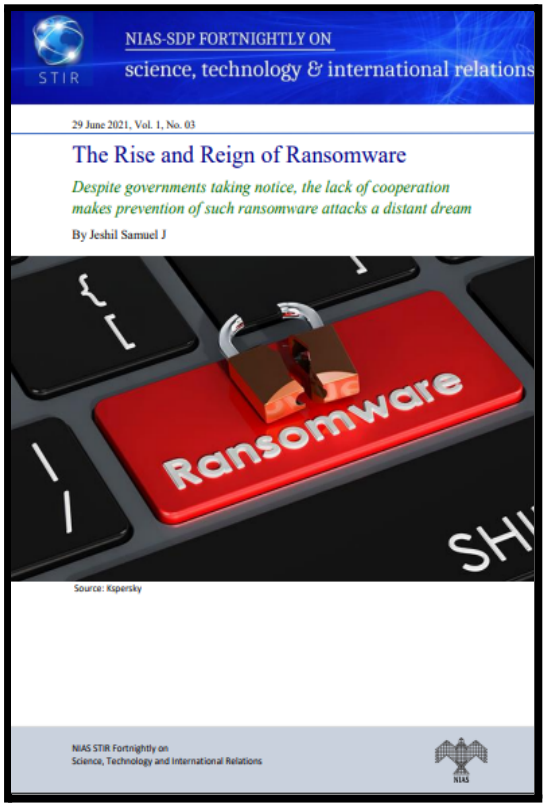
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29 June 2021, Vol. 1, No. 03
The Rise and Reign of Ransomware
Despite governments taking notice, the lack of cooperation makes prevention of such ransomware attacks a distant dream
By Jeshil Samuel J
Ransomware
Source: Kspersky
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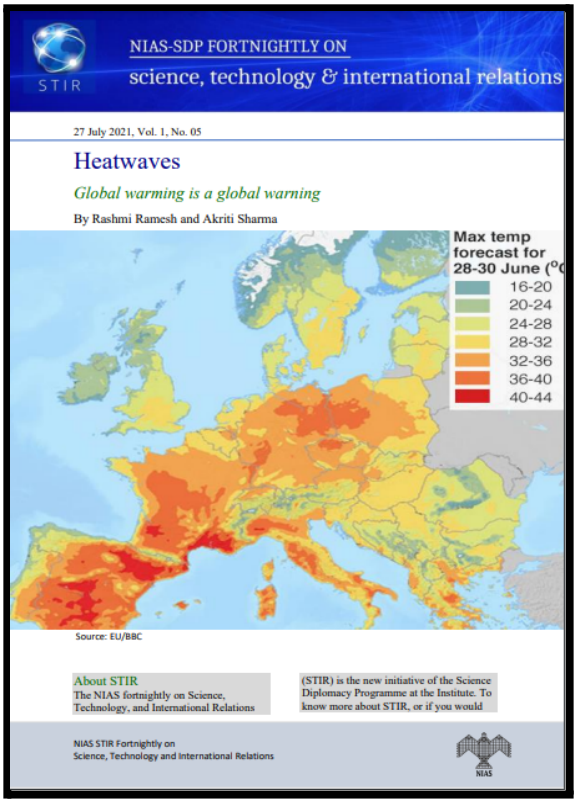
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27 July 2021, Vol. 1, No. 05
Heatwaves
Global warming is a global warning
By Rashmi Ramesh and Akriti Sharma
Max temp forecast for 28-30 June (°C
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Source: EU/BBC
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The reality and potential
By Harini Madhusudan
Source: virginatlantic.com
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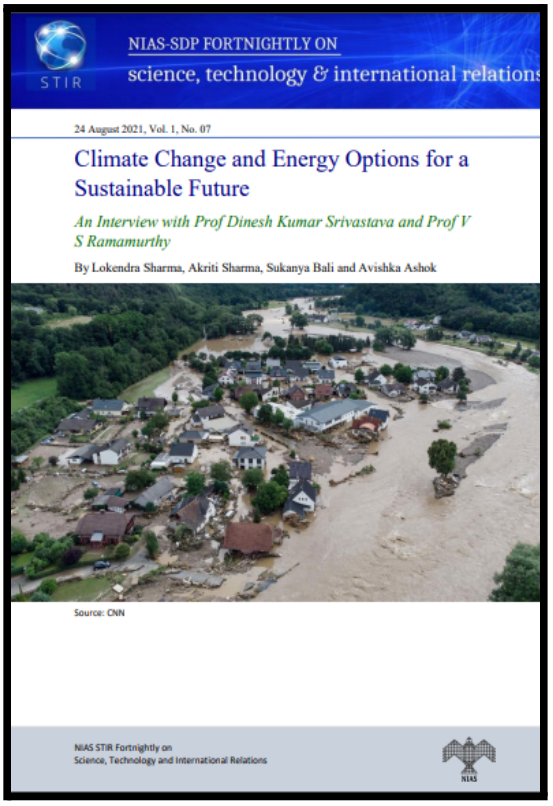
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Climate Change and Energy Options for a Sustainable Future
An Interview with Prof Dinesh Kumar Srivastava and Prof V S Ramamurthy
By Lokendra Sharma, Akriti Sharma, Sukanya Bali and Avishka Ashok
Source: CNN
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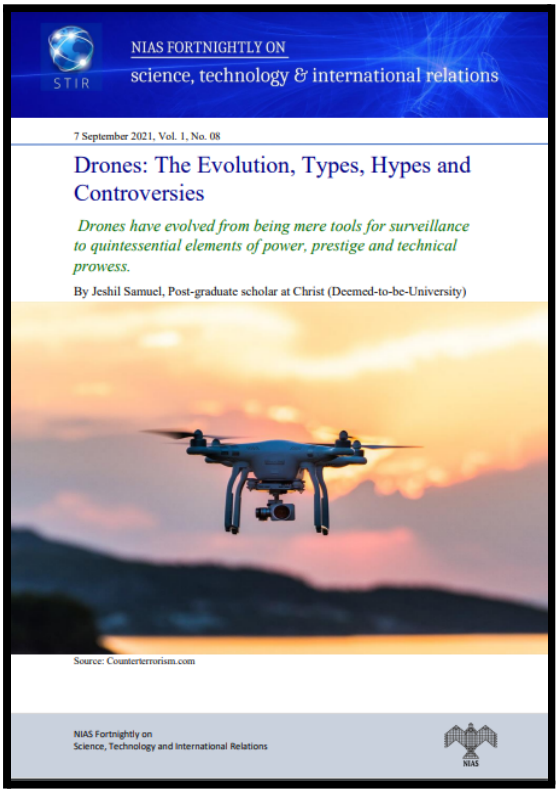
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Drones: The Evolution, Types, Hypes and Controversies
Drones have evolved from being mere tools for surveillance to quintessential elements of power, prestige and technical prowess.
By Jeshil Samuel, Post-graduate scholar at Christ (Deemed-to-be-University)
Source: Counterterrorism.com
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21 September 2021, Vol. 1, No. 09
When Science, Technology and Innovation meet Society
An Interview with two young scientists - João Pedro de Goes Novochadlo and Junyi Gao, from Brazil and China respectively.
By Lokendra Sharma and Akriti Sharma
Source: NIAS-BRICS-YSF
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