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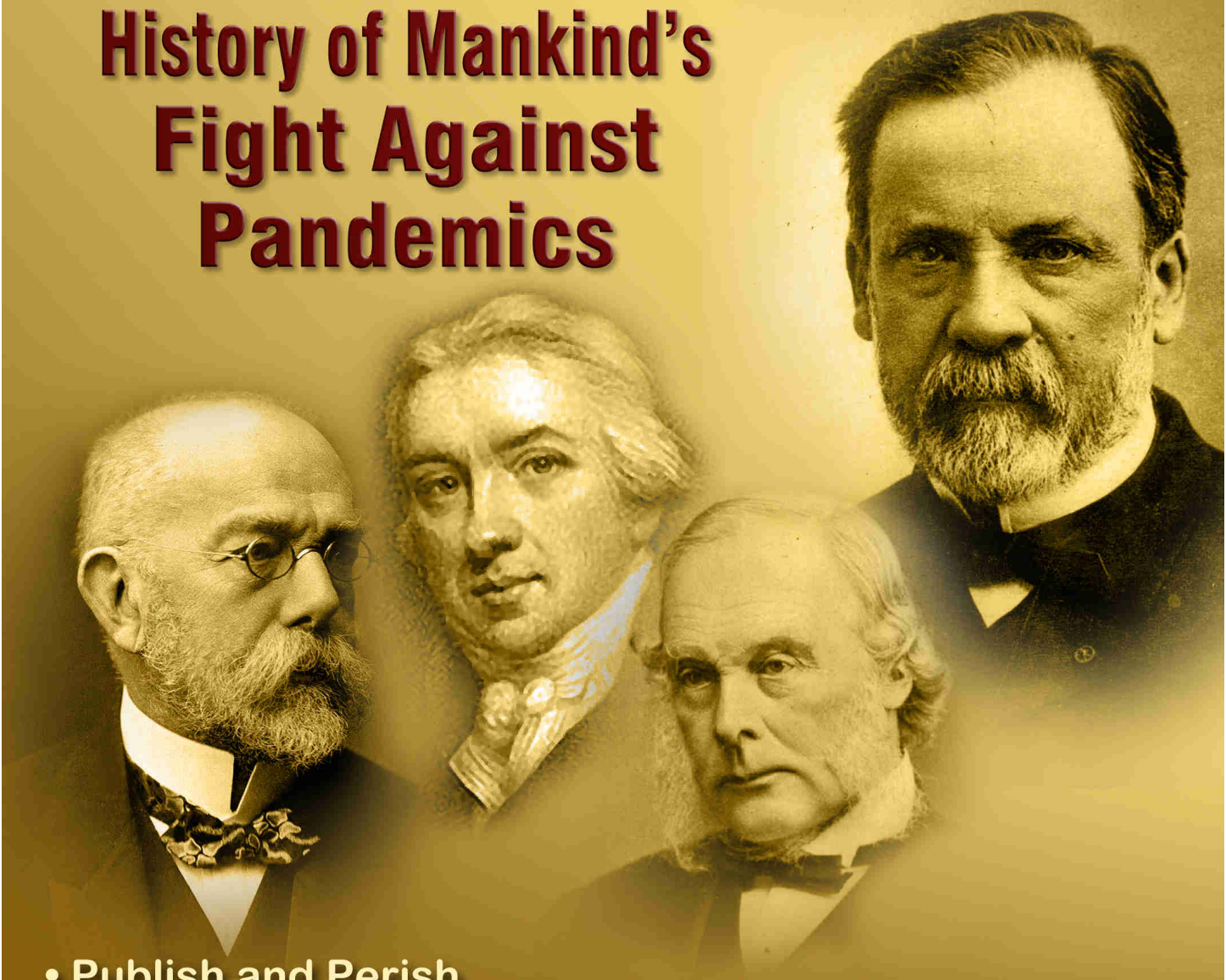
History of Mankind's Fight Against Pandemics



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B R E A K T H R O U G H

A Journal on Science & Society

A Quarterly Committed to the Cause of Science, Culture, and Scientific Outlook

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- Popular articles on science and technology, scientific features, science education, and reports on new discoveries are invited. Articles on philosophical issues in science and those on social implications are particularly encouraged.
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The hype of "Indian Knowledge Systems" – A backward-looking agenda for education

Editorial

The New Education Policy proposes to introduce "Indian Knowledge Systems (IKS)" in various stages of the school and college curricula. In Article 4.27 it says that "Knowledge of India" will include knowledge from ancient India and its contributions to modern India and its successes and challenges. Indian Knowledge Systems, including tribal knowledge and indigenous and traditional ways of learning, will be covered and included in mathematics, astronomy, philosophy, yoga, architecture, medicine, agriculture, engineering, etc. In other words, Indian Knowledge System (IKS) will now infiltrate the whole education system.

We need to note that in every society there were traditional ways of learning, which stressed on prevalent traditions and belief systems. For example, medieval Europe had a knowledge system where education was Church-centric, and propagated beliefs in creationism, Aristotelian and Ptolemaic views of a geocentric universe, etc. In India, the *gurukul* system was in place, where many students learnt from a single teacher, who taught them his understanding of the traditions, values, belief systems and knowledge of that time. This mode of education changed radically following the Renaissance, when it was recognized that personal beliefs and ideas should have no place in education, that we should teach modern scientific ideas that have been tested and universally accepted as truth. In the humanities, it was recognized that ideas of ethics and morality also evolve with time, and we should impart to the younger generation the modern values that will make them useful contributors to a modern society. True, traditional and tribal knowledge are often based on empirical observations and may be useful. But these have to be tested with modern methods before acceptance. Moreover, such traditional knowledge often comes with the baggage of ancient beliefs, and an uncritical acceptance of everything ancient only weakens the faculty of critical thinking.

The NEP makes it explicit that, by IKS, the policy-makers actually mean the knowledge available through the medium of Sanskrit. That is why, in article 22.15 the NEP says that Sanskrit will be mainstreamed with strong offerings in school as well as in higher education. It will be connected to other contemporary and relevant subjects such as mathematics, astronomy, philosophy, linguistics, dramatics, yoga, etc. There will be 'Sanskrit Universities', which will be large multidisciplinary institutions of higher learning. Sanskrit Knowledge Systems will be established/strengthened across the new multidisciplinary higher education system. To train an adequate number of teachers, 4-year integrated multidisciplinary B Ed. Dual degrees in education and Sanskrit will be initiated.

The proposal, then, is to introduce ancient knowledge in the modern education system. It is true that there were many

developments in mathematics and astronomy in ancient India (see our publication Science in Ancient India – Reality versus Myth). But this knowledge has become integrated into the modern knowledge system, which has developed much further in the past three centuries. If now these ancient ideas are taught in today's mathematics classes, students will spend most of their time digesting what the ancients knew a millennium and a half back and not be able to come to grips with modern mathematics. The same is true for astronomy, which has been radically transformed since the invention of telescope and the development of Newtonian mechanics.

But what constitutes the Indian Knowledge Systems (IKS)? A conference on this topic took place at IIT Kharagpur from 6 to 8 November 2020, where the Minister of Education, Mr Ramesh Pokhriyal, announced from the floor of the conference that a Centre of Excellence for Indian Knowledge Systems will be created at IIT Kharagpur. What will the subject of research at this Centre of Excellence? The Director of IIT Kharagpur stated in the inaugural programme that one of the quests will be to find out if the mention of 'Pushpak Vimana' in Mahabharata is really a story, or "if there is any science behind it"! He mentioned that the first eight lines of Bhrigu Samhita contains the whole of modern science and technology including agriculture, electrical science, engines, transportation science, materials science, etc., which the younger generation is missing. He welcomed the thrust in the NEP to bring such ancient science into the education system!

It is disconcerting to hear this from an academic, but our political leaders have been very explicit in expressing what they mean by IKS. Former Uttarakhand Chief Minister and the present Union Minister of Education, Mr Ramesh Pokhriyal 'Nishank' claimed in a public meeting that modern science was a pygmy when compared to astrology developed in ancient India. Satyapal Singh, the former Minister of State for the Human Resource Development, declared that Darwin's theory was wrong, because nobody has ever seen a monkey transforming into a man. The Tripura Chief Minster, Mr Biplab Deb, has claimed that there was television and internet during the time of Mahabharata, because how else could Sanjaya give a running commentary of the Kurukshetra war to Dhritarashtra? The Prime Minister Narendra Modi himself had claimed, while inaugurating the H N Reliance Foundation Hospital in Mumbai on 28 October, 2014, that Lord Ganesha was proof of the fact that the ancient rishis practised plastic surgery at such a level that they could implant the head of an elephant on the torso of a man; that the birth of Karna is a testimony to the fact that the ancient sages had knowledge of test-tube baby technique, and the Kauravas of cloning technology!

To top it all, a 2021 calendar has been brought out by the Nehru Museum of Science and Technology, IIT Kharagpur, which is being widely publicized through social media, in an attempt at a romanticised glorification of ancient India using false claims. These are the glimpses of what will be included in the curriculum in the name of 'Indian Knowledge Systems'.

Such a deliberate design at adulteration of science education with such myths in the name of glorifying the past with false claims will not only discredit the actual achievements that were made in different branches of knowledge in those times, but have dire consequences on the development of scientific temper and critical thought among students in their most impressionable years. All rational minded people need to come together to resist this design. □

The Lawsuit against Sci-Hub and LibGen

Breakthrough Science Society's initiative to counter commoditization of knowledge

On December 21, 2020, three academic publishers Elsevier, Wiley, and the American Chemical Society, filed a lawsuit seeking a ban on two websites Sci-Hub and LibGen which work towards making research papers and other scientific information freely available. *Breakthrough Science Society* immediately sprang into action and on 25 December launched a petition against the demand of these monopolistic publishers. The petition received enthusiastic support of the scientific community as more than 14,000 signatories supported the contention of the statement. Till 10 January, the signatories included 1187 active scientists (faculty members in research institutes), 140 superannuated scientists, 636 teachers and educators, 368 scientific staff working in research Institutes, 159 science communicators, 362 postdoctoral fellows, 6088 students at the bachelors' and master's levels, and 3959 PhD students. In the next stage, an online Convention was organized on 9 January 2021 with the theme 'Make Knowledge Free, Not Private Property'.

We give below the text of the petition, and a report of the Convention.

Text of the petition

Make knowledge accessible to all. No to banning Sci-Hub and LibGen

We are shocked to learn that three academic publishers – Elsevier, Wiley, and the American Chemical Society (ACS) – have filed a suit in the Delhi High Court on December 21, 2020, seeking a ban on the websites Sci-Hub and LibGen which have made academic research-related information freely available to all. Academic research cannot flourish without a free flow of information between those who produce it and those who seek it, and we strongly oppose the contention of the lawsuit.

International publishers like Elsevier have created a business model where they treat knowledge created by academic research funded by taxpayers' money as their private property. Those who produce this knowledge – the authors and reviewers of research papers – are not paid and yet these publishers make windfall profit of billions of dollars by selling subscriptions to libraries worldwide at exorbitantly inflated rates which most institutional libraries in India, and even developed countries, cannot afford. Without a subscription, a researcher has to pay between $30 and $50 to download each paper, which most individual Indian researchers cannot afford. Instead of facilitating the flow of research information, these companies are throttling it.

Alexandra Elbakyan of Kazakhstan has taken an effective and widely welcomed step by making research papers, book chapters and similar research-related information freely available through her website Sci-Hub. Libgen (Library Genesis) renders a similar service. We support their initia-

tive which, we contend, does not violate any norm of ethics or intellectual property rights as the research papers are actually intellectual products of the authors and the institutions.

We strongly oppose any form of commoditization of research information which is a hindrance to the development of science and the humanities. In the interest of the advancement of knowledge, Sci-Hub and Libgen should be allowed to operate in India.

A screen-shot of the online Convention

All India Convention on 'Make Knowledge Free, Not Private Property'

The online All India Convention titled 'Make Knowledge Free, Not Private Property' was held on 9 January 2021, from 4 pm to 5.30 pm. The convention began with a presidential address by Prof Dhrubajyoti Mukhopadhyay, President, Breakthrough Science Society. Explaining the reason for holding the convention, he said that the convention would address the key concerns centering round the debate going on between legality and ethicality of limiting access to knowledge in the context of the recent lawsuit filed in the Delhi High Court. Following the presidential address, a resolution was read out by Dr Uma Ramachandran, member, All India Executive Committee, Breakthrough Science Society.

The speakers were Prof. P Balaram, former Director, IISc Bangalore, Prof. S C Lakhotia, INSA Senior Scientist, Benaras Hindu University and Prof. Soumitro Banerjee, General Secretary, Breakthrough Science Society, and Professor, IISER Kolkata.

