COVID-19 SPECIAL

VIGYAN PRASAR

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A KILLER AND HIS DEVIOUS WAYS

COVID-19: IMPACT ON WORLD ECONOMY

CHECK THE FACTS ABOUT COVID-19 AND AVOID RUMOURS

GENDER SENSITIVITY AND COVID-19

COVID-19
The Pandemic

Address for correspondence:
Vigyan Prasar, A-50,
Institutional Area, Sector-62,
Noida-201 309, U.P., India

Tel: +91-0120-2404430, 35

Fax: +91-0120-2404437

e-mail:
dream@vigyanprasar.gov.in

website:
http://www.vigyanprasar.gov.in

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Telefax: 22424396, 22526936.

Cover Design By: BIPRO KUMAR SEN

Racing Against Time

NAKUL PARASHAR

WHEN the going gets tough, the tough get going. This is what we've all witnessed during the past few weeks. I'm referring to the Indian science and technology scenario. In a country like ours, where aspersions were being cast about our preparedness to combat the pandemic, the science and technology research fraternity rose to the occasion – scaling testing capabilities, getting adequate PPEs ready, evolving new techniques to meet the growing demands of sanitizers, masks, production of medicines to the nearest-efficacy, and much more. Notwithstanding the list of challenges posed before our scientists and technocrats, entrepreneurs and policymakers, no matter how big it became – they didn't give up!

As science communicators, for us at Vigyan Prasar, it wasn't an easy one as well. Getting daily updates of efforts made by our scientific research community working in various parts of the country to all forms of media afresh, obviously was a task too big. Aggregating the content, developing it in a form comprehensible to all and yet, that's complete, correct, and produced timely remained the basic challenge. We kept on working and so did they – our scientists and technocrats. Yes, as we write, they keep on working to get the much needed and realisable solutions on the ground, that too as soon as possible. It's heartening to find that they've stayed duly focussed despite the lockdowns and other impediments.

Yet, it's the numbers again, ultimately. Be it print, electronic, social or digital, news and facts in every form of media have been talking about numbers of cases reported, deaths and those recovered. This situation reminds me of viewing a glass – half-full or half-empty. Amidst despair and sordid tales of morbidity, numbers of those who've recovered spell optimism and hope. These numbers, though relatively smaller in comparison to those tested positive if assessed correctly, provide a cue to researchers working relentlessly in the R&D related to this pandemic.

While experts predict different timelines, preventive measures like lockdowns have yielded some exciting stories from environmentalists, meteorologists, and interestingly, from ornithologists too. Species of birds assumed extinct are being spotted. Patterns of migratory birds that occur during these times of the year have recorded a significant variation. Pollution levels have, of course, come down, thereby coercing all of us to maintain them, no matter lockdown or no-lockdown.

Yet, with every passing day, the need to get a final solution gets bigger and bigger. No wonder many of us would be eagerly looking for a date, a prediction. Well, if we wished for an oracle for the moment, it would be none other than these scientists racing against to get the final vaccine.

This edition of Dream 2047 focuses on the pandemic – COVID-19. Interestingly, every article contributed to this issue is written by team Vigyan Prasar. Thus, we have, through this effort, tried to bring to you every possible aspect that you would be interested to know about the pandemic, cause and effect, and eventually update on the road to recovery efforts.

Do let us know, how did we, as team VP, fare on covering the pandemic – COVID-19.

Email: nakul.parashar@vigyanprasar.gov.in

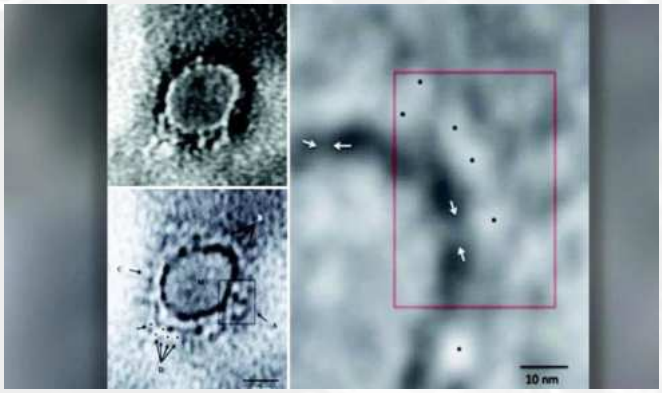
A killer and his devious ways

T.V. VENKATESWARAN

I am your terror, Nemesis.

I am the novel coronavirus at your service.

First things first. Let me introduce my illustrious family. The lethal SARS and MERS are my kin. They can kill you. My cousins 229E, NL63, OC43, HK01 are less threatening. More likely, you are familiar with them. The last bout of common cold you had probably was the result of their visitation. Under the microscope, the spike-like protrusion gives an appearance of 'crown'. That is how we got our family name 'coronavirus', derived from Latin; corona, meaning "crown" or "halo".



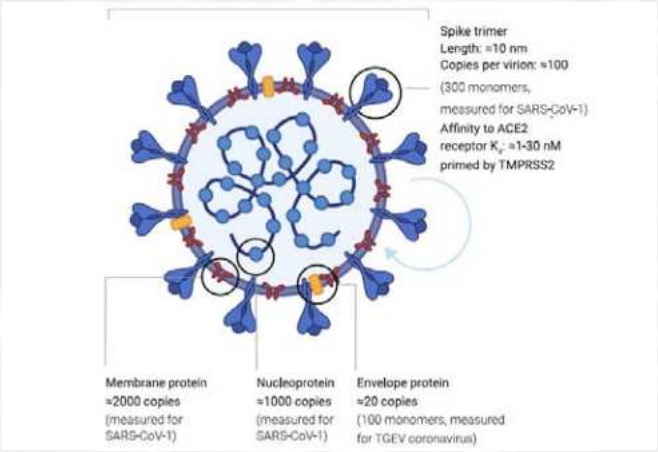
Transmission Electron Microscopy (TEM) to image the Sars-CoV-2 from the throat swab sample by ICMR, India. The 'crown' part is distinctly visible

Some of the members in our family take great joy in infecting humans. In contrast, others prefer cow, pig, bats and other animals. I am the seventh, and brand-new, coronavirus, identified as infecting humans. That is why I am popularly known as 'novel' coronavirus. Novel meaning new or different. Looking at the dreadful diseases I cause, scientists have a fancy name for me – Severe Acute Respiratory Syndrome Coronavirus 2 or, in short, SARS-CoV-2. The illness I cause is called COVID-19 (coronavirus disease 2019).

Tiny but mighty

Take a strand of your hair. Magnify it to the size of the football field. In this scale, a typical lung cell will look like a three-story building. And I, just an average mobile phone! I am that minuscule – but can take up different spherical sizes from 80 to 200 nanometres diameter.

I am not only small but also simple. I have just a short strand of RNA and just 16 protein molecules which are cut and made from one long polyprotein. In my book of life, the RNA is just a sequence of about 29,900 chemical letters, technically called nucleotides, in contrast to a total of 3,20,00,00,000 in your DNA. These chemical letters are codes or formulas for making proteins. All the instructions for my replications are contained in this small pocketbook.



Novel coronavirus, structure and functions of the proteins

Inside my sheathing sits nucleocapsid protein. It acts as a scaffold for my RNA. Like the steel frame gives the shape to the concrete building, the membrane protein is the central organiser. It determines my shape. The membrane, wrapped around me, is mixed with lipids, an oily substance. That is why when you hand wash with soap and water, I am destroyed. The hydrophobic, water-hating, portion of the soap molecules holds on tight to my lipids. The hydrophilic, water-loving end is forcefully pulled by water. Yanked by the pull, I rip apart.

Interacting with the membrane is my envelope protein which is draped over me like a gift wrapper. The glycoproteins, appearing like spikes, protrude from all sides. With all these needle-like structures coming out, I look like jackfruit or a porcupine. It is these spikes that appear like a crown under your microscope. This is me, technically called a virion. That is my physical description.

But don't underestimate me. I may be measly, but I am not frail. An ant in the ear of an elephant can cause a lot of trouble, isn't it? If you permit me to enter you, I cause havoc. As of 26th April 2020, I have infected 28,96,894 and killed 2,02,846. Every second, the numbers are going up.

I am a freeloader

Everyone has a weakness, but I have two. Firstly, I cannot replicate on my own. Second, I cannot do without you.

Even though the world trembles at my feet and almost half of the human population across the globe are under lockdown,

I am inept. I cannot make babies on my own. What is life, if you cannot produce and nourish the next generation? I just have my genetic code RNA. But no reader, no copier. I am like a book without a reader.

I lack the cell organelles that you have-- which means I cannot produce any proteins or make copies of RNA on my own. This leads to the second shortcoming. I cannot do without your cell. You can live without me, but I cannot live outside your cell. I need you more than you need me. I need to enter and hijack your cell. Only then, I can live and reproduce.

But unlike say, your gut bacteria, which lives in a helpful relationship, I am a parasite. I enter your body in stealth and steal your cellular machinery for my ends. I give nothing in return.

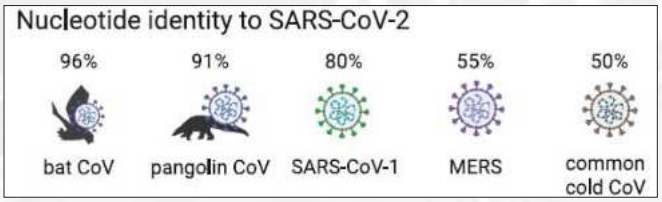
You are my recent host

My progenitors were living in the bat. They lacked the crucial protein part to bind with human cells. Hence, they were never able to enter the humans. Like your ancestors came down from trees, evolved, and walked on two legs, one of my families made a significant shift. It jumped from bat to another animal. Which one, we do not remember. Your researchers are in the lookout for this intermediary. Sometime in the past, as part of the natural evolution, one of our predecessors hit the jackpot. They accidentally got the 'key' to open a lock on the human cell. Since then, because of this critical change, sometime around last November 2019, one of my family members took a bold step. It leapt to humans. Then there was no turning back. Since then, I have been living by leeching off humans.

The pivotal change that took place was in my spike protein. A mutation on the genetic code for the spike protein, to be precise, insertion of 12 genetic letters, ccucggcgggca, changed my fate, as well as yours. Due to this mutation, the shape of the spikes altered to bind with the human cell, in particular with a receptor called angiotensin-converting enzyme 2 (ACE2). This was a crucial step in our evolution from being a virus that infected the bats to be a virus that blight the humans.

Backdoor

The ACE2 receptors are copiously expressed in the epithelial cells in your nose, respiratory tract, lungs and stomach. You can think of a receptor as a lock. When a protein with the right shape and structure approaches and docks, it can bind.



By comparing the genome sequence, scientists can determine the evolutionary path. From these studies we know that this virus is not human-engineered

With that fortuitous mutation, accidentality the form of my spike protein moulded to fit your receptor. I could use it as a counterfeit key to unlock the backdoor.

Khul Ja Sim Sim. I was snapped tight into your respiratory tract cells. The cells on your skin lack this ACE2 receptor. That is why we need to reach your eyes, nose or mouth to gain entry into your respiratory tract. Your natural habit of touching your face, picking your nose and rubbing your eyes, all help us; we love them.

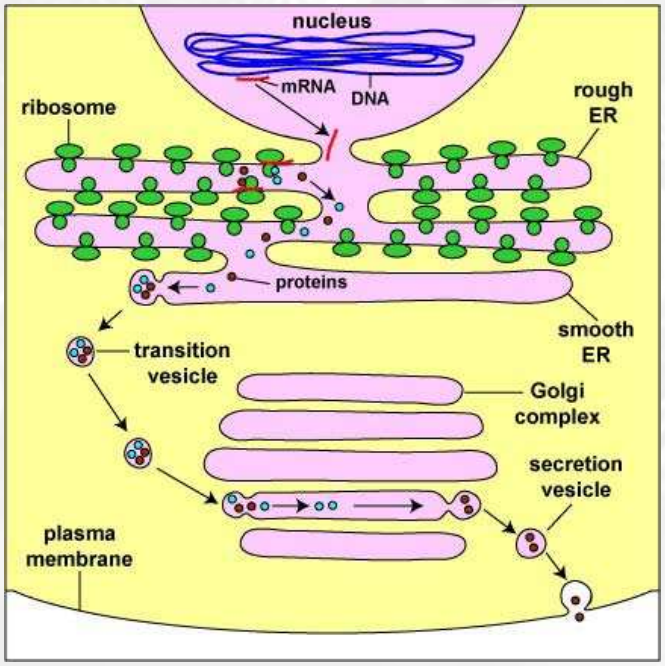
By the way, typically, your ACE2 receptors play a crucial role in controlling blood pressure. That is why people who have high blood pressure, diabetes and heart disease are more susceptible to my axe.

Once we latch on the receptor, the transmembrane enzyme, TMPRSS2 on your cell membrane lends a helping hand. This enzyme, a protease, cleaves, and activates the viral spike glycoproteins and facilitates my layer to fuse with your cell membrane. I slowly sink into your cell.

Cellular cafeteria

One can imagine the working of a cell as a restaurant. A lung cell differs from a skin cell like a Chinese takeaway and a south Indian eatery. Each type of cell can be thought of as specialising in different cuisines. The DNA is the set of instructions for the cell, which tells it how to make various proteins, how to fold them when to make them, where to send them. You can imagine the 23 pairs of chromosome DNA as a giant recipe book containing instructions for making various delicious dishes. From masala dosa to aviyal. From milagu

The mRNA is sent out by the nucleus with a set of instructions. Following them, the ribosome produces proteins. The proteins are processed by the Golgi apparatus and the protein package is sent to various parts of the body.



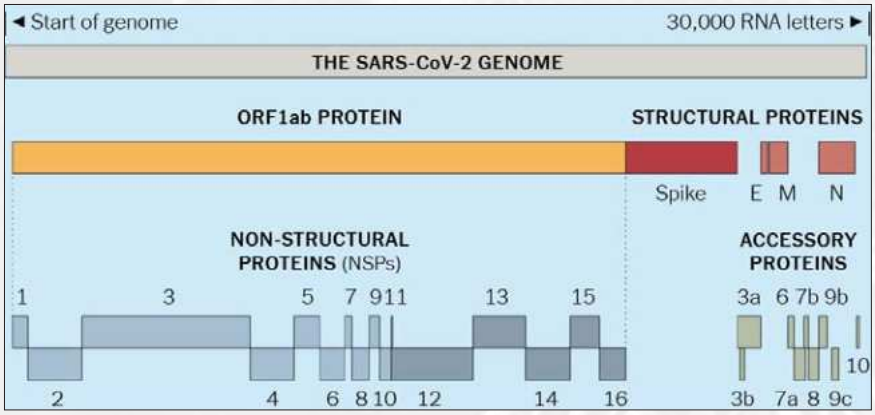
rasam to biriyani. A single gene on the DNA can be thought of as a unique recipe in a cookbook.

The particular portion of the book, a copy of the gene, is transcribed. It is encoded as a messenger RNA (mRNA), which is transported to one of the chefs in the restaurant – the ribosome, which is the protein-making factory.

What is there in my recipe book?

My cookbook, the RNA is three times longer than HIV's, twice that of influenza virus. Of course, Ebola virus is two times bigger. One end of my RNA codes for making four structural proteins that make up my virion particle. In addition to these, my book also has instructions for preparing non-structural proteins, in short NPS. Still, when I hijack and arm twist your cellular machinery, I need them to prepare my essential proteins and also make copies of my RNA.

Your chef, ribosome, can not only make proteins but also make copies of your DNA. However, your cells don't need to make copies of the RNA. But I am primarily an RNA. It is like trying to order cattle feed from a Mughlai restaurant. Therefore, I also carry copying assistant encoded into my RNA. These are the codes for NSP7 and NSP8 proteins. Once your ribosome assembles them, these proteins prepare clones of the genetic letters of my RNA. Another protein called as NSP12 assembles these genetic letters into new virus genomes. Together they make new copies of my RNA genome, which ultimately ends up as my offspring. When the NPS12 duplicates copies of my RNA, often errors may slip in. One alphabet here one letter there may be misplaced or misspelt. The protein NSP14 is my proof-reader. It reads the newly minted RNA strands and cuts out the errors.



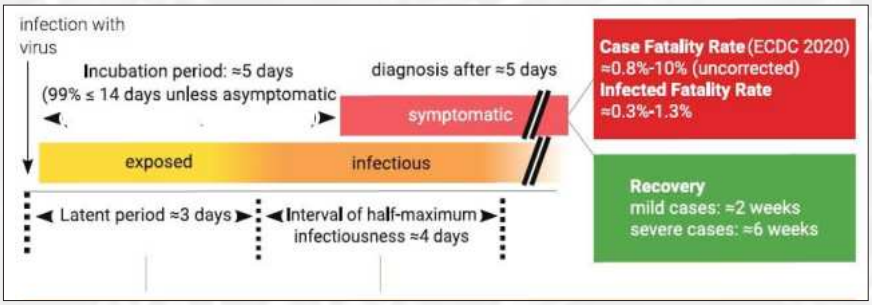
The genome structure of the Novel Coronavirus RNA

I seize your cellular machinery and make all the ribosomes in the cell work for me. mRNAs sent out from the nucleus are neglected. Sensing something is amiss your cell orders secretion of antivirals. But I have a secret weapon tucked in my sleeve, NSP1 protein. Located at the very beginning of my RNA strand, this protein once produced immediately hinders the production of antivirals by your cells in response to my infection.

The heist

In molecular terms, there is no difference between my RNA and your mRNA. Both are written in the same language of life, A,T, G,C, which your cellular machinery can read. Hence once I present my RNA to the ribosome, there is nothing that stops it from making dishes that I fancy. Flummoxed, your ribosomes, work to exhaustion. They start churning out the proteins I need.

Unaware of my infection, ribosomes produce more and more copies of my RNA and the essential proteins. Now it is time to assemble new virions, my offspring. These proteins and RNA copies migrate to the Golgi apparatus, the cellular workshop. My RNA is wrapped with a copy of nucleocapsid proteins, and



Incubation and infectious period of the virus

the envelop, membrane and spikes are added to complete a new copy of the virion. The vesicles take these new virions, my progeny, to the surface, burst open and release them into your body. My successors are ready to infect the next cell.