Prof Balaram in his address pointed out that the present court case has presented an opportunity for the scientific community to introspect. He cited three important factors responsible for the sorry state of science publishing – greed, vanity and decline of scholarship. The commercial interest of the private publishers has been fueled by the vanity of the scientists who try to publish in the so-called high impact factor journals with an eye to earning laurels. He suggested that the open system where pre-publication papers are submitted to institutional repositories is a possible solution. The research institutes and academic societies should put in efforts in improving these repositories.

Prof Lakotia observed that presently research institutes are spending huge sums on subscriptions and author-payments for open access journals. He felt that the 'one nation one subscription' model may address the issue. He also felt that the prevailing publication mode needs to be changed. Open access publication in a 'not-for-profit' mode is a possible alternative. He felt that the science academies and institutes should work towards creating pre-print repositories. He also strongly felt that the copyright law that gives undue advantage to the publisher rather than the author who creates the knowledge needs to be amended.

Prof Soumitro Banerjee said that commoditization of science is the major issue facing science in recent times. Science cannot progress without free exchange of

ideas and access to knowledge by all. The oligopoly of a few publishers is now having a complete control over the dissemination of scientific ideas. The scientific community must take the necessary measures to break free of the stranglehold. He said, there is a difference between what is legal and what is ethical. What SciHub and LibGen are doing is not unethical, because it is meant to provide unfettered access to science to all. He suggested that we should think of a free and open publishing model controlled by the scientific community and not by commercial publishers. While concluding his talk Prof. Soumitro Banerjee stressed that unless science is pursued as a passion and not as a career, we cannot begin to solve the crisis we are facing.

The presentations were followed by a very lively question and answer session. Due to shortage of time all the questions could not be taken up.

At the close of the convention, the resolution presented at the start, to which no objection was raised, was accepted by the house.

Resolution demanding continuation of the services of Sci-Hub and LibGen in India

The pursuit of scientific research involves, on the one hand, finding out what is already known to science and, on the other, making one's own contribution to the furtherance of scientific knowledge and sharing it with others. Scientific journals/publications play a major role in facilitating both these processes.

At present there are two publication models. In the first, the researcher submits the manuscript to a research journal brought out by a publisher like Elsevier, Wiley, ACS, Springer, or World Scientific. The Editorial Board of the journal, comprising scientists of repute, arrange for the peer review of the submitted paper. If it passes the test, it is published by the journal. Neither the authors, nor the reviewers are paid by the publisher. Yet, institutional libraries have to pay very large sums of money as subscriptions to these journals, which most universities are finding increasingly difficult to afford. In the second model, called open access', in which anyone has free access to read any work, authors have to pay large sums of money to the publisher to get their papers published.

In both cases, the money necessary for the entire exercise comes from taxpayers. Research is conducted using taxpayers' money, the government has to support the institutional libraries to subscribe to the journals, and if a researcher wants to publish in an open-access journal, that money also has to come from institutional grants. Thus, in the system in place, a few monopolistic publishers get rich at the expense of the Indian taxpayers. Since most institutional libraries cannot afford the high subscription rates of these monopolistic publishers, a majority of researchers in India are deprived of access to the frontiers of knowledge.

In this situation, the websites like Sci-Hub and LibGen have been rendering great service by making research papers and related information freely available. This Convention requests the Union Government to allow continuation of the availability of SciHub and LibGen in India because (a) these websites are not using the research papers for any commercial purpose, (b) downloading articles for personal use or for research is permitted by the section 52 of the Indian copyright act, and (c) if these websites become inaccessible to researchers, Indian science will be plunged into a deep crisis. □

Publish and Perish

Dr. Sajan Naduvannur

After his much talked about trip to the Galapagos island, Charles Darwin, then twenty-seven years old, at the beginning of a brilliant career, just sat down to 'ponder over' the specimen he had collected. He took another twenty-three years to finally write up and publish his observations, hypotheses, and his magnum opus, the theory of biological evolution. That too after coming to know about Alfred Russel Wallace, another young naturalist who had almost scooped him.

If Darwin were doing this today, his book would not have been counted. He has to start publishing as soon as he begins his voyage and make sure that they get cited by his peers. And his opponents would have figured out that the best strategy was to ignore him. There would not have been any heated debate or discussions. He would be living in a world where scientific discoveries are merely a means of career advancement, and theories stay far away from the public discourse.

Twenty years of meditation over one experiment is too much of time in today's world. Indeed, such a delay would be equivalent to career suicide in the present academic climate. The current mantra is 'publish' - by hook or crook or black magic- 'or perish.' A research scientist is now judged by his peers, employers, funding agencies, and policymakers from the list of publications. Science was once considered a way of knowing the truth about the material world by carefully observing, forming various hypotheses, testing them by means of experiments, and theorizing. Once they had their "Aha" moment, they could proudly write to colleagues and friends elsewhere. They discussed their findings with friends, peers, and the wider public, through letters, talks, and finally write-ups in journals published by scholarly societies, such as the Royal Society in Britain. That era is now considered is too 'romantic.' It is, like everything that was good is dead and gone forever.

The vulgar obsession in our era is to reduce everything to a comparable metric. For research, it is the number of papers and the citation index. Young scientists and apprentices are now encouraged to break their research strategy into 'publons': a little amount of research that will lead to a publication with minimal effort. Publications have gone through an identity crisis. From an idea that has to be read and discussed, it has reduced to a mere index, stripped off all its intellectual pretensions. A mere number, just like a man in a prison yard. Its ideas, arguments, aspirations, and frustrations have all been robbed away, and what is left with is this number, a metric that ostensibly says how important it is or is not. A number that people can flaunt, employers can count and compare, and funding agencies can use ('you are index xx, sorry, that is below our threshold.').

Has this helped science? In a recent essay to the PNAS titled 'Science in the era of selfies' [1], applied mathematicians Donald Geman and Stuart Geman quotes: "Albert Einstein remarked that 'an academic ca-

reer, in which a person is forced to produce scientific writings in great amounts, creates a danger of intellectual superficiality'; the physicist Peter Higgs felt that he could not replicate his discovery of 1964 in today's academic climate; and the neurophysiologist David Hubel observed that the climate that nurtured his remarkable 25-year collaboration with Torsten Wiesel, which began in the late 1950s and revealed the basic properties of the visual cortex, had all but disappeared by the early 1980s, replaced by intense competition for grants and pressure to publish"

But it has certainly helped publishers. Once academic publication was considered the sacred duty of scholarly societies. Now, this is hijacked by private publishers, who make money by selling these articles. The irony is that publishers add zero value to the article. Research is often funded by the public. The articles are carefully drafted, edited, formatted, and typeset by the researchers themselves. It is then reviewed by the members of the research community free of cost. Then the publisher steps in, hosts the finished article in his webpage, or prints them, and sells it to the very same research community at an enormous price. Their subscription charges are so high that libraries now spend more than ninety percent of their funds on journal subscriptions. And even well-funded universities have found this a strain on their resources [2]. The situation has become so absurd that researchers have to resort to illegal means to access publications by their fellow researchers. Sci-hub, a free service that enables researchers to access research papers has been recently challenged by big publishing houses in Delhi high-court, and the Breakthrough Science Society had initiated a massive signature campaign against the move[3]. The publisher, in collusion with the scientist who is under pressure to publish, has developed a murky business model at the expense of taxpayers' money. In that process, the academic publication has become, from a sacred obligation to inform the community to the biggest scam of the modern academic world ([4-8]).

The real casualty here is science itself. Like the proverbial fox who tries to measure the depth of the ocean by his tail, the policymakers have dragged research into the shallow end where it can be measured with their indices. There are some who think that this has made researchers accountable. At least it keeps them busy, as attested by over 25 lakh research papers published every year. Imagine the trash and cacophony in a world where writers are judged by the number of stories they produce, musicians by the number of music they compose, and painters by the number of paintings. Science, as in the arts, can flourish only in an environment that encourages new ideas, nurture scholarship, and value dissent. Outstanding research was done in the past when men of passion followed up their dreams in a conducive social environment. In India, we produced eminent men of science during our freedom movement. It is in those initial days of frugal resources that we built our best universities as well.

Darwin thought his book to be a long argument. He carefully weighed his evidence and arranged them in order to challenge existing ideas and establish a new one. It was widely read, discussed, debated, and criticized. That's what ideas are meant for. The papers can be right or wrong, both ways they contribute to our understanding of the world. In the current deluge, most would fall into the inconsequential 'not even wrong' category, as the Physicist, Wolfgang Pauli would call it. In the end, the paper is not meant to be just counted and indexed, but to be read and assimilated to the

treasure trove of human knowledge.

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The History of Mankind's Fight Against Pandemics:

Pioneers of Modern Medicine

P S Babu*

The practice of giving vaccine 'shots' to infants at prescribed time intervals to prevent diseases that may affect them has almost become household knowledge to most people today. In fact, the near total vaccination of infants and children has almost wiped out the once dreaded diseases of infancy and early childhood like diphtheria, whooping cough, polio. This shows that, the method of vaccination has gone a long way in preventing diseases. Safe drinking water, sanitary disposal of human and household waste, hygienic handling of food, general cleanliness and hygiene in the house and at work places have become common sense to a large section of our population. Even when diseases do occur, doctors can help the patients recover more often than not. In our country these achievements of modern medicine are taken for granted by the city dweller and looked at with envy by rural folk, who do not have the necessary access to scientific health care.

These methods that modern medicine employs against contagious diseases have become very common all over the world. But hardly 200 years before these were nonexistent. It is the story of the keenest minds thinking and fighting against seemingly insurmountable obstacles and achieving victory bit by bit, over the centuries. These are important victories that science has won in the fight against diseases. But we see that the victories have been carried forward but the authors and their initial struggles to understand the human body and its afflictions, have been forgotten, or rather overlooked. Medicine is an ancient art and science. In the 16th century Italy, alongside the glorious renaissance, began a revolution in medicine to critically examine, learn from facts, challenge the ancient tomes, and reject all that do not stand up to reason.

It is a story rarely told. Even the medical curriculum and the text books treat the subject insufficiently. For the practicing doctor, current wisdom, state of the art knowledge has become more and more important. Specialisation has gone fast forward in recent times. A modern practitioner of medicine or surgery has the over arching aim of bringing results to the patient. This would require deep and current working knowledge of one's own speciality and a general knowledge of the protocols of the other specialities. So the modern doctor who continues the fight against contagious diseases is largely unaware of the history of the subject.

The common man regards the working methods of modern medicine too technical and complicated so that there is a mental

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block to go deep into medical science. He finds the diagnostic and therapeutic methods of modern medicine largely effective, but its logic is often beyond him. And moreover, nowadays, he is content with the results of the treatment. So between the specialist who respects the history of his speciality but has no immediate use of it in his practice, and the common man who may be curious, but finds no popular description of medical science, the history has been all but forgotten.

This article is intended as a sketch of the main milestones in the history of modern medicine, along with some of the pioneer scientists and doctors who developed the ancient art of healing into a modern science.

Let's first look at a few of the dreaded diseases of the past centuries.

Plague is a disease we meet with only in history books. It was a deadly disease that killed the maximum number of people in history. In the sixth and seventh centuries, the deadly plague spread over entire Europe and killed nearly 6 crore people, almost half the population of the then Europe. The second wave of plague known as Black Death began in 1346. It killed 15 crore of people, again nearly half the population of Europe at that time. The pandemic that began in 1346 lasted more than three centuries and in 1665 it reached London. Newton who was a student at Cambridge University at that time, left for his village when the university was closed. It is interesting to note that it was during the 2 years he was in his village that Newton discovered the law of gravitation. Plague was defeated in the second half of twentieth century with pesticides and hygiene.

Small pox is a disease that was eradicated in 1980. It was a disease known from ancient days. Signs of the disease have been confirmed in Egyptian mummies. In the early 20th century there used to be 1.5 crore small pox patients per year. 30% of those who were infected used to succumb to the disease. It was a dreaded disease in our country too, and people believed that it was the manifestation of the anger of mother goddess. It was so dreaded that the infected individuals were sometimes abandoned by their relations. There were instances when patients were taken to the funeral pyre even before their death. Small pox was eradicated through a global vaccination campaign.

Cholera was yet another infectious disease that was widely prevalent in our country. Bengal is the homeland of cholera. Sushruta Samhita had described it as 'Vishuchika'. If left untreated the death rate would be around 30 to 40%. Before independence, this disease was a big health hazard in India. In the novels and stories of those times, we can find descriptions of people fleeing from cholera affected villages. In India, in 1950 alone, there were 1,76,000 cholera patients and 87,000 of them died. After 1970, it has not taken the proportion of an epidemic in India, even though some isolated cases are seen. Cholera was controlled through sanitation and making drinking water safe by boiling.

Humanity once remained helpless before such deadly diseases. It was quite common in those days to see lakhs of people dying due to such epidemics and pandemics. People believed that these pandemics were the creation of evil forces or the result of divine retribution. These devastating diseases could be controlled only after the emergence of modern science, when biological phenomena began to be viewed and investigated scientifically in the nineteenth century.

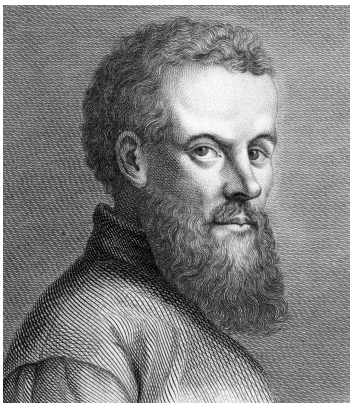
How could science do it? What is the method of science? What is the tool of science that makes it possible to confront

a problem with unlimited energy, the very same problem before which mankind was helpless in the past and which was accepted as man's fate? Science has no mysterious methods. Rather science works to solve mysteries! Its method is something that can be understood by anyone, can be questioned for clarity, and proved experimentally for anyone seeking to know it. As regards the contagious diseases, this method consists of identifying the germ that causes a disease, studying the life cycle of the germ, studying the route of its entry into the human body, understanding the role of insects and other vectors which carry the diseases, and if there is human to human transmission, understanding the route of transmission. And on the basis of the findings of this study taking appropriate control measures to prevent the entry of germs into the body. But this method was not found in a day. The path of progress was not a straight line. There were prejudices to be overcome, many ossified false ideas to be disproved. Later the discovery of anti-biotics also opened the way to treat affected persons and cure them.

The history of the fight against pandemics is also a history of the development of science. It includes the development of the method of analysis which brought the germs – the microbes causing diseases – into focus, the instruments which opened the way, primarily the microscope, the techniques of isolating the microbes, growing them in the laboratory etc. To begin with let us turn the pages of history and learn about some of the great individuals who played leading roles in the fight against diseases.

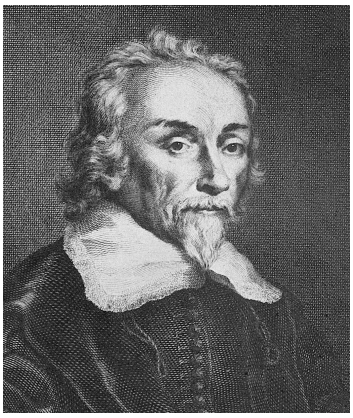
Andreas Vesalius

He is considered as the founder of modern human anatomy. During the Middle Ages, medicine and anatomy were learned from the books written by Galen, the Greek

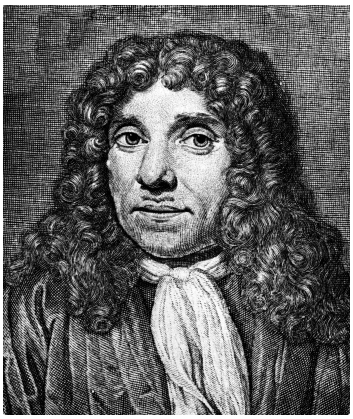


Andreas Vesalius (1514–1564)

physician. As dissection of human body was forbidden, antomy was learned by dissecting monkeys or pigs. Vesalius put an end to this practice. In medical education, he started the practice of dissection of human body. He used this method for his own study and for teaching purposes. He introduced the method of observation and experimentation in medical sciences and corrected the mistakes of Galen. The wrong ideas of Galen corrected by Vesalius include 1) women have 2 teeth less than men, 2) men have 1 rib less than women, 3) the human jaw consists of two bones(consistent with animal anatomy) 4) the human left ventricle has a passage into the right ventricle (to rationalize the erroneous idea of blood flow prevalent in the Middle Ages) He was also a classmate of Michael Servetus, a great Renaissance thinker who had to give his life for the cause of freedom of thought. The book 'De humani corporis fabrica' (On the fabric of the human body) by Vesalius was published in 1543, the same year Copernicus' book was published. It was gradually taken up by the medical professional and became a text book for teaching Anatomy. The great Renaissance artists Leonardo da Vinci, Michelangelo and several others also took forward the method



William Harvey (1578–1657)



Antony Van Leeuwenhoek (1632–1723)

of studying anatomy by direct observation through dissection started by Vesalius for realistic representation of the human body in art.

William Harvey

Harvey, an English doctor, studied medicine at Padua University in Italy, where he was a classmate of Galileo. He continued the work of Vesalius and other anatomists and discovered the circular motion of blood in the body. Galen's theory was that venous blood originated in the liver. Harvey employed mathematics to disprove Galen. He measured the volume of blood pumped by the heart in each beat, and multiplying with the heart rate calculated the amount of blood that would have to be released from the liver in a single day. This would be equal to the weight of human body, which was ridiculous to assume, unless there was a circular motion. Harvey understood that the beating heart has to be studied to understand its function. So he conducted numerous vivisection experiments in animals to understand the working of the heart. Harvey' main work, 'De Motu Cordis' (On the motion of heart) was published in 1628. The medical profession was divided on whether to accept Galen or Harvey. Ultimately the truth of experiment prevailed over blind faith.

Antony Van Leeuwenhoek

Leeuwenhoek, the discoverer of the world of microbes, was a Dutch businessman and scientist. He was running a textile shop in the town Delft in today's Netherlands. In those days magnifying lens was used for examining the quality of thread used in textiles. Leeuwenhoek developed the technique of making lenses with higher magnifying power. A glass rod when melted in the middle and stretched, a thin fiber of glass is formed. When this fiber is melted again a small ball of glass is obtained and this acts as a powerful lens. Apart from observing the textile thread using the lens, he also observed the tissues of animals, blood cells and moving unicellular organisms which he called 'little animalcules'. He prepared descriptions of his findings with pictures and wrote letters to the Royal Society. He sent a total of 190 such letters. The Royal Society found his studies interesting but did not accept the existence of micro-organisms. To verify the findings of Leeuwenhoek, the Royal Society appointed a commission. On the basis of this inquiry, the Royal Society

finally accepted his findings in 1677. While Robert Hooke had done pioneering work with microscope, and described plant cells (in his book Micrographia, 1665), it was Leeuwenhoek who observed independent cell-sized organisms or unicellular organisms for the first time and opened the world of microbial life for us.

Variolation: It is interesting to note that modern medicine learned the technique of preventive inoculation from folk medicine. Variolation was a traditional practice of preventive inoculation prevalent in parts of China and Turkey to save people from the attack of small pox. Variola is Latin word for small pox. In those days 30% of the infected people used to die. The technique of variolation was to take a small drop of the fluid from the blisters on the body of an infected person and apply it on a small scratch on the body of healthy persons. The advantage is that the person will be affected by small pox in a mild way, but will not die. By 1720s this technique of prevention reached England from Turkey. After seeing the technique being used in Turkey, it was Lady Mary Wortley, the wife of Edward Wortley, the British ambassador to the then Ottoman Empire, who brought it to England. She had suffered from small pox. Her brother had died of small pox. She wanted to save her child and so asked the family physician Charles Maitland to learn the technique of variolation from the local doctors in Constantinople. Her son aged 5 years was inoculated. Later when they returned to London this information got shared among her family circles. Her younger daughter was also inoculated by Dr Maitland. This technique became a subject of discussion in the medical circles in London. King George I tested the technique on prisoners and children in an orphanage. After thus satisfying himself about the technique, the King inoculated his two grandchildren. In this manner variolation became popular in England. Here the age old knowledge that certain diseases attack a person only once in his lifetime, and if he survives the attack, he does not get it again was used for prevention.

Edward Jenner (1749–1823)

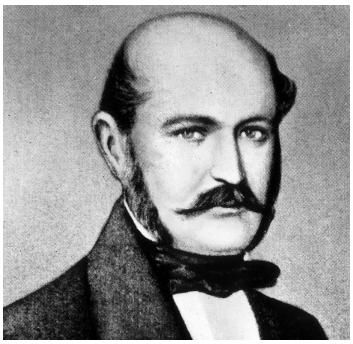
Edward Jenner

The British physician Edward Jenner is known as the Father of Vaccination. He took the principle of preventive inoculation for small pox and perfected the method and the means on scientific basis. In Jenner's time it was not known that it was a microbial germ (today we know it is a virus) that caused small pox. Even though it was more than a century since Leeuwenhoek had discovered microbes, nobody suspected any relation between microbes and diseases.The variolation technique prevalent in England had some limitations – sometimes the disease aggravated and people used to die and sometimes it became contagious. Jenner observed these problems. He also noticed that even when small pox spreads in the community, the milk maids were not affected by the disease. But they used to get a mild

disease called cowpox, a disease primarily of cows. The milk maids seemed to develop some resistance against small pox after being affected by cowpox. In 1796 Jenner inoculated a few people with the pus from the blisters of the cowpox affected persons on an experimental basis. They developed mild fever and were cured soon. Later those people were injected with the pus from small pox patients. It was observed that they developed immunity against small pox. By repeated experiments he showed that those inoculated with cowpox developed immunity against small pox. He introduced this inoculation method to larger number of people whenever the requirement came. This was the beginning of vaccination. Vaccinia is Latin for cowpox, hence the name vaccination for this technique of preventing small pox. Napoleon, who was at war with England in those days, inoculated the entire French army with cowpox vaccine and presented a special medal to Jenner.

What was the inspiration behind Jenner's discovery? Even before the cause of contagious diseases was established, how could he make this discovery of a safe preventive method? We can see that the ingredients that went into the discovery were: (1) The strong desire to prevent a disease (2) Keen clinical observation of the patients' circumstances (3) Scientific method of experimentation.

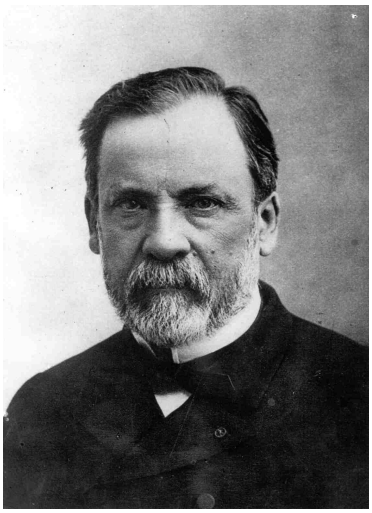
Salute to doctors: Jenner was a doctor who went the extra mile, who dug deeper for truth, and who could see farther than his times. It is men like him who cracked the mystery of diseases, and fashioned remedies from the available resources. Let us salute the countless men and women of the medical profession whose tireless clinical work has brought relief to their patients on the one hand, and created the edifice of medical science bit by bit through the centuries.



Ignas Semmelweis (1818–1865)

Dr Ignas Semmelweis

He was a Hungarian doctor. In 1846 while working in the labor ward of a hospital in Vienna, he made a very significant observation. In the obstetrics ward, where training was given to medical students, the incidence of childbed fever and death rate was more compared to the ward where midwives were trained. He suspected that the doctors who were also visiting other wards were transmitting something that is causing disease in the pregnant women in the labor ward. He instructed that the doctors should wash their hands in chlorinated lime solution before entering the obstetrics ward. This step drastically reduced childbed fever and the post-delivery death rate. Why this is happening could not be explained by him since the microbial cause of disease was not known at that time. He published his findings in a book titled 'Etiology, Concept and Prophylaxis of Childbed Fever'. Other doctors opposed him since the very idea that doctors were spreading disease could not be accepted by them. They ignored his findings and socially isolated him. Finally, in 1865, he suffered a nervous breakdown, was admitted in an asylum where he died due to an infected wound which turned gangrenous. He was one of those who vaguely presaged the infecting agent causing disease. His



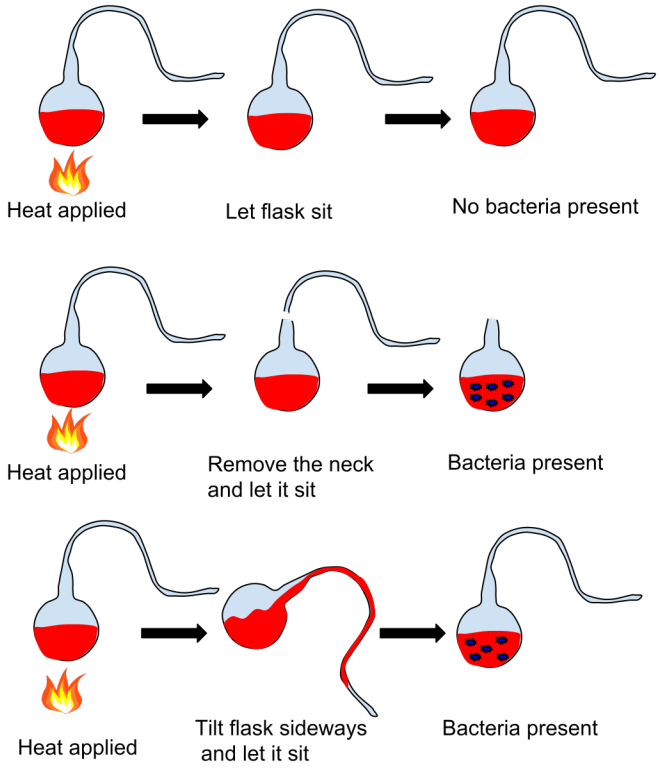
Louis Pasteur (1822–1895)

tragic life is a reminder of the power that prejudice exerts even in scientific persons. There is a lesson for the medical profession here on how corrosive is the combination of privileges and prejudice on a noble profession's standards. Yet on the other hand, Dr. Ignas Semmelweis' work remains a fine example of how, even in the absence of a guiding theory, scientific clinical practice could home in on the solution to a practical problem.