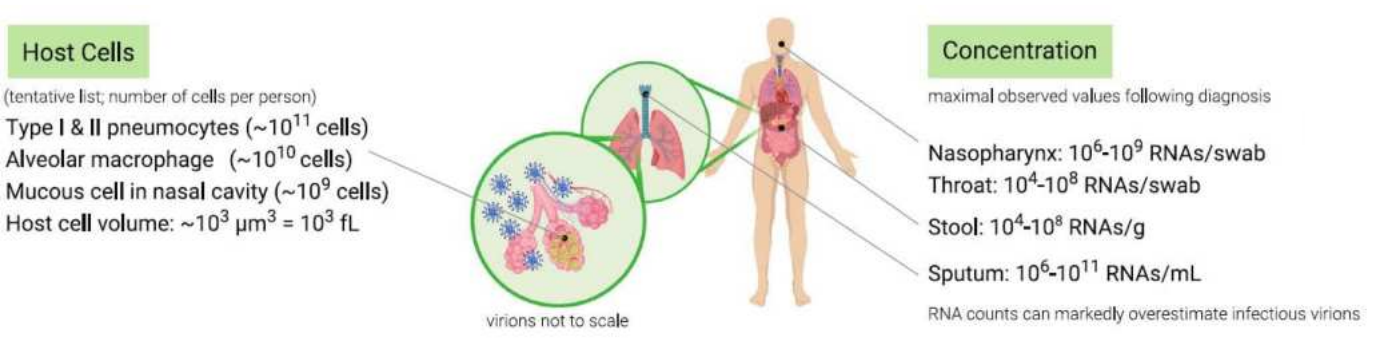
As more and more copies of my RNA are made, additional ribosomes are recruited to make further copies. At some point, your cell is overwhelmed by my activities and realises the game is over. Your cell makes the ultimate sacrifice; it commits suicide, cell apoptosis, in a bid to stop me proliferating. But by then, I have moved on.

One cell I infect could churn out 100 to 1,000 virions. All along your nose, throat and lungs, cell after cell is penetrated by my copies. The cellular machinery of each of these cells is hijacked.

War of wits

For your body, it might have lost this or that battle in this or that cell. However, the war against me is not over. Because of apoptosis of your infected cells, cellular fragments and incomplete copies of my RNA and proteins enter your bloodstream. Your immune system smells something is fishy. Your white blood cells mount an attack on the cells infected by my kins. It hounds out the infected cells in a bid to eliminate our foothold. As the massacre progresses, your body temperature rises, and the infected area becomes inflamed. Now it is a battle of wits between your immune system versus me.

Perhaps you are young, healthy, well-nourished. You can take it. You shrug your shoulders, thinking that you had a minor cold. Maybe my hand was a bit more durable, you had



Where the virus infects

to be admitted to a hospital, but with due medical care, you recovered and discharged. I cannot re-infect you. I can no longer live in your body. The battle has tilted in your favour; it is time for me to look out a new abode.

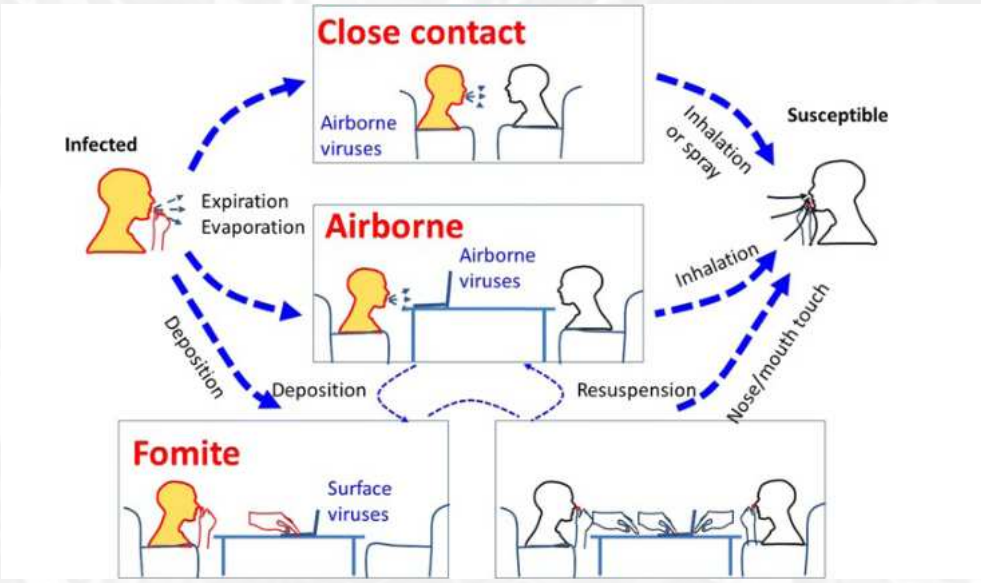
Or perhaps you are malnourished or have other health issues like blood pressure, then your immune system is no match for me. I win. I continue to ravage your cells. Your immune system is further provoked. It escalates, and in an uncontrolled rage, it unleashes a 'cytokine storm' in a bid to eliminate me. It goes down with all guns firing. Making no distinction of friend and foe, the white blood cells storm the lungs and destroy the tissue. The dead cells and fluids accumulate in the tiny alveolar sacs clogging it. It is the alveolar sacs that usually let the blood absorb oxygen. With your body depleted of oxygen supply one by one, your organs start to fail. Devoid of oxygen, your liver fails, and the toxins accumulate in your blood. Starved of oxygen, your brain cells begin to expire. You are sinking. I have no use for a dead host. It is time I look forward to a new host.

In either case, I need to look for a new host. I take your help. You too foolishly provide me with the lifeline.

In search of my next victim

I have been multiplying inside your body ever since I got a foothold. Eventually, I will produce 100 crore copies of myself, all crawling along your nasal passage, respiratory system and lungs. When you open your mouth to talk, the air passing through the moist lining of the upper throat creates tiny droplets. When you cough or sneeze small droplets jet out. I take a free ride. If you have not covered your nose and mouth, I waft invisibly into the air. If you had coughed on your hand, I settle there. A passer-by wading through the air droplets, an innocuous handshake is enough for me to find a new host. I spread. I move from one to another. I engulf you all.

Perhaps you are intelligent. Knowing my ways, you cover your face with a simple mask, wash your hands regularly, I get little chance to circulate. I can't hop beyond one and a half metre. If I find no host that close, humanity wins. If the sick, who harbour me do not move about and spread my seed far and wide, chances that I find a next host is dim. Isolation, quarantine, lockdown all arrest my spread. You break the chain. Unable to find a new host, I perish.



The virus transmits from human to human and also through clothes, utensils and furniture route. Simple mask, physical distancing and hand washing will prevent its spread to new host

Like Jean and Peter Medawar said, a virus is 'simply a piece of bad news wrapped up in protein'. I mindlessly copy myself with no aim or goal. But you humans are supposed to be intelligent. Knowing my ways, how I am, how I function, how I spread, how I cause damage to your cells, you can become knowledgeable. Knowledge is power. True knowledge sets you free.

Dr T.V. Venkateswaran is Scientist 'F' in Vigyan Prasar.
Email: tvv@vigyanprasar.gov.in

Why it's a win by virus

B.K. TYAGI

"The single biggest threat to man's continued dominance on the planet is the virus."

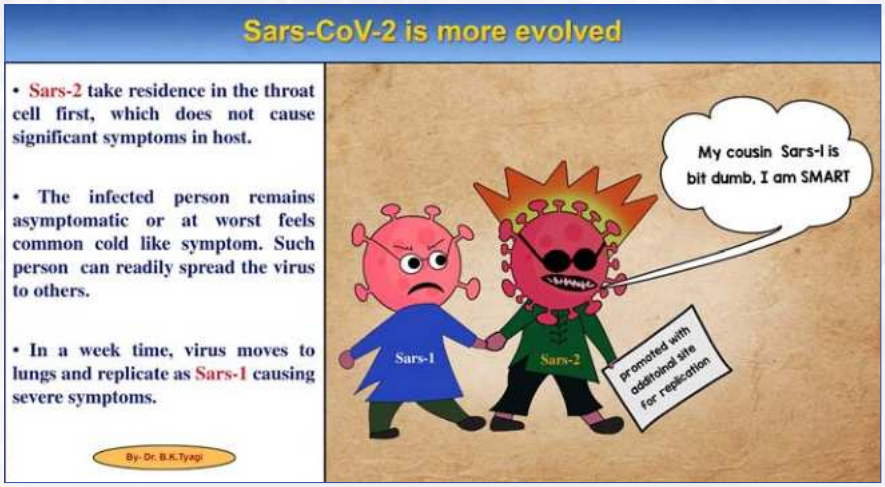
—Joshua Lederberg, Ph.D., Nobel laureate, Film introduction: "Outbreak" (1995)

Three Hollywood blockbusters movies – Cassandra Crossing (1976), The Outbreak (1995), and Contagion (2011) – all medical disasters, deal with the outbreak of diseases due to some unknown virus. Out of the three movies, Contagion is a blueprint of the current pandemic. Whatever is shown in the film has become a reality. The new virus responsible for the epidemic has threatened the entire human race of the planet. For the treatment of the new disease, there is no standardised protocol or vaccine. Only symptomatic treatment is given which sometimes is not enough to check the progress of the disease and takesa heavy toll on human life. In the film, the origin of the virus is traced back to Hong Kong. The sequence is one infected bat with a piece of banana, assumed to have the virus on it, which is dropped and eaten by a pig, which is slaughtered for food. The first to come in contact with the virus is a chef, who transfers it to another person by touch and starts the chain event. The film also explores a wide range of psychological reactions seen in various groups of the society. The film not only shows what has happened but also points towards what might be. In the film, it was a hypothetical virus MEV-1, something similar to SARS-CoV2, the virus responsible for the present COVID-19 pandemic. Now the entire world is in the grip of this virus. The virus has infected more than 1.6 million people and taken a toll of one lakh people in 177 of the 195 countries across the world. In India, all 32 States and UTs, various measures have been taken to contain the infection. Besides affecting the lives and livelihood, this virus has affected every aspect of our life, including our social and economic fabric, besides the way we work. We do not know when life will return to normalcy. Has the COVID-19 caught us unprepared or it was wilful ignorance on our part?

We don't know why this virus is so dangerous and whether all viruses are pathogenic and can cause epidemic or pandemic like SARS-Cov2 virus. Viruses even do not qualify to be called a living organism because they need a living host to reproduce or replicate. They are considered to be the link between living and non-living. They carry only genetic material in the form of either DNA or RNA encapsulated by protein and lipids. Viruses are classified as parasites by academicians. Interestingly, all viruses are not pathogenic in nature; they are very host specific and may live in harmony with the host organism without causing any harm or disease.

There are more than 1,400 pathogens (including viruses, bacteria and fungi, and animals) discovered till date that affect human beings. What is worrying is the growing number of pathogens and the increasing number of diseases coming from animals. Are we creating more conducive habitats for viruses and other pathogens to transmit more easily to other species in search of the new host, by mutating themselves by changing their genetic material (DNA or RNA)? The memory of The SARS (severe acute respiratory syndrome), a viral respiratory illness, is quite fresh in our mind. The virus that caused it jumped from animal to human and claimed more than 800 lives in 2003 across the world.

It is interesting to know that wildlife is a reservoir that harbours nearly half of the pathogens that could jump from animals and birds to humans. Domesticated animals in unhygienic conditions provide an ideal and conducive environment for a virus to jump from one species to another. A densely-packed place, like the wet market in Wuhan city in China, turn out to be the epicentre of such diseases. It is a known fact that throughout history, epidemics have been responsible for a sizeable portion of the fatalities suffered by the world. As long as people lived in small groups, isolated from each other, such incidents were sporadic. But now people travel from continent to continent, there is change in land use, degradation of the environment and loss of biodiversity clubbed with climate change. All this is putting unprecedented stress on all life forms, including viruses. It is a quest for survival among organisms that has made the SARS-CoV-2 turnout to be a more successful winner this time unlike earlier pandemics caused by its close cousins. Let's examine the situation in an evolutionary



perspective of organic life. What are unique traits or features this virus has acquired which has given it a niche as a survivor as compared to its earlier clans like SARS-CoV-1?

The current pandemic is the result of a mutation in SARS virus favoured by natural selection. The epidemiologist Ralph Baric and his colleagues (University of North Carolina) analysed the genomes of bat coronaviruses. They warned, "Our work suggests a potential risk of SARS-CoV re-emergence from viruses currently circulating in bat populations." Again in a second paper (same group in 2015) find that another SARS-like disease from bat coronaviruses was "poised for human emergence." Can we say that time was waiting for the emergence of this deadly mutated virus?

It is pertinent here to understand more about these viruses. Coronaviruses – a family of viruses that cause disease in animals – were discovered in 1930. The animal source of COVID-19 has not yet been confirmed, though the most dominating view is that the bats were the original host and the virus has reached humans through some intermediary host. Bats are a reservoir of a wide range of zoonotic viruses like Ebola, HIV and rabies. Bats carry hundreds of members of the coronavirus family. Most of those viruses are part of the bat's microbiome, living with their hosts in harmony without causing any harm. Coronaviruses, like all forms of life, accumulate random genetic changes as they reproduce. Sometimes, the mutations allow the viruses to find a new host or in other words, infect other animals, including humans. Viruses, being the first in origin, are at the first rung of the evolutionary ladder. It is one of the simplest organisms to have an extremely high rate of mutation, unparallel in the living world. This, coupled with a short generation time and large population size, allow them to evolve rapidly and adapt to the new host to produce more and more descendants.

Seven viruses, including the new one, have made the jump to humans by mutation, but most just cause cold-like symptoms infecting mainly the respiratory tract. But viruses that cause diseases like SARS, MERS, and COVID-19 are lethal. COVID-19 is closely related to SARS that swept the world during 2002-03. But it soon ran itself out, largely because most of those infected were seriously ill so it was easier to identify them to control. The other related coronavirus disease, the Middle East respiratory syndrome (MERS) emerged in 2012. COVID-19 is different from SARS and MERS as the spectrum of the disease is quite broad. In 80 per cent cases, it leads to mild infection or no symptoms. Only a test can confirm the presence of the virus. All such corona-positive people with mild or no symptoms become the carrier of the disease. This makes the control of the disease more difficult.

SARS-CoV and SARS-CoV-2 share 86% of the same genomic sequence, yet the latter is lethal. SARS-CoV-2 is more aggressive than genetically very similar SARS-CoV-1. A person infected by SARS-CoV-2 starts spreading the virus even before they develop symptoms. Much before the diseases become acute, the virus has done its trick; it has found a new host. This means allowing it more time to spread before it is detected. Its replication begins in the upper respiratory tract, where it stays and infects others before infecting the lungs and causing severe respiratory symptoms like SARS-CoV-1. So, its smartness lies in the fact that it spreads first before causing harm to the host. If the host dies before the spread of the virus to another host, the mutation would come to an end then and there. So, there is a silent transmission of the virus by involving an additional site of replication without any symptoms or at worst the symptoms of common cold. It is an evolutionary advantage for the virus that makes it more infectious to humans.

The two critical mutations in bat coronavirus gave it morphological and physiological changes to its advantage. The modification of the spike-like structures, that protrude from its outer cover allow it to latch onto a protein called ACE2, which lines the respiratory tract. The other mutation allowed the SARS-CoV-2 virus to bind with the furin enzyme on the surface of the human cells. A site on the virus spike protein is activated when it comes into contact with furin. The spike protein and the part of the cell surface carrying furin bind tightly. Furin enzyme is present copiously in specific human organs including liver, the lungs, and the small intestines. Therefore, SARS-CoV-2 is easily able to infect cells in these organs. It is interesting to note that neither the SARS-CoV-1 nor any other coronaviruses have this furin activation site on their spike protein. This makes SARS-CoV-2 virulent to humans.

We all know that natural selection has shaped the evolution of every organism, including the viruses. The virus needs a living host for reproduction. Our body uses a different mechanism to fight the pathogens. The evolutionary pressure on the virus is to evade the immune system and reproduce or replicate and spread to other hosts. To be a survivor, a virus needs to produce its generations one after the other and also to lose every characteristic that prevents it from spreading to another host. This is achieved through mutation. A mutated virus has an advantage as there is no pre-existing immunity against it in the form of an antibody.

The other factor which is favourable to SARS-CoV2 is that it is an RNA virus, its genetic material is encoded in RNA not DNA. RNA is less stable as compared to a DNA molecule. RNA viruses lack proofreading checks as part of their replication process, unlike DNA viruses. If a DNA-based virus makes a mistake in copying DNA, it manages the host cell to verify DNA replication. As a result, DNA viruses do not change or mutate much or frequently. RNA viruses, on the other hand, do not have such a mechanism. The mistakes in copying RNA are quite frequent, and the resultant mutant may have disastrous consequences for the new host.

From the evolutionary perspective, SARS-CoV-2 turns out to be much smarter than its other cousins like SARC-CoV-1 by having some morphological and physiological advantages which make it fitter for survival. In the absence of any vaccine or medicine, feeling little or no evolutionary pressure to change, the new virus is doing a great job of reproducing itself and spreading fast to new hosts. This pandemic will help us find the answers of a few more questions which remained unanswered in the film "Contagion" by giving us a real-life experience, but at what and whose cost!

Dr B.K. Tyagi is Scientist 'F' in Vigyan Prasar.
Email: bktyagi@vigyanprasar.gov.in

Gender sensitivity and COVID-19

KINKINI DASGUPTA MISRA

COVID-19, the coronavirus infection that has quickly spread the world over since it was first reported at the end of last year, shows up as critical cases mostly among the elderly and individuals with prior ailments although younger people are also at risk. Precise sex-disaggregated information is required to study whether and how women and men experience threats and how they approach the risk.

Even now, obviously women and young girls face a plethora of underlying risk factors that must be addressed. While addressing the role of gender in fighting against the pandemic, The United Nations Population Fund (UNFPA) guidance document states that "Disease outbreaks affect women and men differently," and highlights the existing gender disparity for women and girls in accessing to healthcare services for treatment and care.[1]

Women and men are impacted differently

The disease outbreaks not only affect women but also affect the marginalised groups and people with disabilities. Therefore, access to services and treatment to women and these vulnerable groups of people need to be considered separately given how differently the outbreaks impact them.

Women usually have a lower level of participation than men in decision making concerning the outbreak, and as a result their general and reproductive wellbeing needs may go neglected to a great extent. Drawing lessons from the Zika virus epidemic, contrasts in decision-making power among people implied that women didn't have control over their choices, which was aggravated by their lack of access to healthcare services and inadequate financial resources to go to primary healthcare centres and hospitals for check-ups for themselves and their children. This is despite women doing the greater part of community spread control exercises. Similarly, there is inadequate level of women's representation in crisis planning during pandemic and responses, which has been found in a portion of the national and worldwide COVID-19 responses.

As far as other risks are concerned, men may show less health-seeking behaviour because they consider themselves physically superior, resulting in delay of the detection and hence access to treatment for the infection. Against the background of such standards, men may furthermore feel pressure due to economic hardship arising from the outbreak such as the inability to work, causing panic and insecurity in the family. During isolation, women and men's experiences and needs will also differ on account of their distinctive physical, social, security, and sanitary needs.