Louis Pasteur

Louis Pasteur is one who has made the greatest contribution in the fight against contagious diseases. In his hands, the microscope became a great weapon against diseases. He made significant contributions in different branches of science and acquired expertise in different fields to make, by far, the greatest single contribution to medical science. He proposed the hypothesis that the cause of contagious diseases is microbes and proved it. This released the search for the causative agent in various infectious diseases. Based on this knowledge, he further developed the vaccination method of prevention against contagious diseases in a scientific manner. He succeeded in employing vaccination against several animal diseases. In humans he developed the vaccine against rabies, tested and proved its efficacy. Thus he laid the foundations of the science of immunology and microbiology. All these achievements were made struggling against the false notions prevalent in the society including in the field of science. The reluctance of the society to accept anything new was something he faced at every step forward. In this social environment, he also made another path breaking discovery that microbes are not spontaneously generated from non-living matter. Let us go through the interesting route through which Louis Pasteur, who began as a researcher in chemistry, brought about a revolution in medicine.

Stereo Chemistry: Pasteur started his research activities in chemistry. The subject of his research was a particular property of organic compounds called stereoisomerism. Today we know that substances with the same molecular formula can have different structures. These are called isomers. A class of isomers having the same chemical properties but slightly different structures – the crystal structure of one being the mirror reflection of the other – are called stereo isomers. Pasteur's study was on these substances. The two possible isomeric forms are conventionally named left and right oriented to signify the difference in 3D structure, very much like left and right hands. This phenomenon is also called optical isomerism, because these substances have a subtle optical property. They change the plane of polarization of light which passes through them. While being equal in chemical properties, they also show subtle differences in their participation in biological processes. Today



A diagram of Pasteur's swan neck flask experiment

we know that living organisms will produce only one of the isomeric forms and can utilise only one type. For example glucose has two variant isomeric forms, glucose D and glucose L; living organisms can make and also consume only glucose D. The study of this phenomenon helped Pasteur to view biological processes as something not reducible to mere chemical reactions.

Fermentation studies: In 1856, the wine brewers in France requested Pasteur to solve a problem they were facing. The problem was that some barrels of wine became sour. Pasteur visited the breweries, collected samples and conducted experiments. He found that the barrels in which wine became sour contained lactic acid. In the barrels containing good wine, along with alcohol, yeast was always present. In the sour barrels, along with lactic acid a micro-organism, a bacillus, was also present. He understood that if the bacillus was eliminated, the problem could be solved. He experimented with several methods to destroy the microbe. He observed that if he used chemical methods, the taste of wine got altered. Finally, he found that if the wine was heated to 60 to 80 degree Centigrade and stored in a closed container, the growth of bacillus could be arrested and wine turning sour could be stopped.

Pasteur disproves the 'theory of spontaneous generation': Pasteur did not stop with his success in solving the practical problem of wine going sour. He observed that two types of fermentation are taking place – one is yeast converting sugar to glu-

cose and the other, the bacillus converting sugar to lactic acid. The scientific community did not agree. Their view was that fermentation is purely a chemical process and yeast or the bacillus had no role in it – the bacillus may have come from lactic acid and the yeast may have come from alcohol. In short, they said that it was not the microbes that were responsible for the chemical change in the grape juice, but it was the chemical change that produced the yeast or the bacillus. It was the prevalent idea of spontaneous generation that made them think so.

Following this Pasteur conducted several experiments to prove that microbes did not originate spontaneously from non-living matter. The 'swan neck experiment' famously put an end to the theory of spontaneous generation and showed that microbes came from outside. Secondly, he also took upon himself the responsibility for finding out the source of the bacillus if it did not originate from the wine. He showed that if a broth containing nutrients that helps microbes to grow (for example, meat soup) is heated and all microbes are killed and then kept exposed to air, microbes will start growing again after some time. By changing the quality of air that is allowed a brief contact with the broth, he showed that the abundance and variety of growth was proportional to the air pollution, specifically the suspended particles in the air.The growth is most high if the broth is exposed to air from a busy street, whereas the growth is negligible if placed at the top of an Alpine mountain, where the air is much cleaner. Thirdly, through these experiments he identified the culture medium suitable for the growth of microbes and found that it was different for different microbes. He also found the sources of microbes in the environment and ways to destroy them. In short, he produced a wealth of ideas and basic knowledge required for further studies about microbes. After solving the practical problem of the breweries, he went after the theoretical explanation doggedly. Thus he laid the foundation for the new branch of science called microbiology.

Germ theory of disease: After extensive study of microbes, Pasteur put forth the germ theory of diseases. Just as two types of fermentation are caused by two types of microbes, different contageous diseases must be caused by different microbes, he argued. Following Pasteur, other scientists also entered into the study of microbes. There was rapid progress. The German scientist, Robert Koch, in 1876, identified and isolated the bacillus responsible for the Anthrax disease in cattle. It was the first time that a microbe was identified as a cause for a disease.

In 1879, Pasteur developed a vaccine for Chicken Cholera and in 1881 developed a vaccine for Anthrax. It is interesting to note that the vaccine for Chicken Cholera was discovered quite accidentally. A one month old culture sample of Chicken Cholera cells was lying idle in his laboratory. Thinking that it had become useless, his assistant asked Pasteur if he could throw it away. Pasteur paused for a moment and told his assistant not to discard it, saying that it might be required for an experiment. Pasteur injected chickens with this sample and found that did not get chicken cholera later; they seemed to develop immunity against the disease. Taking a cue from this experiment, he lightly heated the culture cells of Anthrax germs to weakened them and then injected animals with this. He observed that the animals developed immunity against Anthrax.

He then proceeded to study some diseases in humans. He showed that some of the diseases like the childbed fever which

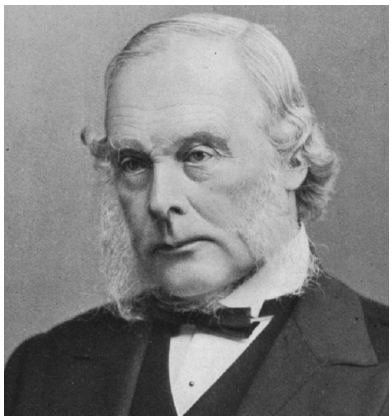
used to take a big toll of women after delivery, septicemia which is still a dreadful disease, gangrene which is a severe infection that may end up in amputation, etc, were caused by germs. But the medical doctors did not accept those findings saying that Pasteur was only a chemist and that he was not technically qualified to speak about diseases. Pasteur continued his crusade for truth. He printed his findings and publicized them among the common people.

Dr. Joseph Lister

He was a surgeon in England. In the surgical ward of the Glasgow hospital where he worked, the wounds of patients used to become septic often. In the period from 1861 to 1865 among the patients that were operated, 45% died. In those days the belief was that infections were caused by bad air and so fans were arranged in the wards for removing bad air. But nobody suspected that the cause of infections could reach the patient through a doctor's hands. It was at that time that Pasteur's germ theory attracted Lister's attention. In 1865, he introduced the practice of washing the surgeon's hands, surgical instruments, and the surgical sounds in carbolic acid. The result was dramatic, the death rate dipped to 15%. Surgery is a branch of medicine where precision is very important. Joseph Lister introduced the principle of disinfection in surgery. He was also a great doctor who was the first from the medical fraternity to approach Pasteur's findings without any preconceptions. When found to be true, he accepted and adopted Pasteur's ideas in his discipline.

Robert Koch

He completed the work started by Pasteur and gave final form to the basic principles of microbiology. Pasteur had done his work with liquid culture media like meat broth.



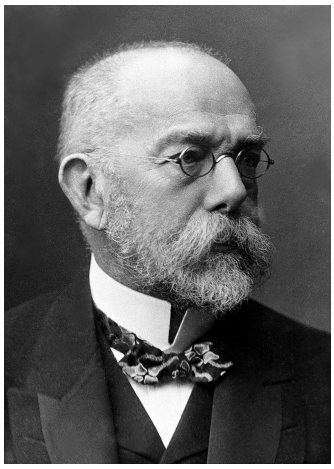
Joseph Lister (1827–1912)

Here the limitation is that the different microbial types cannot be easily separated. Koch overcame this difficulty by developing solid culture media. This allowed the growing of bacteria in pure culture in the laboratory. The students of Pasteur and Koch studied various diseases and identified the specific germ responsible for each of them. The microbes responsible for the following were identified in a short span of time: 1874 – Leprosy, 1879 – Gonorrhea, 1883 – Tuberculosis, 1883 – Cholera, 1884 – Diphtheria and Tetanus. Most of these organisms are bacteria, and the study of bacteria or bacteriology became the major part of microbiology. Koch developed the following postulates for determining the relation between a disease and its cause.

1. The microorganism must be found in abundance in all animals suffering from the disease, but should not be found in healthy animals.

2. The microorganism must be isolated from a diseased animal and grown in pure culture.

3. The cultured microorganism should cause the disease when introduced into a healthy animal.



Robert Koch (1843–1910)

4. The microorganism must be re-isolated from the inoculated, diseased experimental animals and identified as being identical to the original specific causative agent.

These continue to be the guiding principles in microbiology.

The victory over rabies: In 1880, Pasteur started his study of rabies. He took saliva from a boy who had died of rabies with a pipette and injected it in animals. After the animals were infected with rabies, he prepared the experimental vaccine by drying the spinal cord of the rabid animals (It was not known at that time that the causative microbe was a virus as it could not be seen through the optical microscope).

In 1885, even while he was experimenting with animals, he decided to try the vaccine on a boy, Joseph Meister, who was bitten by a rabid dog. The boy's mother brought him to Pasteur with the belief that it was the only hope. Pasteur was not fully confident of conducting the trial. His worry about his lack of preparedness on the one hand and the inner call for saving a life on the other put him in a dilemma. With great moral anxiety, whether he was doing the right thing or not, he made his first attempt of human trial of rabies vaccine on Joseph Meister. It was successful; it was a great victory of mankind over a dreaded disease.

(To be continued)

Economic System, Viral Outbreaks, and the Crisis

Dibyendu Maiti*

1. Background

The viral outbreaks in the recent past and the resultant damage to life and livelihood mandate an urgency to explore a better system that can limit the future occurrences rather than relying short-term measures to mitigate the extent of damages after the spread. The COVID-19 virus emerged in Wuhan, the capital of Hubei Province in China and gradually has broken out all over the world. The economic and social losses incurred by most countries, both developed and developing, due to the recent pandemic, are enormous, much bigger than those of the 2008 global financial crisis. The impact on the labour market has been much deeper. The unemployment rate has crossed 20% of working population in US, the first time since the World War II. The International Labour Organisation (ILO) reported that globally 17.1% of youth (aged 18-29 years) have stopped working after the onset of the pandemic. This is more than 19% in both low and high income countries. The losses go beyond the economic factors. It is difficult to quantify its effect on physical and mental health that impose significant burden on the happiness of individual and social life. The share of persons worried about their mental health because of the COVID-19 pandemic in the USA, UK and Germany ranges from 30% to 40% of total respondents (Statista, 2020), which seems to be three to four times higher than normal.

Such losses are far more if a state is corrupted, whimsical and adopts unscientific and undemocratic measures to deal with the spread of pandemic. It is evident that the countries, which took delayed decisions on banning national and international transfers with the affected regions, called for total lock-down without a proper rehabilitation arrangement for migrant labourers, and possessed poor institutions, have suffered huge losses. Countries like India and Brazil were unable to diminish the pace because of these reasons whereas Korea, Taiwan, Japan and Germany managed to slow down the spread of infection, even without vaccination, by relying on scientific decisions like partial lock-down, restricted transfers and by virtue of having better institutional and medical infrastructure.