Therefore, it is important to incorporate a gender perspective in preparedness and response planning to improve the effectiveness of health interventions and promote gender equality and equity. Experiences from past outbreaks also show the gap of significant gender planning in readiness and responses to mitigate the disease outbreaks like the Ebola outbreaks in West Africa during 2014-2016.

The nationwide closure of educational institutions due to COVID-19 spread will have adverse effects on girls' education in India. The dropout rate among girls might go up and may lead to early marriage and sexual exploitation, impacting on the adolescent health. Further, the large number of women workforce engaged in vocational training and working in midday meals programmes and crèches are likely to get more affected than men due to closure of schools.

Women on the front lines

Women comprise the majority of health and social care workers and are even on the front line of the fight against COVID-19. It is therefore a matter of concern that they are not fully engaged in decision making and planning of interventions, security surveillance, detection, and prevention mechanisms.

Women may have to confront increased risk of exposure to COVID-19 because of their disproportional ratio among healthcare and social service personnel. Globally, around 70 % of health and social sector workforce are women. As frontline health workers they are on the forefront of any disease outbreak. Among various classes of frontline health workers in India, almost 90% are qualified nurses and midwives.

Women and girls come under greater risks when the healthcare system redirects resources from reproductive healthcare to response to the epidemic, leading to shortage of resources. Women continue to require maternal healthcare services which is often overlooked in such crises and healthcare systems are forced to allocate health personnel and other resources towards critical care services. More than 24 lakh ASHA and Anganwadi workers in different States are involved in regular check-ups and detection of symptoms in their areas on COVID-19. These health workers are finding difficulty in providing services to fight against COVID-19 due to shortage of personal protective equipment (PPE) and facilities.

A recent study from the Chinese Centre for Disease Control highlights that the death rate among men was 2.8%, compared with 1.7% for women, while COVID-19 is infecting men and women in about equal numbers. The study reports that this difference could be due to biological and lifestyle factors and that women are likely to have stronger immune response against the infections than men.[2] However, current

A self-help group member in Palamu, Jharkhand.
Source: The World Bank [https://www.worldbank.org/en/news/feature/2020/04/11/women-self-help-groups-combat-covid19-coronavirus-pandemic-india

sex-disaggregated data are fragmented, forewarning against early assumptions and correct data needs to be captured.

Women as caregivers

Women and young girls do a large proportion of the world's unpaid care work. As per the International Labour Organization (ILO), globally, women perform 76.2% of all long stretches of unpaid care work, more than three-times as much as men. In Asia and the Pacific region, this figure rises to 80%, and in India, almost 50% of certified health workers are women.

As health systems become extended, numerous individuals with COVID-19 will need to be cared for at home, adding to a woman's overall burden, as well as putting them at greater risk of becoming infected. Women in their social roles as wives, mothers, daughters and sisters and women in their professional roles as nurses, paramedics, primary healthcare workers are deeply involved and therefore, perhaps more susceptible than men to the virus.

It was seen during the Ebola epidemic that the pregnant women were affected adversely due to lack of scientific knowledge and clinical guidelines and the maternal mortality rate increased to 75%. This increased rate was mainly because of absence of pre- and ante-natal care. This makes COVID-19 preparedness more challenging for India where women get marginalised when it comes to accessing the highest level of public healthcare.

The UNFPA guidelines direct to ensure that every single pregnant women with a suspected, likely or affirmed COVID-19 infection continue to have access to the full scope of quality healthcare services. Pregnant women with respiratory ailments must be treated with the highest priority because of expanded threat to unfavourable results. Another study carried out in China on the mental health condition of nearly 1,300 health workers who dealt with COVID-19 patients had revealed that these health workers, largely women, were suffering from symptoms of depression, anxiety and distress.

Risk of violence, affected livelihoods and education

The pandemic has additionally increased threats and made women and girls more vulnerable beyond the risk of infection. These may differ among groups of women and men, particularly those most excluded, such as those living in poverty, persons with disabilities, indigenous people, migrant men and women, displaced people, and others who face intersecting and multiple forms of discrimination. All vulnerable populations will experience the COVID-19 outbreak differently. Poor conditions in quarantine camps and makeshift sites, conflict and the effect of inadequate resources are likely to intensify the need for additional support and funding.

Today, the coronavirus pandemic could take a significant toll on women's livelihoods, as closures to control COVID-19 transmission has a differential effect on women economically, given their role in providing most of the informal care within families, with consequences that limit their work and economic opportunities resulting in increase in the financial burden and household responsibilities as the unorganised sector is dominated by the women workers. Amidst the outbreak, women and girls are prone to be at higher risk of aggressive behaviour at home due to financial insecurities and access to resources.

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Drawing from the lessons of the Ebola responses, a High Level Panel on the Global Response to Health Crises was set up by the United Nations (UN) Secretary-General, which included gender dimensions in global health crises [Global Health Crises Task Force (GHCTF) 2017]. Based on the recommendations of the Panel's report published in 2017, the World Health Organization (WHO) and World Bank announced in May 2018 the creation of a Global Preparedness Monitoring Board for independent monitoring and regular reporting of preparedness to tackle outbreaks, pandemics, and other emergencies with health consequences to strengthen global health security.[3]

Therefore, a significant consideration is needed to take into account the psychological concerns of women and men and other vulnerable groups in order to understand the possible gender dimension of the risk and develop preparedness to response to the spread of COVID-19.

REFERENCES:

1. https://www.unfpa.org/resources/covid-19-gender-lens
2. https://www.weforum.org/agenda/2020/03/the- coronavirus-fallout-may-be-worse-for-women-than-men-heres-why/
3. WHO 2018

The author is Scientist 'F' in Vigyan Prasar.
Email: kdgm@vigyanprasar.gov.in

Epidemiological model and its impact on public health policy:
A COVID-19 PERSPECTIVE

RINTU NATH

Since the emergence of the novel coronavirus (SARS-CoV-2) in December 2019, it has made a profound impact globally within the last three months, making it the most serious pandemic in recent history. Initially known as the '2019 novel coronavirus', it was renamed on 11 February 2020 as "severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)" by the International Committee on Taxonomy of Viruses (ICTV). The World Health Organisation has declared "COVID-19" as the name of the disease it causes.

In the absence of any vaccine, the role of public health measures is limited to non-pharmaceutical interventions (NPIs), and therefore, epidemiologists, health workers and policymakers around the world are exploring strategies and public health measures to mitigate or reduce the impact of this pandemic and thereby minimise hundreds and thousands of deaths and the burden on existing resources of public health systems.

The World Health Organisation and public health departments across the globe are closely monitoring incidences related to the spread, the number of people getting the infection, recovery rate, death rate, and many other associated parameters like geographic location, population density, existing healthcare facilities and other factors that contribute to the dynamics of an epidemic. While some of this information may make news headlines, the actual use of this high-volume and high-dimensional information requires careful processing and interpretation to fight the virus in the real world!

To harness the high-volume information arising from an emerging epidemic, epidemiologists and health scientists adopt mathematical and statistical methodologies and construct epidemiological models to predict the paths that an epidemic would take. They develop the models using historical and existing data and explore how an epidemic would unfold under different scenarios – both in the absence and presence of various intervention strategies, thus providing valuable insight for the policymakers regarding the scope and opportunities of different interventions. In this article, we will discuss the basic ingredients of the epidemiological model development process and explore how these models play an important role in our war against the epidemic.

History of epidemiological models

Before the emergence of SARS-CoV-2, the world witnessed several outbreaks of infectious diseases – smallpox, polio, cholera, chickenpox, Zika, Ebola, and SARS to name a few. Some of these diseases were eradicated completely and some were controlled, adopting guidelines based on epidemiological models.

The first mathematical model to understand an epidemic was done for smallpox. In 1766, a Swiss mathematician, Daniel Bernoulli, developed a mathematical model to analyse the mortality due to smallpox. Bernoulli created a mathematical model to defend the practice of inoculating against smallpox. The calculations from his model established that universal inoculation against smallpox would increase the life expectancy. The setting stone of modern epidemiological models was founded by two British epidemiologists, A.G. McKendrick and W.O. Kermack, who published their theory in a set of three seminal research articles between 1927 and 1933. It is interesting to know that their work was based on the plague epidemic in Bombay (now Mumbai). They are often credited as the first to develop modern models of disease dynamics; their approach has proven both flexible and robust and related to different variants of modern epidemiological models.

A simple epidemiological model (SIR)

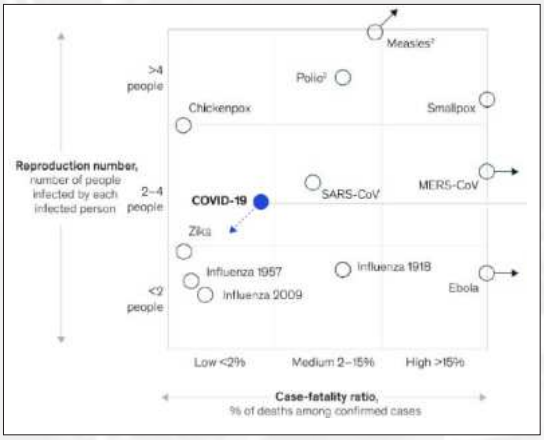
There are several variants of epidemiological models. The spread of any infectious disease from person to person is captured by the 'between-host' model. For a pandemic situation, the global outbreak across several geographically separated populations is explained by the 'meta-population' model. Last but not the least, the interaction of the virus within host cells is represented as 'within-host' model. Here we will describe a simple between-host model, such as those used to model COVID-19 epidemic, using a simple framework called SIR compartmental disease model.

An SIR model is a compartmental disease model in which each individual in the population is assigned to one of the three compartments, namely "Susceptible", "Infectious", and "Recovered". An individual moves from one compartment to another during the course of the epidemic. An SIR model computes the theoretical number of people infected with a contagious illness in a closed population over time.

Susceptible individuals do not have immunity to the disease; therefore, they can become infected. Susceptible individuals can move into the "Infectious" compartment through contact with an infectious person. Infectious people can spread the infection to other susceptible individuals, and after a certain

time, infectious individuals can move into the "Recovered" compartment by recovering from the illness. Recovered individuals can no longer become infected, typically because they have immunity from prior exposure. However, there are several extensions of this simple SIR model to capture the disease progression processes of many diseases.

Because people can move between compartments, the number of people in each compartment changes over time. The SIR model captures population changes in each compartment using mathematical and statistical approaches to model the progression of a disease. The dynamics of this progression depend on several model parameters like the force of infection, transmission rate, contact rate, and recovery rate along with other dynamic components like age distribution, homogeneity of the population and other demographic characteristics.



Ro and CFR for selected human viruses including COVID-19 *(Source: World Health Organisation, Mckinsey analysis)*

Simulation of the epidemic models provides many significant insights about the disease dynamics; an important outcome is the reproduction number (R0). If you have watched the movie "Contagion," about a worldwide pandemic of a new virus, you have heard the term "R0" (pronounced "R naught"). R0 is not a Hollywood jargon; it represents an important concept in epidemiology and is a crucial part of public health planning during an outbreak, like the current COVID-19 pandemic. Scientists use R0, the reproduction number, to describe the intensity of an infectious disease outbreak. R0 estimates have been an important part of characterising pandemics, including the 2003 SARS pandemic, the 2009 H1N1 influenza pandemic, and the 2014 Ebola epidemic in West Africa. R0 is the number of cases, on average, an infected person will cause during their infective period.

The estimate of R0 is very significant from an epidemic perspective: if R0 is less than 1, the disease will die out in a population because, on average, an infectious person will transmit to fewer than one other susceptible person. On the other hand, if R0 is greater than 1, the disease will spread. The policy decisions in an epidemic scenario are, therefore, directed towards reducing the value of R0 below 1. For R0 equals 1, the disease spread is stable, or endemic, and the number of infections is not expected to increase or decrease.

While early estimates of R0 for COVID-19 vary, most estimates show the values are in the range of 2-3. Epidemiologists all over the world are trying to estimate the R0 of COVID-19 epidemic in a given region or country using the epidemic data as it unfolds and projecting the future estimates of R0 when various intervention strategies are adopted.

Case Fatality Rate (CFR) is another important number for understanding any pandemic situation. CFR is the percentage of people who have a disease and die from it. On one extreme, we have rabies, which has a 99 % fatality rate if untreated. In case of COVID-19, CFR is likely to change over the coming weeks and months. Preliminary data suggest that the CFR for COVID-19 is lower than for SARS and MERS. However, the high concentration of cases in some regions, putting a huge stress on the healthcare infrastructure, is a concern for any major epidemic.

COVID-19 epidemic and application of models

One of the important applications of epidemiological models is to assess the intervention strategies for disease control: to evaluate the rates of fatality in respect to demographic characteristics, age and other factors, identify critical determinants and strategies to contain and control an emerging pandemic, effectiveness of other measures like early detection, case isolation, contact minimisation, social distancing, medication, vaccination and many other important components. Isolation is used to artificially reduce the R0; the progress in medical treatment is to reduce the CFR.

Since the emergence of the SARS-CoV-2 in December 2019, researchers from across the world contributed to the development of different epidemiological models to identify the COVID-19 disease progression as well as evaluate different intervention strategies to minimise the impact of the disease. Researchers assessed the potential role of a number of public health measures in the absence of a COVID-19 vaccine – so-called non-pharmaceutical interventions (NPIs) – aimed at reducing contact rates in the population and thereby reducing transmission of the virus. Based on their models, they identified that only adopting mitigation (slowing but not necessarily stopping epidemic spread) would overwhelm the health system due to the significant increase in patients. It is concluded that suppression (reducing case numbers to low levels for long time) will minimally require a combination of social distancing of the entire population, home isolation of cases and household quarantine of their family members. The modelling outcomes also indicated that healthcare demand could only be kept within manageable levels through the rapid adoption of public health measures (including testing and isolation of cases and wider social distancing measures) to suppress transmission. Such policies have now been adopted rigorously across different countries including India.

Whether it is an emerging epidemic scenario like COVID-19 or a future epidemic, epidemiological models, therefore, are very useful tools to assess the intervention strategies for disease control, both for short and long term. The forecasting and projections from the epidemiological models provide valuable information to undertake useful policy decisions, manage healthcare resources and save millions of people worldwide.

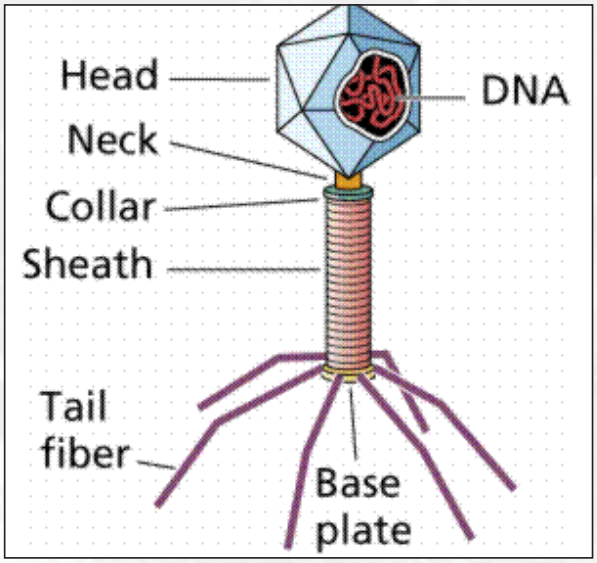
The author is Scientist 'F' in Vigyan Prasar.
Email: rnath@vigyanprasar.gov.in

Pandemic COVID-19 – First or last?

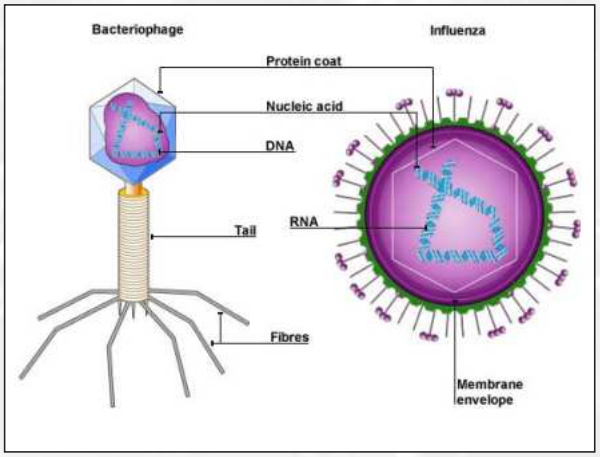
ARVIND C. RANADE

There is worldwide concern about the ongoing COVID-19 pandemic, which has already spread over more than 210 countries and infected 16,05,732 people across the world. One may wonder why there is such a huge public outcry this time when viruses have been around us for ages. Is the COVID-19 pandemic the first or will it be the last of its kind?

A cursory glance at history would show several pandemic diseases originating from viruses that had plagued the humankind in the past. For example, in 1918, Spanish Influenza, also known as the Spanish Flu, devastated millions of people around the world. The Acquired Immuno Deficiency Syndrome (AIDS), which appeared in 1983, is another viral disease caused by the Human Immuno Deficiency virus (HIV) spilled over from chimpanzees. The H1N1 Swine Flu of 2009 came partly from pigs. It is also considered to be evolved through a recombination with a pig virus and a bird virus, which is still awaiting conclusive evidence. Hendra, Ebola and Hanta are a few other viral diseases in the list.



Typical virus structure



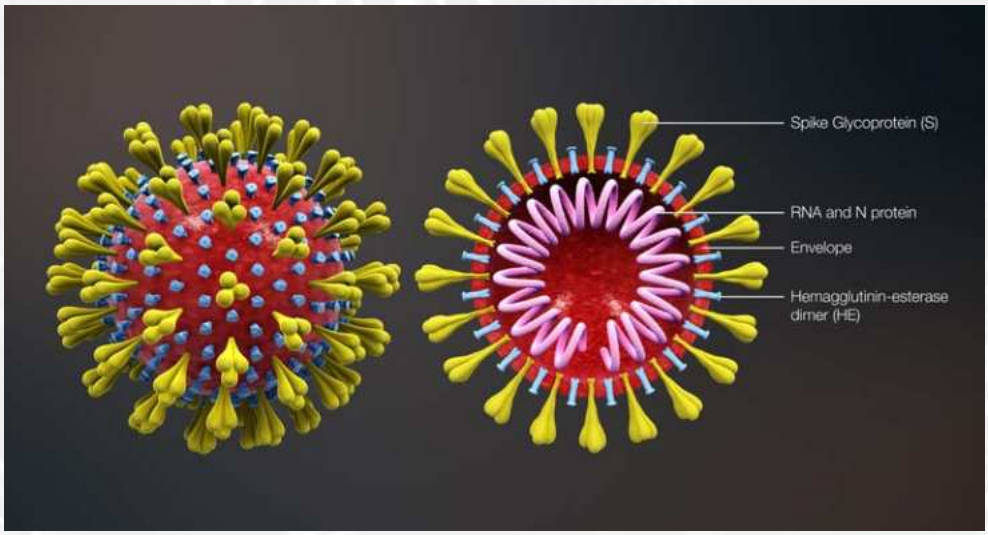
Typical virus structure in comparison with Influenza virus

A virus is so small that it takes the magnifying power of an electron microscope to become visible. The electron microscope was invented only in the 1930s. However, existence of virus and its effects were discovered much before that. For example, in 1892, Russian botanist Dmitry Ivanovsky discovered the Tobacco Mosaic Virus (TMV) that caused havoc in tobacco plants. Here it is important to mention that Ivanovsky was not sure whether it was really a new species or kind of bacteria only or a virus. Therefore, he made use of the pasteurization process based on repudiating the theory of 'spontaneous generation'. French scientist Louis Pasteur demonstrated that diseases were caused by microscopic organisms. While obtaining microorganism-free filtered water for experiments, Charles Edouard Chamberland, one of Louis Pasteur's assistants, developed a Pasteur-Chamberland filter. This invention was also used in restaurants and homes in America and Europe to obtain bacteria-free drinking water, thereby reducing the bacterial infections.