A crisis of this magnitude has not been experienced in the last 100 years after the 1918 Spanish flu. This has happened when science and technology have significantly modernized human civilization. The tremendous progress of science and medical research tends to make us believe that nature has been conquered to a large extent and no longer could pose severe challenges for humanity. But the daunting experience of the COVID-19 pandemic teaches us that nature is still powerful and can threaten human existence if the existing economic system is not conducive to its sustainabil-

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ity.

The COVID-19 pandemic, one of the most devastating viral outbreaks in the history of human civilization, comes in the wake of several outbreaks at local and regional levels. The last two decades have seen the MERS-CoV in Saudi Arabia (2012), Zika virus in America (2016), Ebola in Africa (2014), H1N1 flu (2009), SARS in China (2002). While investigating the remedial approaches for COVID-19, it is utmost important to investigate the root causes behind the rising trend of viral outbreaks and whether the existing economic system regulating the human-nature interaction plays any role.

This article aims to establish that the changing dynamics of human and nature interactions, influenced by the market-based economic system, seems to have influenced the fundamental cause behind the growing trend of viral infection episodes. The production relation driven by profit motive in the market is the root cause for the growing loss of bio-diversity and environmental damage. This triggers the human interactions closer to the wild animals and that essentially raises the possibility of viral outbreaks. The key sources of the recent and past pandemics, and thoughts explaining the origin will be discussed in section 2. The importance of production relation that triggers the bio-diversity losses and climate change is investigated in section 3. Section 4 highlights an account of present crisis in capitalism and its implication in the viral outbreaks. Section 5 ends up with concluding observations.

2. Viral Transmission and Outbreaks

2.1 Popular Beliefs

There are a few doctrines offering explanations for the viral outbreaks but they may not hold up to scientific scrutiny. First, the transmission of a pathogen and its mutation in human body takes place randomly because the evolution of viruses and its mutation are driven by the natural selection process. One cannot anticipate the occurrence of such outbreaks in advance and, hence, should be prepared to bear the consequences associated with the occurrence of such an outbreak. It does not mean that humankind should be helpless and at the mercy of the vagaries of epidemics and pandemics. Second, in order to consolidate political and economic power, to gain access to the world and regional markets, many countries spent substantial amount on manufacturing not only conventional but also nuclear, radiological, chemical, biological, and other unconventional weapons. Such weapons are capable of mass destruction of human lives, property, nature and the biosphere.

It is a popular belief that the viral outbreak could be a result of conspiracy. However, scientific experiments so far suggest that the COVID-19 (SARS-CoV-2) cannot be manufactured in the laboratory and thus refutes the conspiracy theory. Third, the Malthusian theory argued that population grows exponentially while the growth of food resources is linear. This means that a threat to human survival would be an obvious outcome after a critical point when the growth of biological resources falls below that of population growth. However, the theory did not take into account that the birth rate can shrink with better education and medical facilities, and could not visualize that scientific methods of cultivation can increase the crop production manifold. Fourth, a sudden emergence of new pathogenic variants of circulating viruses could be linked to cosmic events in the universe. The Earth's magnetosphere, and the interplanetary magnetic field in its vicinity,

are both modulated by the solar wind that controls the flow of charged particles onto the Earth. A small body moving in the solar system could become a meteor and enter the earth's atmosphere. The COVID-19 is assumed to have arrived on a meteor that was spotted at Songyuan city in North East China on 11th October 2019 (Steele et al., 2020). The meteor was spotted over 2,000 km northeast of Wuhan, where the first cases of COVID-19 were reported. A number of scientists (for example, Graham Lau, a NASA based astrobiologist), however, have rebutted such suggestions. None of these ideas satisfy sufficient justifications to support them.

2.2 Outbreaks: The Origin and Causes

While the previous four doctrines do not satisfy scientific scrutiny, the evolutionary thoughts that explain the interactions between nature and humans behind the evolution of viruses are becoming powerful ideas in elucidating the viral outbreaks. The characteristics and compositions of biological populations change with time over successive generations. The human interaction with nature for livelihood and survival drives mutation, genetic recombination and other sources of genetic variation that govern the future pace and pattern of evolution.

Humans are susceptible to a range of microbes that include viruses. Only some of them are harmful. Viruses have genetic material (DNA or RNA) and protein coats. Vaccines are required to develop immunity against viruses. Once a vaccine is discovered, it does not mean that this can provide a permanent solution to the infection, because viruses evolve with change in environment and they mutate and undergo natural selection. Most of the newly identified emerging viruses are carried by vectors, which cause primary diseases in animals and then jump to humans (known as zoonotic viruses). The elevated mutation rate, when combined with natural selection, allows viruses to quickly adapt to changes in their host environment. They evolve through changes in their RNA (or DNA), but have short generation times. Some of them evolve quite rapidly, and the best adapted mutants quickly outnumber their less fitter counterparts. Hence, their evolution is Darwinian.

2.3 Coronavirus

The current pandemic (COVID-19) is caused by a virus named Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV2). This contains an oily lipid membrane packed with genetic instructions to make copies. Encoded with RNA, it can infect the host cell and is capable of translating into several kinds of viral proteins. Approximately, more than 500 corona viruses have been identified so far in China with unknown bat coronavirus diversity. Seven of them are associated with human diseases. They are categorized into alpha and beta coronaviruses. The alpha coronaviruses are associated with mild symptoms. The beta coronaviruses can cause severe diseases and spread huge infections in the human body. Almost similar outbreaks have been witnessed in the recent past in the East and Middle-East. Two of them, which appeared to be quite severe, are SARS-CoV-1 (Severe Acute Respiratory Syndrome Corona Virus 1) that originated in China (2002) and MERS-CoV (Middle-East Respiratory Syndrome Corona Virus) that broke out in the Middle East (2012).

The genome of SARS-CoV2 is similar to bat RaTG13 coronavirus and the Pangolin coronavirus and originated as a result of tweaking of two genes through natural selection, followed by adaptation. The first

Name	Time period	Type / Pre-human host	Death toll
Antonine Plague	165-180	Believed to be either smallpox or measles	5M
Japanese smallpox epidemic	735-737	Variola major virus	1M
Plague of Justinian	541-542	Yersinia pestis bacteria / Rats, fleas	30-50M
Black Death	1347-1351	Yersinia pestis bacteria / Rats, fleas	200M
New World Smallpox Outbreak	1520 – onwards	Variola major virus	56M
Great Plague of London	1665	Yersinia pestis bacteria / Rats, fleas	100,000
Italian plague	1629-1631	Yersinia pestis bacteria / Rats, fleas	1M
Cholera Pandemics 1-6	1817-1923	V. cholerae bacteria	1M+
Third Plague	1885	Yersinia pestis bacteria / Rats, fleas	12M (China and India)
Yellow Fever	Late 1800s	Virus / Mosquitoes	100,000-150,000 (U.S.)
Russian Flu	1889-1890	Believed to be H2N2 (avian origin)	1M
Spanish Flu	1918-1919	H1N1 virus / Pigs	40-50M
Asian Flu	1957-1958	H2N2 virus	1.1M
Hong Kong Flu	1968-1970	H3N2 virus	1M
HIV/AIDS	1981-present	Virus / Chimpanzees	25-35M
Swine Flu	2009-2010	H1N1 virus / Pigs	200,000
SARS	2002-2003	Coronavirus / Bats, Civets	770
Ebola	2014-2016	Ebolavirus / Wild animals	11,000
MERS	2015-Present	Coronavirus / Bats, camels	850
COVID-19	2019-Present	Coronavirus – Unknown (possibly pangolins)	4,700 (as of Mar 12, 2020)

Figure 1: A Timeline of Historical Pandemics. Source: https://www.weforum.org/agenda/2020/03/a-visual-history-of-pandemics

gene tweaking occurred when a RaTG13-infected pangolin gave rise to a RaTG13 derivative containing the RBD (Receptor Binding Domain) of the pangolin coronavirus. The second gene tweaking occurred when the above RaTG13 derivative infected humans and acquired the furin trigger cleavage site, and this gave rise to SARS-CoV2. Therefore, the most likely path of the coronavirus infections is the bat to pangolin to human route (Mani, 2020).

2.4 Virus Infections: Common Source

While the infection of COVID-19 (SARS-CoV2) originated from the mutant viruses carried by wild animals, a brief account of historical pandemics (Figure 1) clearly reveals that animals are the single most important source for all these pandemics, suggesting a rising trend of zoonotic transmission.

Some of them, like the chimpanzee, live in dense forests and others, like bats, rats and camels, are found in the peripheral forests and surroundings of human habitations. While humans gradually build up the requisite immunity to fight the virus originating from domestic cattle, being in constant contact with them, they could not develop this ability with wild animals, and infections emanating from bats, pangolins, etc., proved to be quite harmful. Note that the viruses originated and mutated among the animal bodies and then jumped into

human bodies through droplet transmission. Those which jump from wild animals appears quite severe.

The zoonotic transmission would likely accelerate when humans and human habitats get closer to wild animals. A recent experiment suggests that 8 of the 15 diseases of temperate climate – diphtheria, influenza A, measles, mumps, pertussis, rotavirus, smallpox, and tuberculosis – may have reached humans from domestic animals. Another three, Hepatitis B could have reached us from apes; plague and typhus from rodents. The other four – rubella, syphilis, tetanus and typhoid – came from unknown sources. The transmission of viral infections takes place through contacts with infected animals and people. Among people, they can be passed on through daily social interactions, through kissing and sex, contact with contaminated surfaces, food, and water. Statistical information has not been systematically gathered to report the global trend. However, the scattered information reveals a rising trend of viral infections, both in variety and number, steadily from 1980s. The proportion of diseases transmitted by the animals and other vectors has risen fast relative to the other sources. In the data analyzed, 65% of the diseases, making up 56% of all outbreaks, were 'zoonoses', meaning that they were transmitted to humans by animals, insects and other vectors. These diseases include Ebola, HIV, the bubonic plague and Lyme disease (Smith et al, 2014).

3. Production Relation, Bio-diversity and the Climate

3.1 Short-Run Crisis and Strategies

The views of mainstream economists in a market-based setting dealing with short-run crisis do not count the evolution dynamics. It assumes that an economy continuously receives external shocks, generating business cycles with booms and recessions around a steady growth path. An episode of viral outbreak is one such external shock, taking the economy into a recessionary phase. Under a recession, individuals lose jobs, production suffers, and incomes fall. At one extreme, a group of economists, belonging to the Real Business Cycle (RBC) School, believes that much intervention is not warranted as it would disturb the natural process of adjustments. An economy continuously gets hit and receives shocks stochastically; some of them work favourably, while others have an adverse effect that exhibits a path of simple harmonic motion. The losses under recession will be compensated by the subsequent boom. On the whole, welfare loss will be nil when an entire cycle is completed and hence, the state does not need to intervene the system. However, this may not be true if the cycle does not follow simple harmonic motion or the distribution of shocks is skewed towards recession.

Even if a path demonstrates a simple harmonic motion, another group of economists, belonging to the New Keynesian School, argues that the net social welfare cannot be zero from a complete cycle. Because, the marginal gain from a boom cannot compensate the marginal loss from the same magnitude of recession. So, the state must intervene to reduce the magnitude of the cycle by using either fiscal or monetary policy instruments. While the fiscal policy, handled by the state (e.g., government spending, tax administration etc.), cannot influence economic outcome, the monetary policy instruments, controlled by the Central Bank, can play some role. Because, the fiscal policy raises deficit, inflationary pressure and brings additional complications in the economy. However, contemporary experience suggests that the

monetary policies are ineffective under a crisis or severe recession (e.g., global financial crisis 2008).

Under a severe crisis, the state needs to rely on the fiscal-monetary policy mix, offered by the old Keynesian approach, which saved the world economy from the Great Depression during the 1930s. A combination of both fiscal and monetary policy measures can be sought as an obvious choice, both for philanthropic and expansionary reasons. This would essentially create an effective demand that generates some economic momentum. However, the recovery would be highly distorted if the state utilizes the fiscal budget inefficiently. Most economies have expanded the fiscal budget to deal with the current pandemic. For example, the fiscal stimulus package is 21.1 % of GDP in Japan, 13% (US), 12% (Sweden), 10.7% (Germany), 9.3% (France), 7.3% (Spain) and 5.7% (Italy). Indian economy accounts for 20% of its GDP that includes direct and indirect spending. Note that these stimulus packages may offer an immediate relief in short-run, but at the welfare cost of future generation. The government will be forced to either impose tax on the future generation or print money to finance the deficit that may raise inflationary pressure and other contingencies later as a consequence. Moreover, none of these approaches count the evolutionary dynamics and environmental consequences in the long-run and cannot offer a decent solution to deal with the future possible occurrence. Therefore, it is immense important to investigate the origin of viral outbreaks and try to address them.

3.2 Bio-diversity Loss

It is evident that the climate is deteriorating fast for human living. The world CO_2 emissions (metric tons per capita) has sharply risen during the last five decades. According to World Bank data, the level of emission has increased from 3.09 metric tons in 1960 to 4.98 metric tons per capita in 2014. The rise of emission increases the temperature globally, raising pressure on the ozone layer and hence creating difficulties for human existence and survival.

The global surface temperatures at a network of ground-based and ocean-based sites have been measured and recorded since 1880. Over the last century, it reveals that the average surface temperature of the Earth has amplified by about 1.0° F. (https://clintonwhitehouse5.archives.gov/textonly/Initiatives/Climate/last100.html). Overall, the global annual temperature has accelerated at an average rate of 0.07°C (0.13° F) per decade since 1880 and at an average rate of 0.17°C (0.31°F) per decade since 1970 [NOAA/NCEI]. The rising temperature is exerting pressure on the forest belt and its canopy coverage on the earth as well as on the levels of ground water, specifically for drinking. It is known that the world's terrestrial biodiversity is concentrated in forests. They are home to more than 80 per cent of all terrestrial species of animals, plants and insects. According to the World Bank, the renewable internal freshwater resources per capita has dropped from 13402 cubic meter in 1962 to 5933 cubic meter in 2014. On the other hand, the forest resources, the homes of wild animals, are also disappearing fast. Within 25 years, the forest area as a percentage of total land area has shrunk from 31.6% in 1990 to 30.7% in 2016.

The falling ground water level and forest resources lead to a threat to the bio-resources. According to Save Earth, a UN organization, 99.9% of all species that have ever lived are now extinct. The extinction rates are estimated to be 1,000-10,000 times higher than would be expected with-

out human presence and 99% of extinction-threatened species are at risk from human activities. There has been approximately 52% decline in biodiversity, as recorded since 1970. If this continues, around 30 to 50% of current species could be extinct or heading towards extinction by 2050.

Dense forests are being set on fire deliberately or naturally due to the rise of global temperature. For example, the bushfires of dense forests are becoming a regular and serious threat to the environment that sustains human living. The Australian bushfires during 2019–2020 and Amazon rain forest wildfires in 2019 are the worst examples in recent times. The bushfires have not only been made more likely and intense by climate change, they themselves further add to the process. Global warming is making bushfires burn more intensely and frequently, and the 2019–2020 bushfires have already emitted 400 mega-tonnes of CO_2 into the atmosphere, according to the Copernicus monitoring program report. This is as much as Australia's average annual CO_2 emissions in just three months. The bushfires killed one billion animals by the beginning of January 2020. This number does not include frogs, invertebrates, or bats and similar species.

On the other hand, almost 20% of the Amazon rain-forest has been lost through human activity since 1970 (mainly due to over-exploitation and illegal activities). The Amazon rain forests produce over 20% of the world's oxygen. As of 29th August 2019, INPE (National Institute for Space Research in Brazil) reported that more than 80,000 fires occurred across Brazil, leading to a 77% year-to-year increase for the same tracking period. This covers 60% of the whole Amazon. Many fires are a result of either deliberate arson or carelessness. In addition, man-made events include arcing from overhead power and cable lines, arson, accidental ignition in the course of agricultural clearing, grinding and welding activities, campfires, cigarettes and dropped matches, sparks from machinery, and controlled burn escapes. Illegal entry to the reserve forests and felling of trees add to the possibility of fires being set off. So, it is evident that the loss of bio-diversity and natural resources is the result of growing economic activities in the forest and poor institutional monitoring of the activities.

3.3 Production Mode

The zoonotic transmission mentioned above suggests that viral infections tend to transmit fast when humans are getting closer to the wild animals. The close contact must be highly influenced by the environmental losses. So, one needs to investigate whether the nature of production relation influences the transmission. In a market economy, the goods and services are produced and exchanged between the producers and consumers on mutually consensus mode. The market determines how much to produce and consume. Mass consumption is embedded in the core tenets of economic growth. The higher the consumption, the higher the production, the higher the sales. With higher sales, higher profits are generated, a large part of which are re-invested to sustain the firm. The profits that determine the overall growth of the economy must be raised. This can be enhanced by either cutting-down the cost of production or raising market value of the products. But, the industrial production releases by-products that damage others and environment in the society, known as the negative externality, and the firm ignores them easily. By ignoring such cost, the producer can keep the per-unit cost at a lower level and thereby raises profit that accelerates its growth.

Let us illustrate the social welfare loss

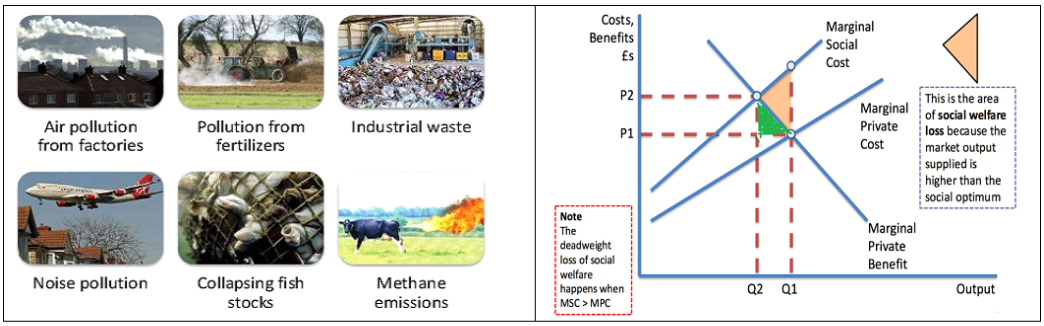

Figure 2: Example of negative production externalities and social welfare loss

arising out of negative externalities generated from economic activities with some typical examples (figure 2). The pollutant released by a factory, by the fertilizers used by a farmer and the industrial waste deposited in the urban fringe by a production unit imposes a cost on other individuals and society (known as social welfare loss), which is not borne by any of the parties engaged in the private exchange. Health and environmental damages instigated by these externalities are definitely a large part of social cost. This is also true for the noise pollution created by aviation, threat to the animal due to the methane gas release and loss of marine resources from over-fishing.

Any commodity produced by a factory meets demand from consumers and is exchanged on mutual agreed value in the market. As consumption rises, marginal private benefit from extra unit of consumption declines and hence the locus of marginal benefit faced by the firm is a negatively sloped (see Fig 2). In other words, the value to be paid by the consumer in exchange for the commodity must diminish. On the other hand, the marginal private cost incurred by the firm for each successive unit tends to rise. If the firm wants to maximize its own profit, the amount of production will be decided where the marginal private costs incurred by the firm should not exceed the marginal private benefit to be earned by the consumer. The producer and consumer pursue a deliberation to arrive at an equilibrium price for the exchange of the goods and services in the market that does not include social costs and damages done by the firm. In equilibrium, if the firm produces q_1 unit of outputs, this will be entirely sold to the consumer at p_1 price in the market. Hence, this is an equilibrium state. However, the amount of pollution generated by the firm to produce q_1 unit may damage environment and deteriorate the health condition of workers and similar issues in the society. If one accounts for such cost and adds to the production cost, the marginal social costs must be much higher than the marginal private costs (see Fig.2).

The equilibrium price, p_1, does not account for the additional social cost. So, the firm releases pollutants (say, CO_2 and toxic substance) that essentially raises temperature, discharges waste that damages human health, and destroys bio-diversity etc. These are the costs to the society and neither the firm nor the consumer engaged in the transaction in the market bear them.

Needless to say that higher the production, greater is the negative externalities and higher is the social welfare loss.

The state must intervene to fix this issue. For example, the state may completely ban or impose an environmental tax by the amount of extra social costs generated by the firm for the production of q_1. The firm revises the profit function by treating it as an additional cost of production and hence finds a new equilibrium state (say, (p_2, q_2)). The firm passes on a part of the tax burden to the consumer by raising the market price from p_1 to p_2, which essentially forces the consumer to cut down demand by the difference between q_1 and q_2. This is still good if the state could finance the corrective measures of the environmental damages and other social costs from the tax revenue.

But, the question is: can the state do the job effectively? It cannot. Even if the state imposes a tax to enforce the social costs, there are various loopholes in the market by which firms can bypass it. Note that the firm loses a bit of profit under the new equilibrium (shown in the figure by the green triangle below the p_1 line). First, the firm always tries to manipulate the system by bribing the regulators to move from new equilibrium (p_2, q_2) towards the old equilibrium (p_1, q_1) to raise profit by any means. How far the firm can proceed depends on the amount of bribe paid, quality governance and the extent of the firm's influence on the regulators to bend the rules and regulations. As long as the extra profit earned from the move is higher than the bribe paid, the firm does so and the state cannot finance the corrective measures for actual social loss. Moreover, even if the state is honest, the regulatory cost for policing such activities is so high that the state cannot effectively implement the taxation, unless individual ethics and morality compel to meet the taxes for a better society. But the tragedy is that such ethics and morality do not enter the market transaction. This apart, when states are in a race to accelerate economic growth or are attempting to escape from the recession, they would either be reluctant to intervene or deliberately ignore taking effective enforcement of compliance. In a political milieu rife with self-interested agents within a market environment, the effective implementation of tax penalties has met with very little success.

Even if the state could impose taxes to deal with the negative externality, it cannot make an accurate estimate of the losses from non-renewable natural resources specifically. The cost of non-renewable natural resources under the market rule is usually accounted for relatively short-term horizons, with almost no account of the future value of these finite resources. For example, the rate of greenhouse gas emissions into the atmosphere has increased sharply along with the acceleration of economic growth. The massive industrial growth of England in the 18th and 19th centuries, the United States prior to the two devastating World Wars, Western Europe (i.e., Germany, France, Italy etc.) in the postwar era, followed by Japan post-World War II, the East Asian Tigers in the last half a century and, of course the Chinese and Indian growth successes more recently, are prominent examples. Such massive growth does not count the amount of CO_2 injected to the environment and so on. The growth under the market with ineffective institution has utterly failed to limit the negative externalities damaging the environment and hence kept on killing nature.

The industrially developed countries are the top emitters in the world. The over-exploitation as a result of extraction, pro-

duction, and the use of non-renewable are largely due to underpricing those natural resources. In addition, the ever-expanding non-agricultural activities and urbanization are constantly putting pressure on them. As a result, natural resources (including forest, renewable and non-renewable resources) are shrinking sharply. That brings humans in closer contact with wild animals and accelerates the evolutionary changes of viruses, and thereby raising chance of infections.

Various national and international institutions have been constituted to deal with the environmental damages. None of these institutions could successfully check the economies from damaging the environment. International cooperation is also key to effective abatement. But, achieving meaningful international cooperation has proven to be a hard task. Even though nations have a common interest in preventing climate change, many are reluctant to reduce carbon emissions voluntarily. The recent Paris Agreement on Climate Change, in which 195 countries adopted the first ever universal, legally binding global climate deal, is indeed a very positive move towards international cooperation to protect the planet. But, the effective implementation in reality is lagging far behind the agreement (Dalby, 2016).

4. Crisis in Capitalism and the environment

The market-based rules have utterly failed to deal with negative production externalities and keep the environment clean. On top of it, contemporary evidences suggest that capitalism worldwide is passing through a severe crisis. Under crisis conditions, it is even more difficult to enforce environmental rules and regulations. The prolonged crisis would deteriorate the environment fast. During the last decade and a half, world economic growth has slowed down, in spite of a bit of revival after the financial crisis of 2008. The growth has dropped down to half from around 6% during early 2000s to nearly 3% in 2019–20, prior to the COVID-19 episode. The slowdown in most of the developed, developing and emerging countries including China, is the factor responsible for the trend.

The recession has been accompanied by rising unemployment and growing inequalities all over the world. In the absence of social security benefits, an individual cannot afford to remain unemployed for long and hence the unemployment figures cannot offer a true picture of the distress of the labour market. Statistics show that the world unemployment rate have gradually increased from 4.76% in 1991 to 5.42% in 2020 before COVID-19 pandemic (ILOSTAT database). In the less developed countries (specifically in Africa), the rate goes beyond 30%. Similarly, income inequality has risen sharply since the 1970s in most economies, including in the developed economies. The Gini index, a measure of inequality that ranges from 0 to 100 (index being 0 for perfect equality of income distribution, to 100 for total inequality of income), shows that it stood at around 26 and stayed there until the late 1970s in UK, and then sharply rose to 34 in 2010s. This trend is true for many countries. More importantly, the richest 10% of adults in the world own 85% of global household wealth, whereas the bottom half collectively owns barely 1%. Even more strikingly, the average person in the top 10% owns nearly 3,000 times the wealth of the average person in the bottom 10% (World Institute for Development Economics Research). Acknowledging these facts, Angus Deaton, the Nobel prize-winning economist, said: "There is this feeling that contemporary capitalism is not

working for everybody". Joseph Stiglitz, another Nobel laureate economist, echoed the same tone in his latest book, *People, Power, and Profits: Progressive Capitalism for an Age of Discontent.* According to him, the world is facing a multitude of challenges, from climate change and inequality to the crisis of confidence in the political and economic institutions. The capitalist system itself is undergoing an existential crisis.