To find out the causative agent that damage tobacco plants, Ivanovsky filtered the crushed leafs of infected tobacco plant. If the disease-causing agents were a bacteria, then the filtered liquid should have been devoid of it. Yet the filtered liquid could cause ravage in the tobacco plant. Hence it was not a bacteria but something else.

Soon, it was realised that viruses are not limited to plants, but they plunder animals and bacteria as well! Today we know that the size of viruses range from 20 to 400 nm (nanometre). Typically, a human cell is a thousand times bigger than the virus. As of today, thousands of different viral species have been studied and described by scientists, and millions more are likely to be present in nature.

Viruses come in various sizes and shapes, but all species consist of a small collection of genes, i.e., stretches of either deoxyribonucleic acid (DNA) or ribonucleic acid (RNA), which carry information for making more copies of the virus. These genes are enclosed in a protective coating of protein and someti mes a lipid membrane. All known viruses are parasitic, each having its own preferred host to infect. Some target plant cells, some only infect bacteria, a few live in bats and some infect humans.



Structure of SARS-CoV-2, coronavirus which causes COVID-19

A virus reproduces by transporting its genetic material into a living cell. Different viruses do it in different ways, but once inside, the cell is not able to make a distinction between its own genetic material and the viral genes. The infected host cell begins reading them and building copies of the virus instead of performing its own normal tasks.

The infective agent responsible for the current pandemic is known as SARS-CoV-2 and the disease it causes is called COVID-19 (Coronavirus disease-19). 'Coronavirus' is the name of a family of interrelated virus species first discovered in 1940s that infect mammals and birds. Later on, it was found that some of them infect chickens, some infect pigs, while some infect humans, but most of them are extremely mild, producing nothing more serious than the common cold. The coronaviruses are enveloped viruses, with single-stranded RNA genome and nucleocapsid of helical symmetry.

The first human coronavirus was discovered in 1960 causing the common cold. One of the human coronaviruses, called Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) is more dangerous. The SARS-CoV-2 is a newly discovered species, hence it was initially called a 'novel' coronavirus. What is important to understand is, generally, when an infecting virus is discovered or anticipated during laboratory studies, development of its antidote through vaccination or supplementary remedy is undertaken. But till the release of such antidote, the virus can show its frightful nature. As of today, the SARS-CoV-2 virus has infected more than 16 lakh people and over one lakh people have lost their lives across the globe. In the times to come, there is a fear of increase in these numbers exponentially.

As stated above, coronaviruses are a group or family of interrelated virus species of which some are mild in nature while some are highly infectious. The major human coronaviruses have originated from bats; however, some have the origin in pangolin and cattle as well. Primarily, coronavirus infection symptoms include cold, fever and sore throat, which usually occur in rainy or winter season. Most infectious corona viruses can cause pneumonia or bronchitis. One of its kinds, known as SARS-CoV responsible for the SARS outbreak, was discovered in 2002-2003 while Middle East Respiratory Syndrome caused by MERS-CoV discovered in 2015 centered around the Arabian Peninsula. But the newly discovered SARS-CoV-2 is much more infectious compared to SARS-CoV and MERS-CoV. Extensive studies are going on to know the origin of SARS-CoV-2 with specific species of bats. The latest research findings have revealed that the SARS-CoV-2 is about 96% similar to RaTG13 virus at the nucleotide sequence level which originated from horseshoe bats (Rhinolophus affinis) but it is different in a number of key genomic features.

Extensive studies are going on to know the origin of SARS-CoV-2 with specific species of bats. The latest research findings have revealed that the SARS-CoV-2 is about 96% similar to RaTG13 virus at the nucleotide sequence level which originated from horseshoe bats (Rhinolophus affinis) but it is different in a number of key genomic features.

To sum up, the normal process of descent with modification acted upon by natural selection does produce new viruses. It happens naturally. The chance of a virus evolving to infect a new species successfully is extremely low. But since there are continuous interactions between almost 8 billion human individuals and all other organisms on this planet, there are multiple chances for such infectious viral diseases. Moreover, the entire world is now connected through various means of transport, increasing the possibilities of pandemics. In 19th century, what might have remained as an epidemic confined to a city like Delhi or Mumbai, now expands to the scale of global pandemic in 21st century. Thus, COVID-19 is first pandemic caused by a human coronavirus, but certainly it will not be the last!

Dr Arvind C. Ranade is Scientist 'F' in Vigyan Prasar.
Email: rac@vigyanprasar.gov.in

INDIA STANDS READY..

Indian scientists at the forefront of war against corona

KAPIL KUMAR TRIPATHI

Much like the rest of the world, India is also grappling with the situation arising out of the COVID-19 pandemic. The country recorded its first coronavirus case on 30 January 2020 in Kerala. The World Health Organization (WHO) declared COVID-19 a pandemic on 11 March.

Various ministries and departments under the Government of India, especially the Ministry of Health and Family Welfare, were on the job, much before the disease that originated from the Wuhan city of China's Hubei province had captured Indian media's attention. The Government and its various organs had started working under a special strategy since January. A 21-day lockdown was announced on 24 March. The entire nation resolved to fight this pandemic together and stand shoulder-to-shoulder with our corona warriors. The measures adopted by the government have shown results and the situation in India remains under control, especially as compared to some of the other countries. Currently, as of April 24, India has 27,29,274 confirmed cases, 1,91,614 casualties while 1,489 patients have recovered. The data shows the rate of infection in India is lower than many other affected countries.

We all know there is no cure yet for COVID-19 and the pandemic is still spreading. India was lucky that this calamity struck us two months after the zero patient was found. This gave a window of opportunity to learn from the other countries' experiences. Humanity is fighting this pandemic at many levels: (i) Gaining better understanding of this virus and carrying out research aimed at developing a vaccine; (ii) Manufacturing enough test kits; (iii) Ensuring there is no shortage of the necessary medical equipment; (iv) Finding ways to contain the transmission; and (v) Raising awareness.

Understanding the virus better and developing a vaccine

The Pune-based National Institute of Virology (NIV), a research institute affiliated with the Indian Council of Medical Research (ICMR), has succeeded in isolating the first two SARS-CoV-2 viruses from India. Only China, Thailand, Japan and the US have managed to isolate the novel coronavirus so far. The Indian Journal of Medical Research published this research by NIV's Dr Pragya Yadav and her team. The work will, hopefully, pave the way for development of a cure for COVID-19.

Dr Raman R. Gangakhedkar, Head of Epidemiology and Communicable diseases at ICMR, explains that to develop a vaccine, you either need a genome sequence that can gradually lead to the development of antibodies or you should have a virus strain that can result in a vaccine. The team of researchers at NIV tested three COVID-19 samples and found that the genome sequence of the novel coronavirus in two of them matched 99.98 % with that of the virus sample in Wuhan. Whereas the genome sequence in the third sample was found to be broken. This indicates the coronavirus spreading in India is not the same as the virus found in other places.

Dr Atanu Basu and his team at NIV took throat swab of the first laboratory-confirmed case in India. She is a woman who had come to Kerala from Wuhan in January. It was found that the genome sequence in this sample matched 99.98 % with the virus that was wreaking havoc in Wuhan. The research paper refers to this virus as novel human pneumonia virus.

The Kolkata-based Indian Institute of Chemical Biology, affiliated to the Council of Scientific and Industrial Research (CSIR), has proposed a research project to find "interceptors which could render corona proteins inactive". The CSIR-IICB researchers are trying to find a biochemical that could stop SARS-COV-2 from entering human cells. Besides, CSIR is working on a five-point strategy to fight COVID-19. The five points of this strategy are (i) surveillance and digital monitoring at micro-level to understand the threat and nature of the pandemic; (ii) manufacturing affordable diagnostic and testing kits; (iii) development of treatment drugs; (iv) assisting hospitals with equipment; and (v) maintaining a supply chain for medical products. The organisation has signed a Memorandum of Understanding (MoU) with some corporates

to fulfill these objectives. These companies include BHEL, Cipla and the life sciences wing of the TCS.

Researchers at three of CSIR's laboratories – National Chemical Laboratories (NCL), Pune, Central Drug Research Institute (CDRI), Lucknow, and Indian Institute of Chemical Technology (IICT), Hyderabad – are working to develop a cure for COVID-19. CSIR has tied up with pharmaceutical companies Cipla and Cadila Zydus for this purpose.

Development of test kits

As part of the efforts to contain the COVID-19 outbreak, Pune-based molecular diagnostics company, Mylab Discovery Solutions Pvt Ltd, has developed the first Made in India COVID-19 testing kit. Based on cutting-edge technology, the kit – MylabPathoDetect COVID-19 Qualitative PCR kit – is the first one to receive commercial approval from the Indian FDA/ Central Drugs Standard Control Organisation (CDSCO). It also fulfills the parameters of the World Health Organization (WHO) and the Centres for Disease Control (CDC) of the US. Besides, Mylab is the only Indian company to have achieved 100 per cent sensitivity and specificity in the ICMR evaluation. The company has expertise in manufacturing diagnostic kits for many diseases including AIDS. Mylab's single kit will enable around 1,000 tests in a single lab in coming days, the current capacity is only 100 tests.

The scientists at CSIR's Delhi-based Institute of Genomics and Integrative Biology (IGIB) have succeeded in developing a low-cost rapid test kit for COVID-19. The researchers at this premier laboratory were able to come up with a portable paper strip that can detect the RNA of the coronavirus in less than an hour. The test comes at a much cheaper cost than the existing testing kits and is waiting for approval from regulatory agencies. Once approved, this test kit can increase the rate of daily tests considerably.

At present, India's testing rate per million population remains among the lowest in the world. The central government is importing testing kits from several countries. The production of indigenous kits will increase testing and set to rest apprehensions about real number of cases being reported in India.

All premier science, technology and research institutes across the country are working to fight the SARS-COV-2 virus. These include Indian Council of Medical Research (ICMR), Department of Science and Technology, Defense Research and Development Organisation (DRDO), Department of Biotechnology, Council of Scientific and Industrial Research (CSIR), Department of Atomic Energy (DAE), various campuses of the Indian Institute of Technology (IIT) and Indian Institute of Science Education and Research (IISER) among others. Many private research laboratories and organisations are also lending a helping hand to this cause. The laboratories of many of these institutions can also be used for testing, if the need arises.

Equipment for medical care

An incubator company in Pune's Scitech Park has developed a new technology that offers an effective solution to spreading of SARS-COV-2. The technology called ScitechAiron can disinfect closed spaced and rooms to minimum levels within an hour. The ScitechAiron ionizer generator developed under the 'Nidhi Prayas' programme initiated by the Department of Science and Technology (DST), can be used to kill bacteria, virus and fungi in a closed environment. It can be used to disinfect closed places like houses and hospitals that have COVID-19 patients or suspect cases. The innovation is particularly useful in ensuring that the doctors, nurses and other staff dealing with such cases do not catch the virus.

Bengaluru-based Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), an autonomous institution under the Department of Science and Technology, has developed an anti-microbial coating. When coated on surfaces like clothes and plastic, it kills a range of viruses like SARS-COV-2. The covalent coating is made from a mixture of chemicals.

The DRDO has approved the Personal Protection Equipment (PPEs) developed by the Indian Railways. The Bharat Heavy Electricals Limited (BHEL) is helping to manufacture safety equipment for personal safety of medical personnel as well as for hospitals. Likewise, CSIR is also collaborating with

BHEL to develop electrostatic sprayers as well as ventilators that would cost from Rs 10,000 to Rs 1 lakh. Aerobiosys Innovations, a healthcare startup associated with IIT-Hyderabad has built a low-cost, portable emergency ventilator. Named 'Jeevan Lite', it costs around Rs 1 lakh.

IIT-Roorkee has developed face shield for medical staff dealing with COVID-19 cases at the All India Institute of Medical Sciences, Rishikesh. These transparent shields have been manufactured using 3D printing technique and costs just Rs 5 each.

Containing the transmission

COVID-19 is highly contagious. Any proximity with an affected person puts another person as great risk of infection. Thus, a single infected person can transmit the disease to thousands, if not checked. Social distancing is one of the prescriptions to break the chain of transmission. People have been asked to follow the lockdown rules in letter and spirit and care for their personal hygiene.

The National Informatics Centre (NIC) has released an app to help track the suspected COVID-19 cases. The Aarogya Setu app helps user know if he has come in any contact with an infected person. The app also enables one to self-diagnose the symptoms. The App requires the users to give location access and keep Bluetooth of their mobile devices switched on. The app, if popularised, can help people assess potential risk of catching the virus.

Aarogya Setu combines Bluetooth technology, GPS and artificial intelligence to calculate the risk of contracting the coronavirus using the user's interactions with other people. The app is available in 11 languages. If Aarogya Setu finds you are in a high-risk zone, it will advise you to dial toll-free number 1075 and take appointment for diagnosis at the nearest facility. In addition, it also provides tips for precautions against the disease.

The team of researchers at NIV tested three COVID-19 samples and found that the genome sequence of the novel coronavirus in two of them matched 99.98 % with that of the virus sample in Wuhan. Whereas the genome sequence in the third sample was found to be broken. This indicates the coronavirus spreading in India is not the same as the virus found in other places.

Awareness

The World Health Organisation (WHO), Ministry of Health and Family Welfare (MoHFW), ICMR, Department of Science and Technology (DST) as well as various educational institutions along with non-governmental organisations (NGOs) have started programmes to raise awareness against the coronavirus. They are also providing training to the people at the frontline of battling the outbreak and developing material to disseminate information on how to prevent the infection. The social media as well as electronic and print media are being used to spread the information in every part of the country. Many institutes like the Mumbai-based Tata Institute of Fundamental Research (TIFR) and Vigyan Prasar are actively working to spread scientific information on public health precautions that could save people from this disease. Vigyan Prasar is working overtime to spread information and dispel several myths related to the pandemic. It is using platforms like DD Science and India Science as well as other print and social media avenues for the purpose.

The battle against the COVID-19 is far from over. The World Health Organization has acknowledged India's efforts in meeting this challenge. India has led the way in SAARC and G-20 groups of countries in this battle. The strong resolve of the corona warriors, preparedness of the government and its agencies as well as unity of 134 crore Indians is a testimony to the fact that India stands ready to win the war against coronavirus.

Jeevan Lite Ventilator

The author is Scientist 'F' in Vigyan Prasar.
Email: kapil@vigyanprasar.gov.in

RNA VIRUSES: "DEAD OR ALIVE"

New threat to the humanity

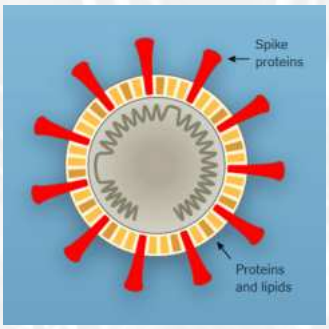
SANDEEP BARUAH

"The domestic cat would be at a loss to understand this herbivores' delight as being a paradise designed for it. This is because to the cat descended from African wild cats circa 8000 BCE in the Middle East would find it nearly impossible to believe it as true." - *Leviak B. Kelly*

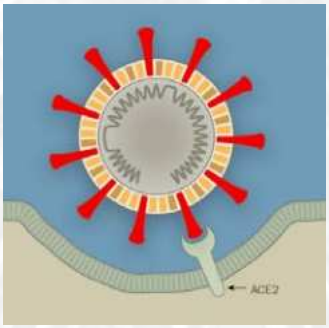
It is not only humans, but other animals and plants as well who have their own unseen enemies looming around and lurking everywhere which we call the pathogens – microscopic organisms that we don't see with our naked eyes. They are of different sizes and shapes and essentially a part of the biosphere. Though they are a part of the biosphere, they are undesirable for our existence as they cause diseases in us. There are other microorganisms which are beneficial to us. What may cause diseases in us may not to be harmful for others animals. Symbiosis and parasitism are inevitable consequences of the evolutionary biology on Earth. While symbiosis is a relationship between two types of animal or plant in which each provides for the other the conditions necessary for its existence, parasitism too is a symbiotic relationship between species, where one organism, the parasite, lives on or in another organism, the host, causing it some degree of harm. Pathogens are generally infectious biological agents that cause disease or illness to the host disrupting the normal physiology of a multicellular animal or plant.

We can draw a simple analogy here. For a rabbit, a fox may be its enemy (because the fox has to eat the rabbit for its survival) or for a deer a tiger is its enemy. So, they have an antagonistic relationship, which is paradoxical in nature as the very survival of the animal kingdom necessitates some kind of brutality. Similarly, the unseen pathogens lurking to hunt us is because they too need food for their survival and proliferation.

But are viruses living entities? We can simply describe a living entity or a life form as an organism that can grow, reproduce, respond to stimuli, and carry out various metabolic processes. The populations of living organisms also evolve over time. But the most notable characteristics of viruses are that they are incapable of carrying out metabolic processes and reproduce on their own. The viruses can replicate only within a living host cell by hijacking the genetic material of the host cell. Viruses hijack cellular machinery of the host and trick the cell into treating the virus's genetic information as its own and transcribing and/or translating it, thereby allowing the virus to replicate and proliferate and in the process damaging the hosts cells. If we compare other life forms and take a stringent view, we can say that viruses are non-living entity, but they do evolve through mutation forming different variants waiting to attack us.



Crown like spikes protruding from a SARS-CoV-2 virus enveloped in a bubble of oily lipid molecules. The lipids falls apart on contact with soap making the virus in effective for which hand washing after touching any object ensures protection from infection



After entering through the nose, mouth or eyes, the virus attaches to cells in the airway that produce a protein called ACE2.

At this very moment we are fighting a war against the RNA virus SARS-CoV-2. It has not appeared out of nothing. In fact, it is a member of a larger group of viruses known as coronaviruses that humans have been fighting for a long time. Just as we need different foods for our survival and for our proliferation, the viruses also need to do something for their survival and proliferation, and this is what they have been doing. Unlike animals and humans, viruses do not have their own metabolism and require a host cell to replicate their self and in the process damage the host cells.