The crisis of capitalism is revealed by the example of two key statistics – labour share (distributive share of workers in the value addition) and degree of market power (monopolization). An economic activity produces a value of commodity with the help of labour and capital (the main two factors of production), which is accounted for by subtracting the material costs from market value of the output. The credit of value creation should go to the hands of factory owners (workers and capital owners) and should be distributed between them. As their production relation is antagonistic, the distribution cannot make both of them happy simultaneously and is very much influenced by their respective bargaining positions. The strength of bargaining position depends on the political ideology of the state, regulatory supports, quality institutions, and market conditions. If the bargaining position of workers weakens, their distributive share falls definitely.

Suppose, GA denotes the value addition, W and R represent the wage and profit bills paid to them respectively, the distributive share of workers is represented by labour share (i.e., percentage share of W/GA). In other words, a higher labour share represents improvement of workers' welfare and purchasing power of an economy. Needless to say that the share falls due to a drop of either wage rate or employment opportunities. Both wage rate and employment opportunities depend on the number of firms engaged in the production. If fewer firms operate in the market, they enjoy a monopoly element in setting market price. If P represents a market price of a commodity produced by a firm and MC is marginal (additional) cost incurred to produce the same unit, the ratio of P/MC (say, m) represents the mark-up – the price setting over its marginal cost. If $P = MC$ then $m = 1$, and the firm sells its product at its marginal cost and does not earn more than normal profit. If perfect competition prevails in the market, there is no distortion and social losses. However, higher the value of m, greater is market power of the firm. A firm can inflate its price at a given marginal cost when it faces lower competition and less number of rivals. So, m accounts for a degree of market power and represents a proxy of the degree of monopolization. It can, therefore, be argued that the greater degree of monopolization and lower distributive share of workers are not healthy signs of capitalism. The monopoly firms can sustain its production for long if its rivals do not survive and workers do not find jobs and thereby reduce their purchasing power in the economy.

Anecdotal evidence suggests that the labour share of workers engaged in the aggregate economy has been declining sharply in most countries. A recent study conducted by the IMF highlighted a sharp downward trend in the labour share of workers in a large pool of countries and that has led it to being recognized among policy makers as the most important economic and social problem of the present time. In the advanced economies, the labour share began to decline from the early 1980s and hit the bottom during 2007–08 prior to the global financial crisis of 2008–09 (Dao et al, 2019). ILO (2017) highlighted that the labour share of national income, in terms

of total earnings for all employees and self-employed persons in Europe has declined from 75% in the 1970s to 65% in the recent years. On average, OECD (Organisation for Economic Cooperation and Development) countries have experienced a sharp fall from 64% to 59% during the same period. The IMF study further revealed a sharp drop from a much lower 55% of national income to 50%, for some advanced countries. In a sample of 35 advanced economies between 1991 and 2014, the labour share declined in 19 of them, which accounted for 78% of GDP in 2014. The drop is not confined to the developed countries only. In a sample of 54 emerging and developing economies on average, the labour share declined in 32 economies, which accounted for about 70% of emerging market GDP in 2014. The decline in these countries has been concentrated in the early 1990s to a large extent. It was also observed that the sharpest decline in the labour share was in the manufacturing sector, followed by transportation and communication, while some sectors (food, accommodation and agriculture) witnessed an increase. In the emerging and developing economies, the sharpest decline was found in agriculture. The declining labour share of national income is, of course, accompanied by the huge rise in the profit share going to the capital owners and a small proportion of elite employees within the labour share.

On the other hand, it is further evident that the market is getting imperfect and hence firms enjoy market power in setting price over its marginal cost. Using a disaggregated level of information over 43 countries, De Loecker and Eeckhout (2018) estimated that the average mark-up exceeds one for all the countries in 2016 and ranges from 2.84 (Denmark) to 1.19 (Portugal). Collecting the shreds of evidence from publicly listed firms in 33 advanced economies, Diez et al (2018) confirmed that the corporate market power has increased. Mark-ups have been rising steadily since the 1980s, and at an accelerated pace since the mid-2000s. This have been driven by small number of "superstar" firms in the upper strata of the industry distribution that are able to extract increasingly large markups. Measures of firm-level profitability have mirrored this increase in markups.

Now, why is the labour share declining and the firm gaining greater market power in the recent time? The current phase of globalization does not offer equal opportunities for all, especially for lower income people, and has weakened the bargaining position of workers (Rodrik, 1997; Stigliz, 2020). There is no doubt that the market reform measures prescribed by the World Bank during the last two to three decades has favoured the producer by weakening the bargaining position of workers. On top of this, the current phase of technological progress, led by information and telecommunications innovations and automation, replaced the workers fast, further reducing their bargaining strength. The automation of tasks that were previously performed by labour is the root cause for a permanent reduction in the labour share. Innovations are accelerating production and, thereby, bringing down the market price of the goods and services. Thus, technological progress still substitutes workers more than proportionately so that the labour share falls even faster. As a result, the aggregate savings have grown globally relative to the national incomes and that has accelerated capital-to-output ratios. The drop in labour share is driven by the rising industry concentration and the growing dominance of "superstar firms".

In the face of rising monopolization and declining labour share, the market cannot operate efficiently. The firms are getting

greater market power with the help of better technology – information technology and artificial intelligence as well as regulatory reforms. But, the demand for the products produced by them keeps falling with the declining labour share and rising unemployment. Moreover, small and medium enterprises, which could not compete with the 'giant' firms, face severe competition and that forces them to cut down the cost of production by ignoring environmental compliance to remain in the market. This is more pronounced at the time of recession hitting the economy. Hence, even a small external shock that generates recessionary pressure essentially devastates the economic growth and development outcomes and hence generates severe crisis. More importantly, a state is not inclined to implement strict compliance of environmental regulations in order to encourage productivity of firms, seen as a way to escape from the crisis at the cost of environment. The shock in the financial sector had done exactly the same thing during 2008-09 and the world economy has not come out of that crisis yet.

In the post-financial crisis, many countries including China were trying to revive the growth by ignoring the over-exploitation of natural resources. The compliance of environmental rules and regulations are relaxed in many countries to come out the recessionary phase. Moreover, a benevolent state aiming to ensure its incumbency cannot enforce such compliance effectively. The negligence to ensure such compliance allows firms to sell their products either at lower prices or reap higher profits by selling at the same price. Such negligence brings a clear threat to the eco-system and thus pushes humans to closer contact with wild animals gradually, which raises the possibility of viral outbreak. Therefore, the economic crisis aggravates environmental degradation and that stimulates further the possibility of such viral outbreaks.

Thus remains the question of regulating self-interest and how to build effective institutions, norms and culture that essentially exercises self-restraint in the activities damaging environment and health conditions. With the ability to perceive both immediate and long-term consequences resulting from the interference with nature by the progress of science and technology, society should change the production relation, interaction, culture, behaviour and move away from a system that threatens their very existence. The present mode of production driven by profit motive is largely concerned only about immediate tangible results for its survival, and hence disregard long-term sustainability. The severity of viral outbreaks in future depends on how and to what extent such mode of production could be governed by the norms, institutions and culture that may preserve long-term sustainable goals effectively.

5. Concluding Remarks

This article attempts to show that viral outbreaks are rising both in terms of number and death-tolls. The economic principle, driven by pure self-interest, which drives the production and consumption activities in the market is the root cause for the increased carbon emission, rising temperature and damage to nature and bio-diversity. This market and institutions therein cannot effectively curtail the negative externalities and social welfare losses created by economic activities. This calls for remedial strategies like an increase in R&D funding for research into bio-diversity, virology, climate change and medical development, as well as for building effective institutions and governance for regulating natural sources.

Recently, Krugman (2020), an eminent

economist, has recommended a 2% increase of R&D expenditure as a case for permanent stimulus in the post-corona pandemic period in the US. This may also be true for the developing world. But the problem is that it may further raise the fiscal deficits. For example, Japan has been quite successful in mitigating the damage control of the economy with the help of a higher R&D, in spite of the prolonged recession in the economy. If the R&D expenses are successfully and effectively spent, the improved health and environmental conditions can improve productivity, reduce the deficits and address the development outcome and more importantly, well-being of lives.

Therefore, a permanent rise of R&D share, say 2% of GDP, would encourage growth of the economy by preserving environmental resources, improving health conditions and creating spillover effect on private investment. The high growth gradually stimulates revenue (in the form of tax income keeping the tax rate at the same level). The increased tax revenue from the higher growth would gradually bring down the fiscal deficit in the medium to long-run, if not in the short-run. So, the permanent rise of R&D could reduce the frequency of epidemics and pandemics and resultant losses without putting much burden on the fiscal deficit. However, this adjustment and transmission mechanism would be extremely slow for an economy with a large informal sector and where extra-legal activities thrive.

Of course, a rise in R&D expenditure may mitigate the problem for some time. However, it cannot rule out the future occurrence of outbreaks to a large extent, as along as the economic principle of self-interest and maximum profit that drives activities in the market ignores the damage occurring from the negative externalities on the environment and unless steps are taken to rectify this cultural mind set. Humans have the ability to judge and understand the consequences on nature and, therefore, could try to change the economic activities in such a way that human livelihood can progress continuously and harmoniously with and sustain nature. The socio-economic system that they build would determine human interaction with nature and the path of resultant evolution. Therefore, the possibility of future outbreaks depends on the extent that the cultural and behavioural changes are shaped to replace and regulate purely self-interest mode of operation and institutions on the matter of environmental regulation.

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Mushroom and Health Benefits

Prakash S Bisen*

Introduction

Mushrooms can be found in forests around the world. Given the proper environment, mushrooms will grow and can offer a good source of natural vitamins and minerals. Mushrooms can also bring illness and even death to people who are unaware of certain types of wild mushrooms. Cultivated mushrooms are therefore the preferred and most reliable source of supply.

Mushrooms are commonly used for various dishes in different shapes and forms. The most commonly and easily cultivated mushrooms around the world are white button (Agaricus brunnescens (bisporus), oyster mushrooms (Pleurotus Ostreatus), ear mushrooms (Auricularia polytricha), and straw mushrooms (Volvariella volvacea), Shiitake (Lentinula edodes) Reishi mushroom (Ganoderma lucidum). Macrocybe sp., Agrocybe sp. types can also be cultivated successfully but will require more attention and knowledge. Mushrooms (often refers to the fruiting body of the gill fungi), yeasts and algal foods are frequently mentioned as alternative sources of food. Of these, mushrooms are the most preferred.

It is estimated that about 300 million tonnes of fresh mushroom can be produced from just one-fourth of world's annual yield of straw (2,325 million tonnes). It was calculated that approximately 317 million metric tonnes of fresh mushroom could be produced annually that would provide 197g of fresh mushrooms daily to each person in the world.

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Morphology

Mushrooms can be defined as a macrofungus with distinctive fruiting bodies, epigeous or hypogeous, large enough to be seen with naked eyes and picked up by the hands. The mushroom fruiting body may be umbrella like or of various other shapes, size and colour. Commonly it consists of a cap or pileus and a stalk or stipe but others have additional structures like veil or annulus, a cup or volva. Cap or pileus is the expanded portion of the carpophore (fruit body) which may be thick, fleshy, membranous or corky. On the underside of the pileus, gills are situated. These gills bear spores on their surface and exhibit a change in colour corresponding to that of the spores. The attachment of the gills to the stipe helps in the identification of the mushroom (Figure 1).