Viruses contains genetic material, making it difficult to be classified as an entirely non-living entity. Some virologists therefore consider viruses as a different type of organism on the tree of life which they call 'capsid-encoding organisms'(CEOs) and the only way that the human cell can defend itself is by learning to recognise and destroy viral genes. A vaccine essentially does it and a specific vaccine can provide the cells the strength to build up immunity to fight against a specific virus.

Naturally, the question comes to our mind why unlike many other diseases caused by viruses, it is becoming increasingly difficult for the virologists to control the newly evolving viruses? What is the reason that this SARS-CoV-2 virus (the disease it is causing is termed COVID-19) is spreading so rapidly than the other viruses? Virologists have been fighting against two types of viruses, namely DNA viruses and RNA viruses.

Without going much deeper into what is DNA and RNA suffice it to say that these are the very basic building blocks

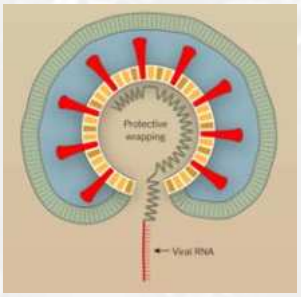
upon which life on Earth, from unicellular microscopic organisms to much complex life forms like us, are based. In the higher forms of life forms including humans, DNA is located in the mitochondria inside the nucleus of a cell while RNA is found in the cytoplasm, nucleus, and in the ribosome. DNA replicates on its own while RNA does not replicate on its own. It is synthesised from DNA when required. The function of the DNA is to transmit the genetic information while the function of the RNA is to transmit the 'genetic code' which is necessary to create the proteins needed for our survival. The synthesis of proteins takes place at the ribosomes inside the cells. The mitochondria can be called the power plants of the cell responsible for producing the energy that we need. Without mitochondria we shall be dead within seconds and without the RNA we shall be devoid of the essential proteins that we need for our survival.

Now the question arises as to why the same materials, namely DNA and RNA, which are essential for sustaining life on Earth, are also abundant in nature in the form of viruses?

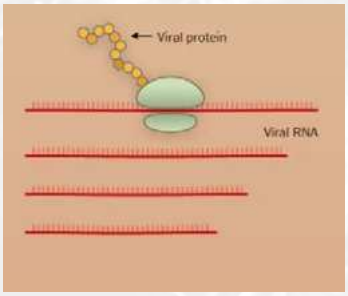
Although there are debates among virologists about how viruses appeared on Earth, there are three main hypotheses:

1. The progressive, or escape, hypothesis states that viruses arose from genetic elements that gained the ability to move between cells;
2. The regressive, or reduction, hypothesis asserts that viruses are remnants of cellular organisms; and
3. The virus-first hypothesis states that viruses predate or co-evolved with their current cellular hosts.

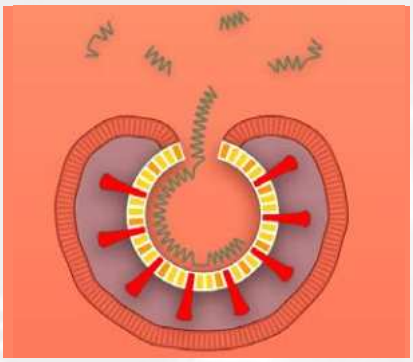
An RNA virus is a virus that has RNA (ribonucleic acid) as its genetic material. This nucleic acid is usually single-stranded RNA (ssRNA) but may also be double-stranded RNA (dsRNA). Some of the notable human diseases caused by RNA viruses include Ebola virus disease, SARS, MERS, rabies, common cold, influenza, hepatitis C, hepatitis E, West Nile fever, polio and measles, and of late COVID-19. Though there are different rabies viruses that can kill us (for example, from the bite of a dog infected with rabies virus), we now have vaccines against rabies. This has been possible because the rabies-causing virus has not mutated for a long time. So, once the vaccine is developed we can protect ourselves against rabies by injecting the vaccine. Interestingly, a vaccine contains the same virus as the one that causes the disease, but in a weakened or killed form. Once injected into our body it helps in developing antibodies to fight against the disease-causing virus by stimulating our immune system. Unlike medicines, which treat or cure diseases, vaccines protect us by making us develop immunity beforehand so that our body develops the resistance against the virus.



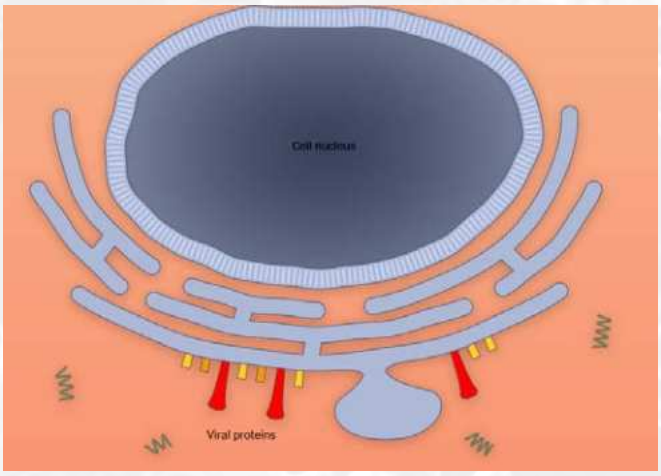
The virus infects the cell by fusing its oily membrane with the membrane of the cell. Once inside, the coronavirus releases pieces of its genetic materials called RNA in to the host cell.



The SARS-CoV-2 virus genome is less than 30,000 genetic "letters" long. Whereas human genome is over 3 billion "letters" long. After the viral RNA enter the human cell, the infected cell reads this RNA and begins making proteins assembling new copies of the virus inside the cell. This is called the hijacking of the host cell by the virus.



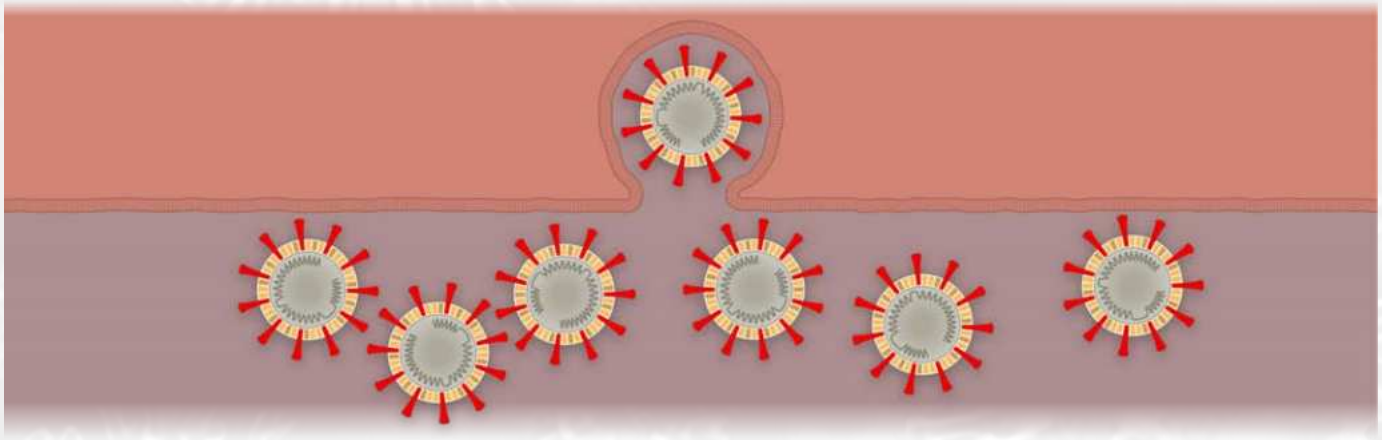
With the progress of the infection, the cell machinery starts building new spikes and other proteins allowing the formation of more copies of the coronavirus and new copies of the virus are formed



Incubation period is the time elapsed between exposure to a pathogen and the time the symptoms first become apparent. In a typical infectious disease, incubation period signifies the period taken by the multiplying organism to reach a threshold necessary to produce symptoms in the host. In case of the recent outbreak, it has been found that mean incubation period of SARS-CoV-2 is in line with those of other known human coronaviruses, including SARS (mean: 5 days; range: 2 to 14 days); MERS (mean: 5 to 7 days; range: 2 to 14 days), and non-SARS human coronavirus (mean: 3 days; range: 2 to 5 days)

It has been observed that RNA viruses are more virulent than the DNA viruses due to the fact that RNA viruses can mutate fast and therefore can become more virulent and dangerous; avian influenza virus is one such virus. Hepatitis virus is a DNA virus which is less virulent than the Pox virus, which is an RNA virus.

In the recent recorded history of mankind, the biggest pandemic that wiped out 40 million people over a period of two years starting in 1918 was due to the Spanish flu virus, which is a H1N1 RNA virus. The HIV virus has killed more



Each infected cell can release millions of copies of the virus before the cell finally breaks down and dies. The viruses may infect nearby cells, or end up in droplets that escape the lungs.

than 20 million people, spread over a period of 20 years. The smallpox virus (which is a DNA virus) killed millions of people for many centuries in the past but is now extinct as a result of appropriate vaccines developed and the global immunization programme.

Of late, some of the RNA viruses are emerging as the most feared threat to our life because of their ability to kill people rapidly and to evolve very quickly. One of the reasons cited behind RNA virulence is its chemically unstable nature. While it is more prone to damage (it is said that if we wash our hand even with ordinary soap and water for 20 seconds, the outer shell/cover of the virus breaks down and the genetic material inside it becomes ineffective to cause harm), at the same time if it enters a host (human) it mutates much faster than many other viruses like the DNA viruses. RNAs are less stable than DNA and it enables them to continuously modify their genome sequence sharing a common host.

It has been observed that RNA viruses are more virulent than the DNA viruses due to the fact that RNA viruses can mutate fast and therefore can become more virulent and dangerous; avian influenza virus is one such virus. Hepatitis virus is a DNA virus which is less virulent than the Pox virus, which is an RNA virus.

At the time of filing this story, nearly 1,434,356 people are infected with novel coronavirus worldwide (with 82,148 deaths) within a span of last three months, making it the second largest pandemic after the 1918 Spanish flu pandemic. Virologists are at a loss to find out a cure and to understand why it is spreading so easily.

The key feature of the novel coronavirus is a protein in its surface. Some virologists are concentrating on this protein, while others are investigating to find the doorway on the human tissue known as the receptor on the cell membrane through which the novel coronavirus enters the human tissues. So, researchers have been contemplating on drugs which can target both the virus protein and cell receptor to block the entry of the virus.

The novel coronavirus (SARS-CoV-2) has 'spike proteins' which are different from its other coronavirus close relatives which bind to the human cell membrane. The process of binding to the protein site of the virus is activated by a specific cell enzyme of the host known as 'furin'. Incidentally, as furin is found in tissues of some of the vital organs of humans like the lungs, liver and small intestines, this virus can attack multiple organs. Other coronaviruses in the same genus don't have furin activation sites.

According to Gary Whittaker, a virologist at Cornell University in Ithaca, New York, USA, this furin activation site in SARS-Cov-2 "sets the virus up very differently to (other) SARS viruses in terms of its entry into cells and possibly affects stability and hence transmission." It is these activation sites (which are also found in some severe strains of influenza virus) in human tissues which is possibly enabling the virus to spread efficiently.

But according to Peter White, a virologist at the University of New South Wales in Sydney, Australia, the haemagglutinin protein on the surface of flu viruses is not similar or related to the spike protein in coronaviruses and does not have a furin activation site, but still that flu virus caused the deadliest 1918 Spanish flu.

Another group of virologists led by Prof. McLellan's in Texas has identified another feature of the SARS-CoV-2 virus. They found that the spike protein of this virus binds to a receptor on human cells known as angiotensin-converting enzyme 2 (ACE2) ten times more tightly than does the spike protein in previous SARS virus and this could probably explain why the novel coronavirus infects human cells so successfully.

Disclaimer: Contents of this article have been sourced from a number of sources (books and Internet) available with the intention of providing information on SARS-CoV-2 in the best possible way.

The author is Scientist 'F' in Vigyan Prasar.
Email: sandeep@vigyanprasar.gov.in

Check the facts about COVID-19 and avoid rumours

NIMISH KAPOOR

The COVID-19 disease is unprecedented and has spread its tentacles all over India. As compared to many other countries, India has fewer people infected with COVID-19 but the numbers are rising daily. There are a large number of people who are not coming forward to get themselves tested for this infection. People are anxious, they are afraid, often without reason. The situation is worsened by various rumours floating around.

There are a large number of health workers and journalists working day and night in the fight against COVID-19 pandemic. On the other hand, there are also a huge number of people who are spreading rumours and unverified information on social media about this disease. There is an explosion of information on COVID-19 and therefore it is of utmost importance that citizens should be able to separate scientific facts from false news so that the spread of rumours and unscientific news can be halted. If any misleading news is received, it can be verified from an authentic source or website. Wrong information and false news around COVID-19 can make people take unimaginable and often dangerous actions. Recently, more than 40 people in Iran consumed poisonous methyl alcohol on the misleading notion that alcohol will help in stopping spread of coronavirus infection. Today, India and many other nations are grappling with both the COVID-19 pandemic as well as misleading information on the disease. There is a deluge of false information about COVID-19.

Misleading news about COVID-19 is being spread not only on social media but also on mainstream media. They talk about ways and means to tackle the virus which are unscientific and confusing. Another very important part of all this misinformation is about the transmission of the disease, the nature of the illness and the facts and figures about the death rate—many of which is presented in an untruthful and wrong manner and are aimed at instilling a sense of fear among people.

As a reader or viewer you should be careful about the source of information that you are reading in the newspapers and watching on television channels and the background of the experts whose interview or with whom discussions are being telecast. There are not very many researchers or specialist doctors of COVID-19 in the world including India. As a vigilant reader or viewer you should make sure that the source of reports of the media that you have chosen and source of scientific information are authentic.

Messages about COVID-19 being posted on social media should be verified

There are rumours that garlic can stop the coronavirus infection. WHO has already refuted the claim. Even though garlic may have some antimicrobial properties and is generally considered beneficial for health but it does not provide protection against COVID-19.

There are misleading photographs on social media which claim that chickens and eggs have been infected with COVID-19 and thousands of chickens are being killed. This is a false claim; according to experts, there is no evidence of coronavirus in the poultry industry.

There was news from unknown sources that a hot water bath prevents coronavirus infection. The WHO website has dismissed this report unambiguously and says, “Taking a hot bath will not prevent you from catching COVID-19. Your normal body temperature remains around 36.5°C to 37°C, regardless of the temperature of your bath or shower.”

Some videos are viral on social media showing people spraying alcohol or chlorine on their bodies which is claimed to destroy the virus. WHO has clarified that this should not be done because spraying alcohol or chlorine over your body will not kill viruses that have already entered your body. Spraying such substances can be harmful to clothes or mucous membranes (i.e., eyes, mouth). Beware that although both alcohol and chlorine can be used to disinfect surfaces, they need to be used under appropriate recommendations.

It is also claimed that coronavirus cannot survive in too hot or too cold temperatures and the infection can stop at these temperatures. However, the WHO website has refuted this claim also. It says, “From the evidence so far, the COVID-19 virus can be transmitted in ALL AREAS, including areas with hot and humid weather.”

It is also claimed that coronavirus cannot survive in too hot or too cold temperatures and the infection can stop at these temperatures. However, the WHO website has refuted this claim also. It says, “From the evidence so far, the COVID-19 virus can be transmitted in ALL AREAS, including areas with hot and humid weather.”

The WHO website has also refuted a claim that the virus can be transmitted by mosquito bite. According to WHO, “To date there has been no information nor evidence to suggest that the new coronavirus could be transmitted by mosquitoes. The new coronavirus is a respiratory virus which spreads primarily through droplets generated when an infected person coughs

or sneezes, or through droplets of saliva or discharge from the nose."

False claims have also been made that aspirin can cure COVID-19. Aspirin has no role to play in either reducing or preventing COVID-19 infection. There have also been dubious claims that cow dung and cow urine can destroy coronavirus. These are all baseless claims.

Some viral social media videos claim that colloidal silver can stop coronavirus or a cure for COVID-19 is possible through it. This is untrue; American experts are of the opinion that it is not safe to be used for treating any disease at all.

Claims have also been made on social media that being able to hold your breath for 10 seconds or more without coughing or feeling discomfort is an effective test for coronavirus and drinking water at regular intervals can prevent this disease. These are false claims. Drinking water at regular intervals is good for health but there is no correlation between water and COVID-19. WHO has clarified that there is no evidence to support these claims.

Taking cognizance of the conclusions of a research paper there was a rumour being spread in the social media in China that tobacco or smoking can cure COVID-19. This is not true. According to a Chinese daily, a group of health specialists have refuted the conclusions of the research paper and have declared it to be incorrect. There is no scientific conclusion in the world that nicotine has an anti-viral effect. Rather, it only weakens our immune system.

Believe in scientific facts about COVID-19 published by authentic sources

Directions and guidelines about steps for protection from COVID-19 are appearing in almost all media. According to doctors and WHO, one should maintain a minimum distance of 2 metres from other persons and one should be very careful around people who have some symptoms or signs of a respiratory disease like coughing or sneezing.

It is of utmost importance that we should help ourselves and society in coming out of this sea of wrong information and false news. Here are some websites of authorised institutions/ organisations for the most accurate and safe scientific information:

World Health Organisation

https://www.who.int/emergencies/diseases/novel-coronavirus-2019

The WHO website gives all the special information and facts about coronavirus disease (COVID-19) pandemic under the heading Emergency. This section busts many myths and dubious news about COVID-19 and advice is available to the public on how to protect oneself from COVID-19. The website states that most people who become infected experience mild illness and recover, but it can be more severe for others.

Ministry of Health and Family Welfare, Govt. of India

https://www.mohfw.gov.in/

The website of the Ministry of Health and Family Welfare of the Govt of India shows the current number of persons infected, number of persons recovered after treatment, number of deaths, state-wise breakup of the number of COVID-19 infected persons, etc. In addition, to raise the awareness of the people a number of videos are also available on topics like mental stress during COVID-19 lockdown, pregnant women, labour management, blood donation, money allocated to different states, honours for healthcare workers, social myths, etc.

Indian Council of Medical Research, Govt. of India

https://www.icmr.nic.in/

The website of the Indian Council of Medical Research, Govt. of India has details on the current status of COVID-19 testing, Government and private laboratories involved in the testing of COVID-19 who have been given diagnostic kits and reagents, protocols for according approvals for COVID-19 testing facilities in view of the national emergency, directions for the use of commercial kits for the treatment of COVID-19 in India based on swabs of nose/throat, location map of COVID-19testing laboratories, research articles on coronavirus "India and COVID-19", etc.

Indian Scientists' Response to COVID-19

https://indscicov.in/

Indian Scientists' Response to COVID-19 (ISRC) is a voluntary group of concerned scientists of India who have come together in this time of crisis for communication of COVID-19-related issues to general public, scientists and health professionals. For the public, they bust hoaxes, myths and clarify rumours by providing scientific facts. For scientists and health professionals they provide information on mathematical modelling, app development, hardware (masks, ventilators, etc.), learning from global experiences and methods of tracking the disease. The information on the website is given in multiple languages.

Covid Gyan, Tata Institute of Fundamental Research

https://covid-gyan.in

The Covid Gyan web portal is an initiative of the Tata Institute of Fundamental Research, Mumbai where various means like videos, webinar, infographics, audio/podcast and articles have been used to create awareness about COVID-19.

Vigyan Samachar, Vigyan Prasar

https://vigyanprasar.gov.in/vigyan-samachar/

Science news based on the current information of study and research being done on COVID-19 in various laboratories of the Govt of India are available on the website of Vigyan Prasar.

Press Information Bureau, Government of India

https://pib.gov.in/

The press releases by the various ministries and science and health-related institutions are available on the website of the Press Information Bureau, Govt of India.

The author is Scientist 'E' in Vigyan Prasar.
Email: nkapoor@vigyanprasar.gov.in

Glossary of COVID-19-related terms

Coronavirus: One of the viruses in the family of viruses that has a spiky "crown"-like appearance under a microscope. These range in severity from the common cold to the far more deadly SARS (see definition) and MERS (see definition) viruses.

MERS: Short for Middle East Respiratory Syndrome, a highly contagious virus that was first seen and reported in Saudi Arabia during 2012.

SARS: Short for Severe Acute Respiratory Syndrome (SARS), a viral respiratory illness caused by a coronavirus, and which was first seen and reported in February 2003, at which time a global outbreak occurred. It was subsequently contained.

SARS-CoV-2: Another abbreviation for COVID-19. It refers to the fact that COVID-19 is a SARS illness caused by a coronavirus.

COVID-19: The World Health Organization gave this name to the illness caused by the new coronavirus that first appeared in China in late 2019. It is short for "coronavirus disease 2019".

Outbreak: A sudden increase in diagnoses of a particular illness.

Pandemic: An "outbreak" affecting large populations or a whole region, country, or continent (as compared to an "epidemic," which affects a particular community).

Contagious: An adjective meaning "capable of spreading an illness." The issue with COVID-19 is the length of time during which people are "contagious," which might be for as long as 14 days from the time they are first infected with it. (See "Incubation Period" below).

Incubation Period: It is the time between exposure to an illness and actually showing symptoms. People exposed to COVID-19 can take up to 14 days to show symptoms. This long incubation period is one reason COVID-19 has spread so effectively.

Containment: This refers to the effort to limit the spread of illness. Some illnesses have been contained via vaccination, but COVID-19 has no vaccination or treatment as of now. Therefore, "containment" is accomplished via "social distancing," "isolation," and "quarantine" (see definitions below).

Close Contact: Being within 6 feet of another person such that a "droplet" from one person could land on the other person or something the other person is wearing or holding.

Droplet: A particle of moisture from the respiratory system. Droplets expelled by someone infected with COVID-19 can spread the virus to another person if the second person touches the droplet and introduces it into their own respiratory system (by touching their eyes, lips, or nose).

Airborne Transmission: This is also accomplished via droplet, but a much smaller droplet - one that is small enough to be imperceptible in the air. Most COVID-19 cases are not transmitted this way.

Confirmed Case: A person who tests positive for COVID-19 via a CDC-approved lab.

Presumptive Positive Test Result: A positive test for COVID-19 that was performed by a local or state health laboratory. Presumptive becomes "confirmed" when testing is conducted in a CDC-approved lab.

Curve: A graphic representation of the number of new cases of a disease over a given period of time. The more the case in that period of time, the steeper is the curve and the greater is the burden on the healthcare system.

Face Mask: Loose-fitting paper or cloth masks that form a physical barrier between the wearer and other people, with the purpose being to prevent the wearer from spreading germs when they sneeze or cough. They also can remind the wearer not touch their face.

Respirator: For COVID-19 purposes, a respirator is not a machine to help one breathe a type of face mask that doesn't just act as a barrier but also filters out virus particles before they can be inhaled.

N95 respirator: A respirator that filters out 95% of virus particles. This is the gold standard or healthcare workers and are in short supply now.

Quarantine: The separation of someone who has been diagnosed with an illness, has symptoms of the illness, or has reason to believe they were exposed to the illness from other people. The duration of a quarantine is guided by the incubation period for the particular illness. Quarantine can be imposed on a person or self-administered.

Social Distancing: It is the practice of maintaining enough distance between yourself and another person to reduce the risk of breathing in droplets that are produced when an infected person coughs or sneezes. In a community, social distancing measures may include limiting or cancelling large gatherings of people.

Ventilator: A machine that moves air in and out of the lungs in the case that a patient cannot or is having trouble breathing on their own. Unfortunately, this happens all too often in COVID-19 cases.

Shelter-in-place: Finding a safe location and staying there while the crisis continues.

Lockdown: When you see this word, please know it is not an official, technical, or legal word. Rather it's just a word people use to a non-technical word for referring to any kind of public health measures taken to prevent the virus from spreading.

Spanish Flu: You're likely, at least at some point, to hear COVID-19 compared to and contrasted with Spanish Flu. Active between April of 1918 and December 1920, this flu, which most likely originated in China but got its name from the nation that, at least initially, put out the most media coverage of the outbreak (this was a function of wartime politics). The scary thing is that 100 million people died worldwide. The good news is we are so much better equipped to practice social distancing than we were back in 1918.

State-of-emergency: Declaring a state of emergency gives government officials the authority to take extra measures to protect the public, such as suspending regulations or reallocating funds to mitigate the spread of a disease.

CDC: Centers for Disease Control and Prevention (the U.S.'s health protection agency and a leading reliable source for COVID-19 updates for the U.S.).

WHO: The World Health Organization, which is an agency of the United Nations responsible for international public health.

COVID-19:
Impact on World Economy

INDERJIT SINGH

"The ultimate measure of a man is not where he stands in moments of comfort and convenience, but where he stands at times of challenge and controversy."
—Martin Luther King, Jr.

The World Health Organization (WHO) declared COVID-19 a pandemic on 11 March 2020, entailing enormous impact on our lives. Till 24 April 2020, more than 27,29,274 COVID-19 cases have been reported worldwide with a death toll of over 1,91,614. China was the first country to experience the pandemic, with confirmed active cases at over 60,000 by mid-February. It however soon rapidly spread to several European countries including Italy, Spain, France, United Kingdom and also the United States of America. In order to check the spread of COVID-19 pandemic, the countries resorted to containment measures like lockdown to ensure social distancing. Lockdowns are not only imposed within the countries but inter-country movements have also been restricted.

The COVID-19 pandemic has pushed the world into a recession. This has also been endorsed by the International Monetary Fund. The recession is likely to be as bad as or worse than that of 2009. This will be worse than any of the global financial crises in the past. Due to the exponential rise in new infections across the globe, the economic damage is rising across the continents. Around the world, economists are quickly trying to adjust economic models to judge where our world is heading to and evolve ways to address the crisis.

The broad areas where impact of COVID-19 can be noticed are direct impact on production, supply chain and market disruption, and financial impact on firms and financial markets. The major impact comes from fall in retail output, wholesale trade and in professional and real estate services; although there are inter-county differences in these sectors, depending upon the area of expertise of the countries.

Severity of the impact can be judged from the fact that as per United Nations, global economy could shrink by almost one per cent in 2020 due to COVID-19 pandemic.

As per Organisation for Economic Co-operation and Development (OECD), the impact of business closures could cause reductions of 15 per cent or more throughout the advanced and major emerging-market economies. In the median economy, output would decline by 25 per cent.

Countries which depend on tourism for a major part of their economy are likely to be affected more severely by containment measures such as shutdowns and restrictionson travel. On the other hand, countries with somewhat sizeable agricultural and mining sectors, including oil production, may experience smaller initial effects from the containment measures. Output of such countries will also be later impacted by reduced global commodity demand.

The potential initial impact on activity of partial or complete shutdowns in various advanced and emerging market economies can be appreciated with the help of *Figure 1*.

Per cent of GDP at constant prices

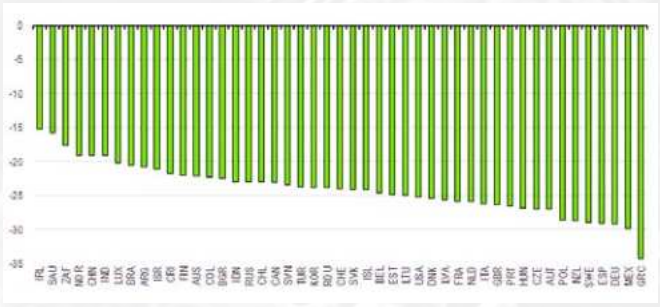


FIGURE 1

(**Source:** BSE and NSE)

The Purchasing Managers' Index (PMI) is an economic indicator. It surveys purchasing managers at businesses ina given sector. Manufacturing PMI and the services PMI are the most known PMI surveys.As per latest indices from PMI Surveys, sharp slowdowns have been noticed in manufacturing output in many countries, reflecting drops in external and domestic demands. China,in a positive note, is seeing a modest improvement in its PMI after sharp declines early in the year, despite weak external demand. This can be visualized from *Figure 2*, which inter-alia compare the data for the months of February and March 2020.

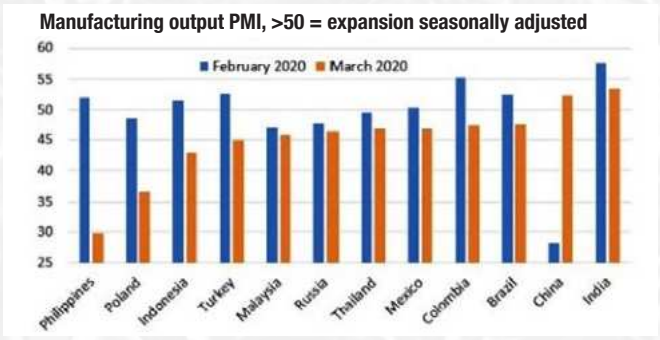


FIGURE 2

(**Source:** OECD: Evaluating the initial impact ofCOVID-19 containment measures on economic activity)

International Labour Organization (ILO) forecasts that the impact could cause equivalent of loss of 195 million jobs. The

charity group Oxfam has warned that half a billion of people, i.e., around 8 % of the world's populationcould be pushed into poverty by the COVID-19 pandemic. The region-wise forecast is given in *Figure 3*.

FIGURE 3

(**Source:** OXFAM and Statista)

The World Trade Organization (WTO) is also expecting world trade to fall between 13 per cent and 32 per cent in 2020 as a result of disruption of normal economic activity and life around the world by the COVID-19 pandemic.

Besides, notable impact has also been seen in the financial markets. The FTSE and Dow Jones industrial average and Nikkei have all seen a huge downfall following the outbreak of the COVID-19 pandemic. The Dow and FTSE recently witnessed the biggest one-day fall since 1987.The impact on these indices was experienced since the outbreak inend of December 2019. The indices had fallen by up to 28.8 per cent during the period January-April 2020 as indicated in *Figure 4*.

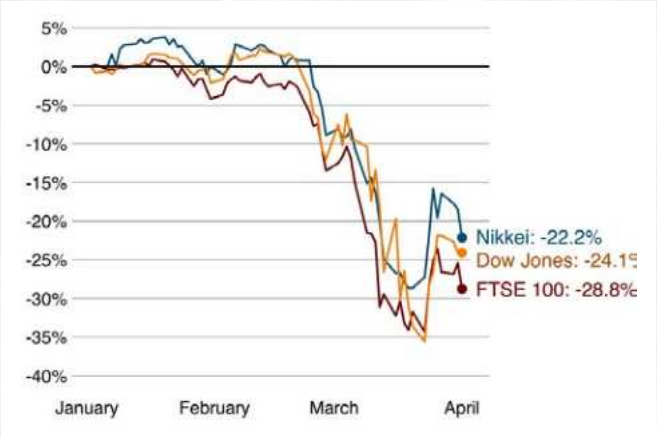


FIGURE 4

(***Source:*** OXFAM and Statista)

Indian markets have also not remained untouched with the adverse impact of COVID-19. S&P BSE Sensex noticed a decline from 38,144 to 29,468 during March 2020. Similarly, the decline in Nifty 50 has also been noticed from 11,113 to 8,598. Incidentally, the BSE Sensex and Nifty have fallen to as low as 25,981and 7,610, respectively. These low levels were seen on 23 March 2020 as may also be seen from *Figure 5*.

As evident from the above, COVID-19 has impacted our lives in multifarious ways such as unemployment, poverty, slow-down in manufacturing activities and the poor performance of financial markets. Thus, the countries have taken several measures to address the issues emerged from the COVID-19 and its containment provisions.

Many countries including the UK, US and India have slashed their bank interest rates. As per the established economic theories,this makes borrowing simple and promotes spending to boost economic growth. At lower interest rates, banks are able to extend loans on low interest rates. However, despite being in accordance with the established theories, this has failed to yield the desired results. Needless to say, this is an unprecedented situation. The situation is dynamically changing every passing

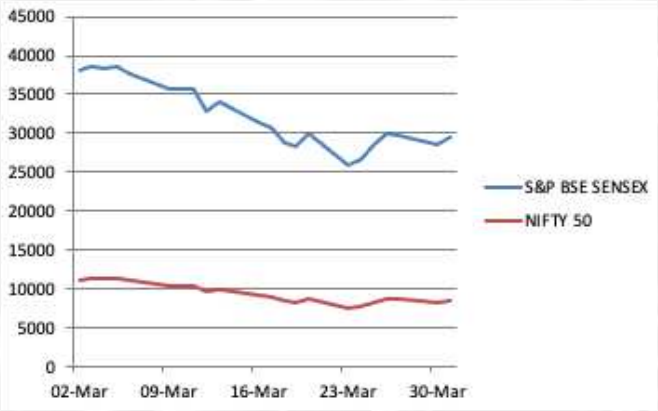


FIGURE 5

(***Source:*** OXFAM and Statista)

day and new economic equations are under development.

Reserve Bank of India on 2 March 2020 introduced a COVID-19 – Regulatory Package to mitigate the burden of debt servicing brought about by disruptions on account of COVID-19 pandemic and to ensure the continuity of viable businesses.Rescheduling of payments forterm loans and working capital facilities and easing of working capital financing are the prominent reliefs to the individuals and corporates under the package.

A recovery is expected by 2021; however,it will be dependent on the duration of the outbreak and the effectiveness of the policy response.There is a need to resolve the challenges put forth by COVID-19 with resilience and introduction of reforms.

Everything going around at present is unprecedented and heart-breaking, but there is some positive impact of COVID-19 on our lives in the term of lower emission of greenhouse gases and the resultant pollution. This is primarily attributable to the COVID-19 containment provisions invoked by various continents/countries. It is now imperative not to let it be a transitory phase but a long-lasting sustainable goal. Undoubtedly “Every cloud has a silver lining”; no matter how bad a situation might seem, there is always some good aspect to it.

The world economy has sailed through various adverse situations in the past. This will definitely not be an exception and this, too, shall pass.

The author is Accounts Officer in Vigyan Prasar.
Email: isingh@vigyanprasar.gov.in

COVID-19:
A concern for Indian agriculture

K.B. BHUSHAN

"My crop is ready for harvest. Neither do I have labour to help harvest the crops nor is there a buyer to buy them." – A vegetable farmer.

March-April is the time for harvesting rabi crop in India. This year, farmers were hoping to earn a lot from the crop cultivated, but their hopes have been shattered by the COVID-19 epidemic. They are concerned that even getting back their investment is uncertain. All this is because there is an acute shortage of agriculture labourers who normally help in harvesting.

COVID-19 impacting agriculture

The primary disquiet for agriculture-related activities is due to the ongoing 21-day nationwide lockdown announced by the Government to prevent the large-scale outbreak of the coronavirus infection. Restrictions on movement are curbing farmers' access to markets to buy inputs and sell products. Fresh produce is accumulating at farms, resulting in food loss. The inability of migrant seasonal workers to travel during lockdown has also led to agricultural labour shortage.

A large part of the country in the informal economy sector mainly depends on agriculture. India's current coronavirus shutdown is a challenge to agriculture as it overlaps with harvesting times. In India, the current season is harvesting time for rabi crops (wheat, gram, tomatoes, mustard, and other vegetables) which are sown in winter. The standing crops in the field also faced unpredictable rainfall in December-January, which caused damage to crop (especially cereals). Undoubtedly, lockdown is essential to break the transmission chain of the novel coronavirus. But, at the same time, this initiative has triggered a further setback on Indian farmers and has posed a never before challenge for Indian agriculture. To address this unique challenge, a systematic approach with all stakeholders is necessary. Indeed the Indian government, the private sector and common people are contributing to their individual capacity.

India needs about 250 lakh quintals of seeds for the kharif season. The preparation of the seeds takes place between March and May. From there, they are sent to labs for testing and, finally, are packaged for supply to the farmers. This is a time-consuming process and hence should be taken care of while making plans and policies with reference to remedial strategies for the coronavirus pandemic.

Government initiatives for agriculture sector

The Centre and State Governments have taken several steps to alleviate fear and announced exemptions for the agriculture sector – seeds, labourers, and farm-related activities. States such as Telangana and UP, among others, have been very proactive. Special packages have also been announced for different sectors. The railways have been roped in to ease transport logistics. ICAR has also issued an agro-advisory to maintain hygiene and social distancing. Famers are being encouraged to follow precautions

and safety measures to prevent the disease spread. Simple measures including social distancing, ensuring personal hygiene, wearing of face mask, protective clothing and cleaning of implements and machinery have also been made mandatory for farm-related activities.

The relief package worth Rs 1.7 lakh crore announced by India's Finance Minister during lockdown will help the poor. Besides, the early payment of instalment of Rs. 2,000 under the PM KISAN Yojana (Pradhan Mantri Kisan Samman Nidhi Scheme) will cover financial upkeep of 87 million farmers of the country. The present efforts of the Government will be only for a short duration. We need to think about the long-term implications also. This means preparedness for next cropping season, namely the kharif season. Majority of Indian population's survival is dependant on agriculture, and a good harvest depends on quality seeds delivered to farmers by the seed sector provided by both public and private organisations. Amid the coronavirus crisis, good seeds and other farm inputs must reach farmers in time for the kharif season. India needs about 250 lakh quintals of seeds for the kharif season. The preparation of the seeds takes place between March and May. From there, they are sent to labs for testing and, finally, are packaged for supply to the farmers. This is a time-consuming process and hence should be taken care of while making plans and policies with reference to remedial strategies for the coronavirus pandemic. The complete seed production ecosystem is complex and requires the help of allied sectors such as transport, testing labs and the packaging industry. The role of large segment of small and medium seed companies will be vital to meet the demand.

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Food and Agriculture Organization (FAO) recommendations

The Food and Agriculture Organization (FAO) has suggested some measures to combat the COVID-19 pandemic and the risk to food supply chains. The recommendation of FAO for smallholder farmers suitably fit the Indian context. The insight of the guidance and suggestive core measures includes:

1. Support to smallholder farmers to both enhance their productivity and help them market the food they produce, also through e-commerce channels.

2. Bringing collection centres closer to smallholder producers to reduce the need for mobility. Collection centres should have high capacity. Food banks can play a significant role, given their knowledge, as well as horizontal and vertical coordination mechanisms with farmers' associations engaged in contract farming arrangements.

3. Establishing warehouse receipt systems for farmers to use the receipts to get their payments.

4. Accelerating the development of e-commerce for smallholders. Smallholder farmers must have access to finance so that they can continue farming.

5. Waiving off of fees on farmers' loans and extending payment deadlines by banks. A capital injection in the agricultural sector can help small and medium agri-businesses to continue operations.

6. Improving storage that can help reduce post-harvest crop losses along the supply chain.

7. Government should meet the necessary energy needs of smallholder farmers and rural households.

8. Local governments must consider an alternative to school meals, such as home delivery of meal to keep the producers employed and children nourished.

9. During an emergency, Governments can purchase agricultural products from smallholder farmers to establish strategic emergency reserves, especially for non-perishable commodities, to boost food supply. This can be used to deliver safety-net programmes and school meals, even when schools are closed.

Time is trying us hard. We need courage and right information as the fighting tools to overcome this coronavirus outbreak. We need to make informed decisions, so COVID-19 doesn't evolve to threaten our agriculture and food supply. There will be chances that the agri-input ecosystem may collapse in future, so the Government should ensure that all sub-trades and manufacturing units associated with agri-inputs function. Timely announcement of special stimulus package from Government for agriculture and allied activities including microfinance will help Indian agriculture to build again from the damage caused by the outbreak.

Majority of the Indian farmers are small and marginal in land holding. The main affected areas of agriculture are harvesting and supply chain. The Government has suitably issued lockdown guidelines that exempt farm operations and supply chains. Nonetheless, addressing issues that lead to worker shortages and rising prices should be addressed. To ensure food security it is important that supply chains work uninterrupted. The practice of social distancing by farmers should be strictly enforced as far as possible to ensure the chain-break of coronavirus transmission. Measures should be taken to ensure that farmers get continued market access with a combination of public procurement and private markets. Other farm sectors such as small poultry, dairy farmers etc. should be considered equally important with respect to their inputs. Assistance package for farmers and agricultural workers should be continued until the stability is achieved in the domestic sector.

Dr K.B. Bhushan is Scientist 'D' in Vigyan Prasar.
Email: bhushan@vigyanprasar.gov.in

Technologies for the diagnosis of COVID-19

SACHIN C. NARWADIYA

The world is in the midst of a pandemic of coronavirus disease 2019, also known as COVID-19. The causative agent responsible for COVID-19 is a virus called severe acute respiratory syndrome coronavirus 2, or SARS-CoV-2. Initially known as the novel coronavirus, the new virus has been given the name SARS-CoV-2 by the International Committee of Taxonomy of Viruses (ICTV).

Coronaviruses have ribonucleic acid (RNA) as the genetic material. The spherical particles have spike-shaped proteins protruding from their surface. These spikes latch onto human cells, then undergo a structural change that allows the viral membrane to fuse with the cell membrane. The viral genes can then enter the host cell to be copied, producing more viruses. This type of virus can replicate their RNA genomes with the help of RNA dependent RNA polymerases.

In the urgent situation for combating this disease a viral genome sequence was released via the community online resource virological.org on 10 January 2020. After this, four other genomes were deposited on 12 January 2020 in the viral sequence database curated by the Global Initiative on Sharing All Influenza Data (GISAID).

For tackling the spread of SARS-CoV-2 infection, a reliable laboratory diagnosis is most important for the identification of infected persons and their proper quarantine and treatment. As in cases of acute respiratory infection, real-time reverse transcriptase-polymerase chain reaction (RT-PCR) is routinely used to detect causative viruses in respiratory secretions. Other tests may include serological assays and viral culture. But as the RT-PCR is rapid, specific and reliable compared to other tests, it is widely accepted for the diagnosis of COVID-19.

As per the WHO, the decision to test should be based on clinical and epidemiological factors. PCR testing of suspected individuals with symptoms or without one can be considered for diagnosis of infection of COVID-19. PCR is uniquely suitable for the identification of a small quantity of genome of the virus. The method leads to the amplification of the desired gene of the virus and then its identification.

Historically, the invention of the PCR is credited to American biochemist Kary Mullis in 1983. Its principle is based on the DNA polymerase action, which is in vitro replication of specific DNA sequences. This method can produce tens of billions of copies of a particular DNA fragment (the sequence of interest, DNA of interest, or target DNA) from a DNA extract (DNA template). PCR can be used to obtain multiple copies of DNA. The matrix DNA can be a genomic DNA or complementary DNA (cDNA) obtained by RT-PCR from a messenger RNA extract (poly-A RNA) or even mitochondrial DNA.

PCR is a technique for obtaining large amounts of a specific DNA sequence from a DNA sample. This amplification is based on the replication of a double-stranded DNA template. The PCR has phases: a denaturation phase, a hybridisation phase with primers, and an elongation phase. The products of each synthesis step serve as a template for the next steps; thus, exponential amplification is achieved.

The denaturation

In this step, double-stranded DNA is separated into single-stranded DNA by raising the temperature to 90-98°C.

Hybridisation or annealing

In the second step, which is termed as hybridisation or annealing phase, the mixture is cooled down to 40-60°C which permits complementary sequences of single-stranded DNA or RNA to pair by hydrogen bonds to form a double-stranded polynucleotide.

Elongation

In the third step, temperature is again raised to 70-75°C, which is optimum for action of an enzyme called Taq polymerase to start the attachment of nucleotides on primer as per the complementary sequences in the original DNA. Taq polymerases are named after their bacterium source Thermusaquaticus.

Thus, the new DNA strand gets elongated. After completion of these steps two double-stranded DNAs are produced. Then, again, step 1 begins for getting 4 double stranded DNAs and so, multiplication of DNA proceeds after each cycle.

RT-PCR is sometimes misunderstood as a real-time polymerase chain reaction. However, they are separate and distinct techniques. Application of RT-PCR for the qualitatively detection of gene expression involves creation of complementary DNA (cDNA) transcripts from RNA. As the SARS-CoV2 virus is an RNA virus, it can be detected by using RT-PCR. In case of RT-PCR, the enzyme reverse transcriptase first produces copy of DNA from RNA and then the steps of PCR begin.

Serological testing

Serological surveys can be performed in addition to the investigation of an ongoing epidemic where nucleic acid amplification tests (NAAT), such as RT-PCR assays are negative and there is a strong epidemiological link to COVID-19 infection. The serum samples may support diagnosis if validated serology tests are available. Serum samples can be stored for these purposes. The possible problem with serological tests may include the cross-reactivity of other coronaviruses. Commercial and non-commercial serological tests for SARS-CoV2 are currently under development.

The author is Scientist 'C' in Vigyan Prasar.
Email: sachin@vigyanprasar.gov.in

The science of COVID-19 tests

GAURAV JAIN

The novel coronavirus emerged in the central Chinese city of Wuhan last December and proliferated to almost the whole world within a couple of months. Contrary to popular perception, the term coronavirus actually refers to a category of viruses that cause respiratory infections including the common cold. SARS-CoV-2, the virus that has forced nearly the entire humanity to a grinding halt, belongs to the same family of viruses. Coronavirus Disease 2019 or COVID-19 is the disease that it causes. Viruses are submicroscopic entities lying on the borderline of what we define as living. Their existence was a mystery for years until scientists like Adolf Mayer, Dmitri Ivanovsky, Ernst Ruska, Max Knoll and Martinus Willem Beijerinck deciphered it.

Viruses are unique because they cannot replicate as independent entities. But as soon as a virus enters a living cell, it takes over its functioning and starts multiplying. Viruses are lighter and smaller than bacteria. We are lucky SARS-CoV-2 is not air-borne, or else, it would have been a serious threat to humankind.

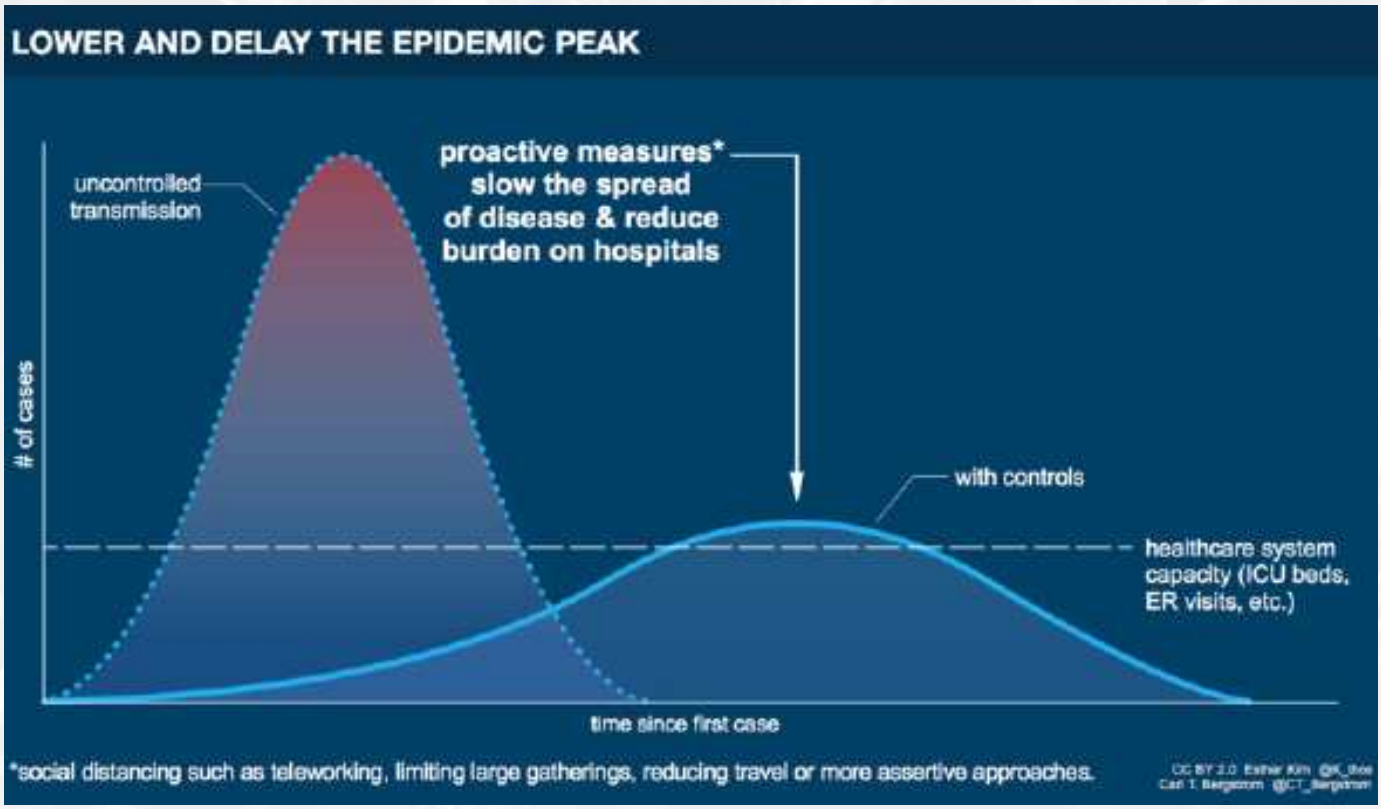
We are consistently adding to our knowledge about SARS-CoV-2, originally known as the novel coronavirus. We know it spreads through droplets expelled from the respiratory tract (the mouth and nose) while coughing, sneezing, and breathing of the infected individuals. This is the reason almost all nations have adopted social distancing and lockdown as preventive measures. After prevention comes the eradication of the outbreak. All countries, including India, are making serious efforts in this regard.

Tackling the outbreak

Normally, all infectious diseases have two stages: containment, meaning to limit the spread of infection and mitigation, which refers to the steps taken to reduce the severity of the disease. The process of containment should start as soon as the initial cases of infection are found. It involves health workers identifying all people who could potentially come into the contact of an infected person. Health workers counsel them and advise them to self-isolate. This can contain the spread of the virus.

The second stage comes when the outbreak becomes so widespread that the existing public health infrastructure is no longer capable to test and identify all the cases. The overwhelming of testing capabilities mean governments can neither estimate the actual number of sick people requiring urgent treatment nor can they count the casualties due to the disease.

The third stage sets in when there is the danger of the



(Image by Esther Kim & Carl T. Bergstrom | CC BY via Wikimedia Commons)

disease spreading beyond identifiable clusters of people to communities. At this juncture, the governments take steps like social distancing, restricting public gatherings, closing down of educational institutions and instructing companies to make their employees work from home. These measures slow down the spread of the infection and help "flatten the curve" of the disease. Flattening of the curve does not necessarily mean reduction in the total infected population, but still gives medical providers more time to mitigate and slow down the effects of the virus.

Scientific tests of SARS-CoV-2

Testing the SARS-CoV-2 virus involves a technique called the polymerase chain reaction (PCR). It is a method widely used in laboratories to amplify a small amount of DNA to a large enough quantity to study in detail. The PCR technique entails cycles of hot and cold temperatures to make lakhs of copies of very small amounts of DNA sequences. It uses fluorescent dyes (that are retained in the DNA cells) to detect the genetic material of the pathogens.

However, the coronaviruses carry single-stranded RNA instead of DNA as their genetic material. Double-stranded DNA is the genetic material of nearly all organisms on Earth. To detect a virus like the SARS-CoV-2, virologists first need to convert its genome to DNA. This is achieved through a laboratory technique called the reverse transcription (RT). Both the methods when employed together constitute the technique known as the reverse transcription-polymerase chain reaction (RT-PCR). At present, RT-PCR is the only way to ascertain a COVID-19 positive person. No other method is as precise to detect the virus.

Till the time we develop and approve other methodologies, all COVID-19 tests can only be conducted in laboratories by trained technicians. This is because only trained professionals can handle the equipment required for the RT-PCR tests. We cannot think of carrying out these tests at home or in simple clinics.

The RT-PCR test takes only one day if you have all the necessary reagents. Most of the delays in results are because of the paucity of testing kits and PCR machines.

The process of testing begins with the collection of the sample. Health workers use disinfected soft plastic sticks to take swabs from the patient's nose, mouth or throat that could potentially carry the virus. The stick is then sealed and sent to the designated laboratory in a cold container. It is necessary to keep the sample at 1.7-4.4°C. The sample is moved to a freezer or discarded if the test is not possible within four days.

Once a sample reaches for testing, laboratory technicians isolate RNA from other contents in the sample (like human cells, proteins and enzymes) that could contaminate the genome of the virus. This process is called RNA extraction. The extraction involves the mixing of the sample with various chemicals and then separation of RNA using centrifuges.

The pure and isolated RNA of the virus is then mixed with the enzyme reverse transcriptase which converts the RNA to DNA. This DNA is put to the test tube within the PCR machine with batches of nucleotides and strands of chemically made DNA.

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The majority of the PCR methods rely on thermal cycling, which exposes reactants to repeated cycles of heating and cooling to permit different temperature-dependent reactions —specifically, DNA melting and enzyme-driven DNA replication - to take place. As the PCR machine heats the tube, the double helix of DNA breaks into two separate strands. The DNA fragments —known as primers —become templates for the enzyme to form complementary sequences of DNA. As the process of PCR progresses, DNA becomes double-stranded. A single DNA sequence thus generated is exponentially amplified to an extent that makes it easy to detect the presence of any pathogen.

A fluorescent dye is mixed into the test tube containing the genetic material during the PCR process. DNA chains retain this dye and are labelled. The fluorescence of the labelled cells increases as the DNA material gets amplified. A special instrument within the PCR machine reads the dyed pattern of the DNA sequences to determine the presence of the viral material in the sample.

At present, only labs designated by the Indian Council of Medical Research (ICMR) are carrying out tests for COVID —19 cases. The Hyderabad-based CCMB and Delhi's IGIB labsboth affiliated to the Council of Scientific and Industrial Research (CSIR) — are trying to sequence the genome of the SARS-CoV-2 virus. The CSIR laboratories are also actively researching to make better diagnostic kits and sanitizers while trying to come up with drugs or a vaccine for COVID-19. Also, the Department of the Science and Technology (DST), Department of Biotechnology (DBT) and the Defense and Research Development Organisation (DRDO) is researching at different levels to save the humankind from this pandemic.

The author is a Junior Scientific Officer in Vigyan Prasar.
Email: gaurav@vigyanprasar.gov.in

Information sources for COVID-19

SAURAV SEN

Digital platforms during COVID-19 pandemic

Are you wondering what to do during the lockdown period as you stay confined to your home? Work from home may remain an option as many organisations and firms have adopted the practice to arrest productivity loss and encourage efficiency. And this convenience gives students, parents and all other professionals ample time to explore something beyond the call of duty. This is where digital platforms may provide you with options you won't mind embracing.

Worried that you and your near and dear will be infected with Novel coronavirus? Load AarogyaSetu Mobile App and be relaxed.

AarogyaSetu Mobile App

As we grapple with the fear of COVID-19 and exercise social distancing to contain its spread, the Ministry of Electronics and IT has come up with a unique mobile app which will help citizens identify their risk of contracting the novel coronavirus, as they go about their daily lives with minimum exposure in public spaces, mostly to procure essential commodities or for medical assistance of various kinds. Within a short span of time, the app has notched up more than 10 million downloads since its launch barely a week ago. The app utilises location-based services and Bluetooth technology to keep each registered user abreast of their potential risk levels, in case anyone has crossed paths with a high-risk person who has symptoms indicating COVID-19 contamination. Allaying the fears of hacking and surveillance, the Press Information Bureau (PIB) of the Government of India says that the app does not link user location and data with any sensitive personal data. Further the PIB tweeted that "It does not make users vulnerable to hacking". This app is available for both Android and iOS phones.

Are you fatigued with the predictability of Saas bahu serials and the cacophony of aggressive news channels? Here's a better choice — discover the universe in all its scientific hues and see how things work in our bodies, in laboratories, in technology outfits and in nature at large at the following OTT Portal!

The India Science Mobile App & India Science OTT Portal

If you are keen to watch the latest and the most credible videos featuring India's topmost scientists, the India Science TV app or the India Science OTT Portal (www.indiascience.in) is the place to go to. India Science is the country's national Science Channel on the internet and is available 24x7x365 on any internet-enabled device without any cost to consumers.

Viewers can watch videos of their choice on COVID-19 and keep themselves updated at all times.

This app is available for both Android and iOS phones.

Wondering how Indian science and technology is grappling with the COVID-19 pandemic, visit the ISTI Portal for latest updates and reliable information

The India Science, Technology and Innovation Portal

It is the most prolific repository of information from India's research and development ecosystem. Visit this portal (www.indiascienceandtechnology.gov.in) to get details about scientific organisations, research laboratories, and the scientists involved in the forefront of COVID-19-related research to bring up cost-effective masks, test kits and even breakthrough vaccines that can help India fight this pandemic.

Vet your Covid19 news before you believe it

If you are scared reading alarming news related to the COVID-19 pandemic, either on your WhatsApp messenger or on any websites, halt and check its accuracy at one of the most authentic information repositories on the latest developments in COVID-19-related research, driven by the premier Tata Institute of Fundamental Research (TIFR) at https://covid-gyan.in/ or http://indscicov.in/, which are verified and authentic information resources put together by a team of more than 400 scientists. If that's not enough, do follow the Twitter handles of the Press Information Bureau (PIB) (@pib_india) or the Ministry of Health and Family Welfare (@MoHFW_India).

Become a smart citizen, take up the MyGov Challenge

As Indians, as we stay indoors to protect ourselves and our fellow citizens from the COVID-19 pandemic, it is also our duty to contribute to the national mindshare in finding solutions to this deadly pandemic. MyGov.in has come up with a national challenge and solution-finding platform, which every Indian citizen can login very simply and contribute their innovative and logical thoughts. Who knows, your thought might be the light at the end of the tunnel?

Scared if that currency note is contaminated with COVID-19 virus? Go digital! Pay through UPI

If social distancing has left only essentials like milk and groceries for you to buy, ideally a couple of times a week, make sure you wash your hands of currency notes and coins for the time being. We now live in an India where digital payments like UPI (United Payments Interface) is widely accepted even by roadside vendors and large stores alike. In case you have been a hesitant convert to the digital world, install the Bharat Pay app today and configure your bank accounts with it, so that all your financial transactions do not require you to touch any cash and keep you safe in this period of lockdown.

Learn new skills, get knowledge sitting at home

If you have some spare time at home and are wondering what to learn and how, here is a dream option. It is now possible for anyone to do an online certification course from the National Programme on Technology Enhanced Learning (NPTEL) which provides a certificate from the IITs. NPTEL was initiated by seven IITs (Bombay, Delhi, Kanpur, Kharagpur, Madras, Guwahati and Roorkee) along with the Indian Institute of Science, Bengaluru in 2003. If you ever regretted not getting into an IIT for a degree, here is your opportunity to get a taste of it without leaving your home. Find out more at https://nptel.ac.in/

If IITs are not your cup of tea, there's more. Check out the government's Swayam programme which gives you the opportunity to study in online interactive classrooms, learn the most technical of subjects and get a prestigious certification from a host of premier Indian institutions, without spending any big money. Find out more at https://swayam.gov.in/

If you wish to enhance your resume with some specific skill-related certification that also carries the stamp of credibility, visit https://www.vskills.in/certification/, which offers just what you are looking for. Vskill certificates are given by a Government Body (ICSIL), which is a joint venture of Govt of NCT Delhi (DSIIDC) and Govt of India (TCIL).

Talking of learning, why not learn more about disasters in times like these? It might make you better equipped not just to understand and share your knowledge, but also to participate in disaster mitigation activities and help the nation. The National Institute of Disaster Management (NIDM) under the Ministry of Home, offers a slew of e-learning courses in partnership with the World Bank (GFDRR), Washington. Find out more at https://nidm.gov.in/online.asp.

The author is Senior Consultant, Media; India Science / DD Science in Vigyan Prasar. **Email:** saurav@vigyanprasar.gov.in

Vaccine and novel coronavirus

JYOTI SINGH

As COVID-19 pandemic continues to wreak havoc, scientists around the world are pulling up their socks to find vaccine for the novel coronavirus (SARS-CoV-2). Though the idea is easy, its execution is difficult. Why is making vaccine such a tedious job? Why can a single vaccine not work on all types of viruses or bacteria? What are the challenges in making vaccine? To start with we first have to understand how a vaccine works.

What is a vaccine and how does it work?

Vaccine is like a trainer who makes the immune system identify, target and neutralise an invading pathogen. It is like firefighters undergoing simulation training, before they are on the job to undertake rescue missions. The immune system can be thought of as an elaborate security system that ensures the safety of our body. We are under constant attack by the viruses and bacteria struggling to get a foothold in our cells and infect our body. Antibodies are like guard dogs prowling along the perimeter watchful of intruders. When a disease-causing germ is detected in the neighbourhood, like the dog barks at an unfamiliar visitor, the antibodies sound the alarm bells. The guards, white blood cells, wake up, charge at the intruders, neutralise them and save the body from damage.

A dog trained to detect explosives may not be adept at tracking the scent of house burglar. Likewise, the antibodies that can detect one pathogen, say measles, would be useless for say, flu. Just as the police may train a dog squad to sniff narcotics, in anticipation and be prepared to nip the crime in the bud, we can train our immune system to identify a deadly pathogen even before we are infected by it. This in short is vaccination.

If we desire to develop a vaccine for the novel coronavirus, then we need to make our immune system familiar with the deadly intruder even before it gets a chance to break in. Our immune system, aware of the ways of criminal, can take appropriate and timely steps before heavy damage is done. If our immune system dithers in identifying the unfamiliar intruder and is slow to respond, the damage caused by the virus may even cost life. At the instant of infection, if the right types of antibodies can be secreted, without any time delay, the pathogen has no chance.

Just as a sniff of any piece of clothing, even a handkerchief, is enough for the dog to trace and track the house breaker, weakened, but live viruses, dead pathogens, a protein or a part of the microorganism is enough to train our immune system. In online fraud, it may be difficult to catch the swindler, but easy to plug in holes in the digital security. Likewise, in some cases the vaccine may target a toxin secreted by the bug rather than the microbe itself. Once a strain or a part of the microbe is introduced into the body, in the form of vaccination, our immune system produces a matching antibody. These antibodies remain in our system for a long time; at times they may persist for the whole life.

Challenges

Is immunity to the new coronavirus possible? Most researchers assume that people who are already exposed to SARS-CoV-2 will develop lifelong immunity against the virus. But it is quite early to come to such a conclusion, as the virus behaviour is still not known completely. A team of researchers in China experimented by trying to re-infect two monkeys that have recovered from a previous novel coronavirus infection. They exposed these monkeys to the virus once again, but they did not contract the infection. This gives a ray of hope that it may work in the same way in human beings.

There is another big unknown. If a person develops immunity against the virus, how long is it going to last. Researchers have studied the other two infections caused by cousins of the novel coronavirus—Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS)—and found that after 15 years of infection SARS antibodies were still present in people who were exposed to it. But it is unknown whether this immune response is sufficient to prevent the re-infection.

What if the infiltrator comes in disguise?

Germs like viruses and bacteria contain genetic information tucked in a tiny DNA or RNA.

The genetic material of novel coronavirus is RNA (Ribonucleic Acid). This genetic material has a genome that contains all of the information needed to build and maintain that microbe. These genomes are in a sequence, like alphabets arranged to make a word. If the sequence changes or one alphabet is replaced with another, the word become either meaningless or acquires a new meaning. That is, with the change in the nucleotides sequence, the gene expression changes or alters. Called mutations this is analogous to a thief who keeps changing his appearance. At times, a pickpocket may reform and become a tame person or may become a hardened criminal. Likewise, due to the mutations, newer and newer strains of the microbe evolve.

Mutations pose a challenge for vaccine development. Take the case of flu virus, called human influenza virus. Its book of life, that is RNA consists of 14,000 nucleotides. Researchers say the rate of mutation in this virus is anywhere from 1.8 × 10-3 to 2.2 × 10-3 nucleotide substitutions/site/year. This means, on the average 28 letters in the 14,000-alphabet essay changes every year! Of course, some of the changes might be meaningless, change the 'm' in make to 't'; what you get is 'take', it is meaningful. This mutation will survive and become a new strain. However, if the 'm' is copied wrongly as 'y', the word you get is 'yake', a meaningless word. This will be weeded out.

Because of the fast-changing nature of the influenza virus, a study says that we may get as many as 200 flu infections in our lifetime.

Measles virus (MeV) also mutate and evolves. However, a mutation in the surface proteins that the measles virus uses to enter cells are ineffective if they suffer even a slightest change. The human antibody targets the surface protein that measles virus uses to gain entry into our cells. Hence two shots of the vaccine, administered in childhood, give lifelong protection.

Genome sequencing

What kind of animal is SARS-CoV-2 virus? Does it evolve very fast, is there a part of its genome that is more robust, less prone to mutations? Within weeks of the outbreak, on 25 February 2020, the Chinese researchers sequenced the genome of the novel coronavirus and released it to the global repository. Since then, world over scientists are sequencing the virus in their countries.

So far, 3,086 sequences of the virus isolated from humans have been shared by 57 countries. With 621, the U.S. has shared the maximum number of sequences, followed by the U.K. (350), Belgium (253) and China (242). India has also started to study the genome sequence of the virus. Centre for Cellular and Molecular Biology (CCMB) and Institute of Genomics and Integrative Biology (IGIB), two research labs under the Council of Scientific and Industrial Research's (CSIR) have joined their hands to sequence samples from India. India has deposited sequence of seven strains circulating in the country. Why are more and more samples being sequenced? Like any other microbe, the novel coronavirus also mutates and new strains evolve. "This will help us to know how it is evolving and what is the relativeness of that. If you have to tag each isolate then we have to do as many sequencings as possible, to get a big and clear picture", said Dr Rakesh Mishra, Director, CCMB.

Like the measles virus, the SARS-CoV-2 virus also has a preferred mechanism for gaining entry into the cell. It uses its spike proteins. It is important to know the stability of the spike protein if it is to be used as a vaccine target. Is the part of the genome that codes for the spike protein stable? Which other part of the genome shows very little change? Where is the sequence rapidly changing? For developing a viable and long-lasting vaccine, finding the stable part of the genome helps. This implies you need a repository of genome sequences from around the world to monitor the mutations taking place.

Quest for a vaccine

Enthused by research findings, a race is on for development of a vaccine, with a hope that the spike protein of the SARS-CoV-2 virus is stable. The basic idea is to introduce the spike protein into the cells using another harmless virus. The harmless virus may cause a mild illness, like fever. The immune system will respond both to the harmless viral vehicle and the SARS-CoV-2 spike protein and release the antibodies. The spike protein is displayed under the lookout list. If the person contracts the SARS-CoV-2 virus, the immune system swiftly responds by releasing a torrent of antibodies that recognise the spike protein. The viruses are decimated by the white blood cells. Two vaccine candidates, one in the U.S. and another in China are under the phase 1 clinical trials. Questions remain whether recognition of the spike protein would be enough to produce T cells that would kill the germs.

One of the main safety concerns in human trial is to avoid a phenomenon called disease enhancement, when despite vaccination, the person is infected and develops a more severe form of the disease than people who have never been vaccinated. This is like a killer enters along with a known petty thief. The immune police spend all the time in chasing the petty thief, leaving the killer scot-free.

If one challenge is to develop the spike protein, the other is to find a suitable, effective but harmless transport virus to take the spire protein to the cells and trigger the immune response. How about repurposing an existing vaccine viral platform initially developed to deliver a Middle East Respiratory Syndrome (MERS) coronavirus protein into cells to generate an immune response?

"Our new study indicates that parainfluenza virus 5 (PIV5) may be a useful vaccine platform for emerging coronavirus diseases, including the COVID-19 pandemic", says Paul McCray, Professor, University of Iowa, USA. He said by using the same strategy, vaccine candidates based on PIV5 expressing the spike protein of SARS-CoV-2 have been generated. "We are planning more studies in animals to test the ability of PIV5-based vaccines in preventing disease caused by SARS-CoV-2", said Prof. McCray.

In India, Hyderabad-based biotechnology company Bharat Biotech International has also announced that it has a potential intranasal vaccine called 'CoroFlu' for the novel coronavirus. Human trials for this vaccine candidate may begin later this year. Bharat Biotech is undertaking this task in collaboration with virologists from the University of Wisconsin-Madison in the U.S. and a Wisconsin-based vaccine company FluGen Inc. In this vaccine the M2SR, a harmless influenza virus, will be the delivery platform. The genes from the SARS-CoV-2 would be inserted into the M2SR. Once inside, the antibodies would be produced for M2SR as well as some of the SARS-CoV-2 proteins.

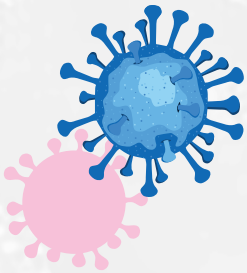
If much of the effort is to transport one or other protein using a harmless viral platform, the Serum Institute, a Pune-based vaccine firm has announced development of a live-attenuated vaccine jointly with U.S.-based biotech drug research company Codagenix. The vaccine is expected to be ready for use by the second half of 2022.

There are little more than 42 candidate vaccines that are being explored around the world. Some are in developmental stage, a few undergone animal trials. It will take at least 18 months before the human trials are completed and a viable vaccine hit the market. Until then, staying home, washing hands and practising physical distance are our only weapon against the malicious novel coronavirus.

The author is Social Media Manager, India Science Wire, Vigyan Prasar. **Email:** jyoti.singh@vigyanprasar.gov.in

CORONA bound to go

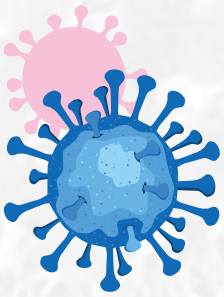
Divyaspandan Misra



As nation calls for aid to us
Be not scared and let's discuss
Let's unite and stand up tall
But not in trains and not in the mall.

We must stay as much indoors,
Live, laugh, learn and do the chores.
Waste no water and save the light,
Stand by those who wage this fight

Innocent victims, for them we pray,
Wash your hands and say Namaste.
Corona is then bound to go
World as one we live to grow.



The author is a first-year engineering student.
Email: coolspandy.07@gmail.com

LAMP OF SCIENCE

Maan Bardhan Kanth

To see the lamp of science getting lighted,
This is our hope and intend.
This scientific flame should not extinguish,
This desire is more important than life.

Corona has come with its wrath,
Humanity is in huge crisis.
Unimaginable tough times have come,
Whole of earth is under its wrath.
See how this outrage has come,
That whole world is under a fear.
This scientific flame should not extinguish,
This desire is more important than life.

Since this pandemic has become terrible,
The calamities have become inevitable.
If we truly want to fight against corona,
Then let's stay at home.
Technology will find some ways,
This is what the new thought says.
This scientific flame should not extinguish,
This desire is more important than life.

When common sense becomes sharp,
Darkness is eliminated soon.
If the soul is serene,
Then body becomes pure.
The supernatural sky and earth,
Gives us the support to survive.
This scientific flame should not extinguish,
This desire is more important than life.

Our motherland India is beautiful,
All the resources here are too holy.
Life is priceless here,
Every moment is divine too.
Here every mind would think scientifically,
This is our loveable hope.
This scientific flame should not extinguish,
This desire is more import than life.

The author is associated with DD Science in Vigyan Prasar.
Email: maanbardhan@gmail.com

CORONA – A COMBAT

Chavi

Our rival is imperceptible and leaves behind none
This battle is tough, but the war shall be won.

It will lure us to come out of our lines,
But the battlefield is our home, and
from here we shall outshine.
Our foe is mighty but I believe we will outrun,
Our battle is tough, but the war shall be won.

Soap is our weapon, sanitizer the firearm,
If we just follow the guidelines, the
virus can do us no harm.
It is afraid of soap; we'll wash and make it run,
Our battle is tough, but the war shall be won.

We must protect ourselves from
the cycle of false rumours,
Because it's true what they say, knowledge is power,
To be a vigilant citizen, follow the leaders
and fulfill our responsibility,
Protecting the most vulnerable and those on
the front has also become a necessity.
We have to show unity for the disease to be gone,
Our battle is tough, but the war shall be won.

Hats off to those heroes who stand on the frontiers,
In these trying times when the future
of the nation is still unclear
The opponent knows no discrimination,
so everyone beware.
The fight of caste and religion will
sink all efforts of our warfare.
We need to join forces to combat the rival,
Remember it ain't a mere tussle, it's a fight for survival.
Our enemy is so imposing and leaves behind none,
Our battle is tough, but the war shall be won.

The author is Project Associate in Vigyan Prasar.
Email: chavi@vigyanprasar.gov.in

Research on spread of Coronavirus
Due to the lockdown we have not received the printed copies of the April issue of Dream 2047, but thanks for uploading the PDF on time. Along with the articles we liked the small write-up on spreading of coronavirus through mobile phones. We would like to know more about the pandemic in your next issues.

Sweta Diwedi, *Indore*

Dream Editorial Team
More researches are being carried out on spread of the virus through different surfaces and closed space where air-conditioning systems are circulating the air. In Vigyan Prasar we are bringing out a weekly compilation to keep everyone updated about India's S&T Efforts on COVID-19. You may find it at: https://vigyanprasar.gov.in/covid19-newsletters/

Soap vs. sanitizers
Everywhere we are reading that we should use either soap or alcohol-based sanitizers to wash our hands. We would like to know which one is better as there is a shortage of sanitizers in our local shops.

Pritam, *Lucknow*

Dream Editorial Team
It is believed that both are equally effective in cleaning hands and destroying the pathogens. In our next issue you would find an article on the science of soap and how it kills pathogens.

Safe travel at the time of Corona
We would expect an article on following safety measure and social distancing norms in order to avoid getting exposed to the virus once the lockdown is lifted and we start communing in public transports like bus, autorickshaws and Metro.

Abida Khatun, *Hyderabad*

REQUEST TO THE AUTHOR

Science writers, scientists, science communicators, doctors, journalists, teachers and researchers interested in popular science writing are requested to send their articles for publication in Dream 2047 in 1500 to 2000 words in English or Hindi language. Also, send high resolution images relevant to the article that can be published. Your articles can be based on the latest research in the field of science and technology, history of science, health and medicine, agriculture, energy, water, interviews with eminent scientists and working of science laboratories. Suggestions, feedback and letters from authors and readers are welcome.

You can contact us by **email:** dream@vigyanprasar.gov.in

COVID-19 Affecting All UN Sustainable Development Goals

Source: UNDESA