Mushrooms are the fleshy fungi which constitute a major group of lower plant kingdom. The mushroom is a common fungal fruit body that produces basidiospores at the tip of club like structures, called basidia, which are arranged along the gills of the mushroom. Beneath the mushroom, in the soil, is the mold colony itself, consisting of a mat of intertwined hyphae, sometimes several feet in diameter. The mushrooms first appear as white tiny balls consisting of short stem (stipe) and a cap (pileus), which begin to open up like an umbrella (Figure 2

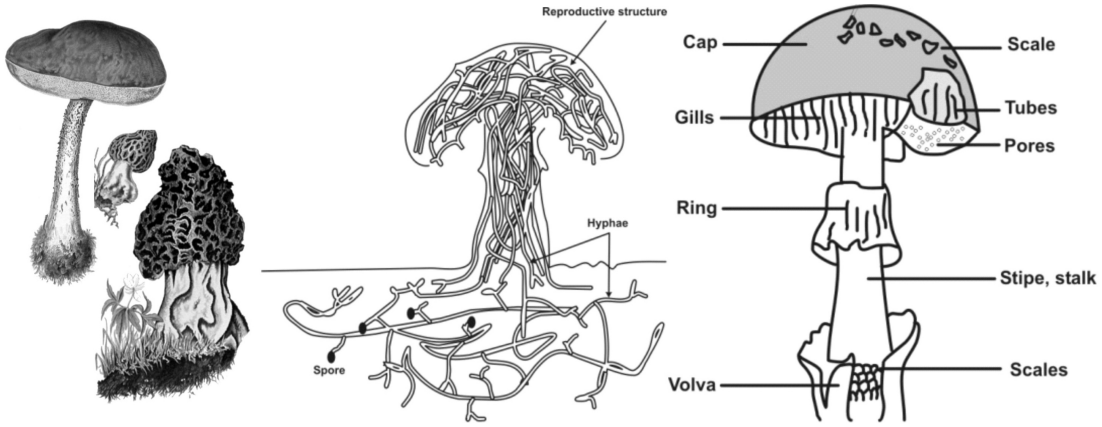

Figure 1: Morphology of Mushroom.

and Figure 3).

The delicate membrane or veil (velum) enveloping the cap tears off, if allowed to develop fully, andlamellae (gills) radiating from the stalk into the cap become visible. These gills become darkened as the basidiospores (seeds) develop into millions and fall to the ground for starting their lifecycle once again for second generation of mushrooms. Since mushrooms grow independently of sunlight so they can be grown in complete darkness but the darkness is not an essential prerequisite. They are relatively fast growing, do not require fertile soil, since grown on composted or uncomposted agro-wastes and their culture can be concentrated within a relatively small space. In addition to floor, air space is also utilized resulting in higher production. It is a labour intensive indoor activity which can help the landless, small and marginal farmers to raise their income, diversify economic activity and can create gainful employment especially for unemployed/under-employed youths, weaker section of the society and women folk. Agaricus campestris is one among several types of mushroom seen growing wild (Table 1). It is popularly called temperate mushroom or 'Khumb' and grows on dead organic matter under suitable environmental conditions. It derives its carbonaceous food by decomposing lignin, cellulose and hemicellulose present in agro-wastes with the help of extracellular enzymes secreted by the mycelium. Microbic protein available in compost is the chief source of organic nitrogen for its assimilation.

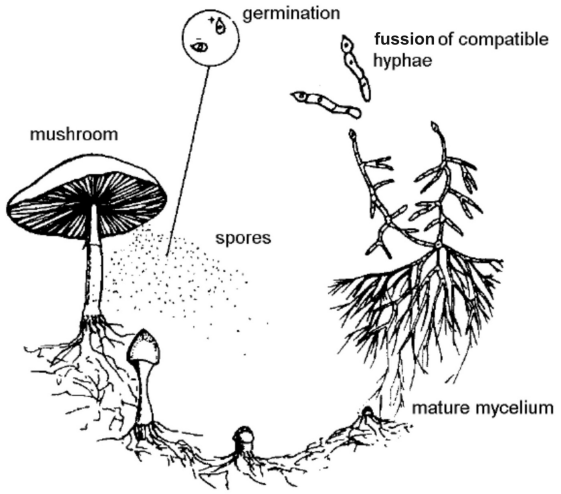

Figure 2: Life cycle of mushroom in natural environment.

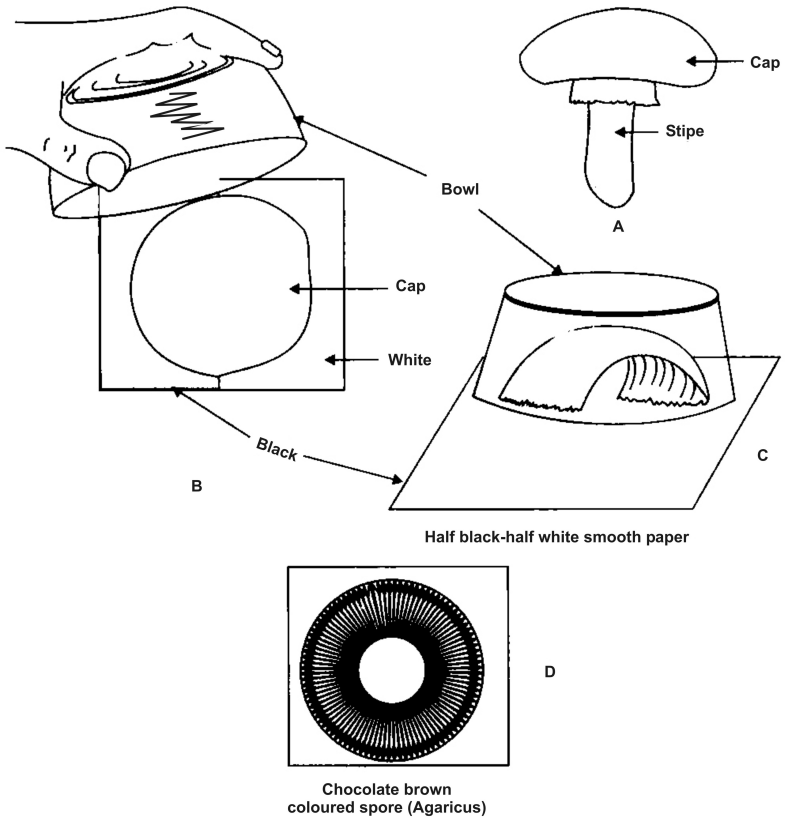

Figure 3: Flow diagram explaining spore print method for identification of mushroom.

Food value of Edible Mushrooms

The use of mushrooms as food is probably as old as civilization itself. They have been a delicacy since ancient times. The Egyptians regarded them as a food for Pharaohs. The Greeks and Romans described them as 'food for the Gods" and were served only on festive occasions. These were earlier preferred for their flavor and taste while their nutritive value was recognized later. Mushrooms provide a rich addition to the diet in the form of proteins, carbohydrates, minerals and vitamins. The protein content of fresh mushrooms (3g/100g) is about 3.7 per cent. It is twice as high as that in most vegetables except green peas, Brussels sprouts and pulses and is much lower to meat, egg, fish and cheese. They have a high percentage of all the nine essential amino acids with traces of sugar and without cholesterol having low caloric value (less than 35 Kcal per 100g), richer in vitamins (B1, B2, Niacin, B12, pantothenic acid and vitamin C) than most vegetables and almost free from fat (0.2g / 100g), a good source of minerals P, K, Fe and Cu recognizing them as a valuable source of nutritive and protective food.

Cultivated edible Mushrooms

Presently about a dozen fungi are cultivated in over 100 countries with a pro-

INCUBATION PERIOD			
Type of mushroom	**Incubation time (weeks)**	**Mushroom Flushes***	**Production time** (weeks)**
Oyster mushrooms *(Pleurotus ostreatus*	4	1st	5
		2nd	8
		3rd	11
		4th	14
		5th	17
Ear mushrooms *(Auricularia polytricha)*	4	1st	4-5
		2nd	8-9
		3rd	11-12
		4th	14-15
		5th	*Beware of mites*
Lentinus squarrosulus	4-5 or more	1st	5-6
		2nd	8-9
		3rd	11-12
		4th	14-15
		5th	17-18
Lentinus polychrous	4-5 or more	1st	5-6
		2nd	8-9
		3rd	11-12
		4th	14-15
		5th	17-18
Straw mushrooms *(Volvariella volvacea)*	*3-4 days for mycelium and 4-5 days for fruiting body.*	1st	*7-9 days*
		2nd	*14-16 days*
		3rd	*21-23days*

* Flushes means harvesting time or number of harvests
**Production time is the number of weeks following inoculation. This will depend on the season and to the amount of care given by farmers.

Table 1: Incubation period for the cultivation of few selected tropical mushroom.

duction of 2.2 million tones. Five genera, Agaricus, Lentinus, Volvariella, Pleurotus and Fiammulina, contributed about 91 per cent of total production. White button (Agaricus brunnescens (bisporus)) has the largest share (56%) followed by shiitake (Lentinus edodes) (14%), paddy straw (Volvariella volvacea) (8%), Oyster (Pleurotus sp.) (7.7%) and others (13%). USA produces about one-fourth of total white button mushroom production (0.35 million metric tonnes) followed by China (0.31), France (0.2), Netherlands (0.15), UK (0.12) and Taiwan (0.062). It is now grown in almost all the continents. Technology for its cultivation has advanced to a state in

which this mushroom can be grown profitably in locations with climatic conditions quite different from those in Europe and America where mushroom culture had its beginning and greatest development.

Studies show that certain types of mushrooms have a direct impact on body activities (Table 2).

Important Medicinal Mushrooms

Mushroom have a long history of use in traditional Chinese medicine. In fact it is estimated that in China more than 270 species of mushrooms are believed to have medicinal properties with 25% of them thoughts to have antitumour capability. Ganoderma lucidum (Reishi mushroom), Coriolus versicolour (turkey tail), Grifola frondosa (Maitake), Lentinula edodes (Shiitake), Cordyceps species (Keera ghas), Tremella fuciformis, Poria cocos and Pleurotus species (Oyster or Dhingri) have gained importance in modern medicine for their various pharmacological, immunological, anticancerous and other medicinal values.

Poisonous Mushrooms

The order Agaricales, commonly called gill fungi contains over 270 genera. These include the mushrooms, the toadstools and the boletes. The edible species are called 'mushrooms' and the poisonous ones, toadstools. These fungi are incapable of causing infectious diseases but produce toxic substances that poison a person who ingests them. These poisonous substances are collectively known as mycotoxins (myco = fungus + toxin = poison) and result in mycetismus (mushroom poisoning) following ingestion of poisonous mushrooms. These mushrooms contain lethal substances that destroy liver cells and excite the nervous system. The most deadly mushrooms are the death cap-Amanita phalloides, the closely related destroying angles-Amanita virona, the fool's cap-Amanita verna and the fly-agaric-Amanita muscaria. In the death cap, toxic principle is a mixture of α and β amanitin and phalloidin-both complex cyclic polypeptides containing sulfur. Cooking does not destroy the toxin nor is it affected by the human digestive juices. Symptoms of poisoning appear only after 8-24 hours of ingestion and by time the toxin is absorbed by the body; neither vomiting nor a stomach pump can help then. Eating poisonous mushrooms may result in various types of reaction like nervous disorder, gastric disorder, haemolytic disorder and muscular disorder. Some time even edible mushrooms can cause indigestion in healthy people and some people may be allergic to a species which is harmless to others. Causes of discomfort and indigestion may be due to eating too much, or eating mushrooms with indigestible food, or having been incorrectly cooked. Mushrooms may also cause illness if they are taken with alcohol.

Cultivation of Mushrooms

The most common mushrooms that can be cultivated using straw as the principal ingredient are Agaricus brunnescens (= A. bisporus) and Volvariella volvacea. Other edible species that can be artificially cultivated using straw as main substrate are mostly species of Pleurotus and Stropharia. Another quite popular mushroom, Lentinus edodes can be grown on freshly cut wood of several tree species. Usually the wheat and rice straw are used for the cultivation of species of Agaricus and Volvariella, respectively.

Termitomite sp.	Good for brain and memory
Volvariella volvaceae	Heal wounds
Coprinus sp.	Help the digest and decrease phlegm
Auricularia sp.	Clean lungs
Agaricus sp.	Increase mother's milk
Hericium erinacius	Heal wounds in intestine
Pleurotus sp.	Decrease muscle malpighia
Lentinula edodes	Good for baby's cartilage
Flammulina velutipes	Good for liver
Agrocybe cylindraceae	Good for kidney and urine
Schizophyllum commune	Decrease leucorrhea
Dictiophora sp.	Cure dysentery and decrease rotting
Trimella fuciformis	Good for sperm, semen and Kidney
Lentinus sp.	Control the whole body system

Table 2: Mushrooms as nutraceuticals.

Mushroom Type	Genus	Spore colour
Gilled mushroom	*Amanita*	White to pale
	Chlorophyllum	Green
	Clitocybe	Fleshy colour
	Hebeloma	Rusty to yellow brown
	Hygropharus	Cream
	Inocybe	Brown or cinnamon
	Lepiota	Green
	Naematoloma	Purple brown
	Panaceolus	Black
	Pleurotus	Lavender
	Russula	White, cream or yellow
	Schizophyllum	Pink, salmon or flesh
Tubed mushroom	*Boletus*	Yellow to olive brown
	Cyrodon	Yellow to yellow brown
	Suillus	Yellow brown to cinnamon
Puffball mushroom	*Scleroderma*	Purple black

Table 3: Specific spore prints of mushrooms.

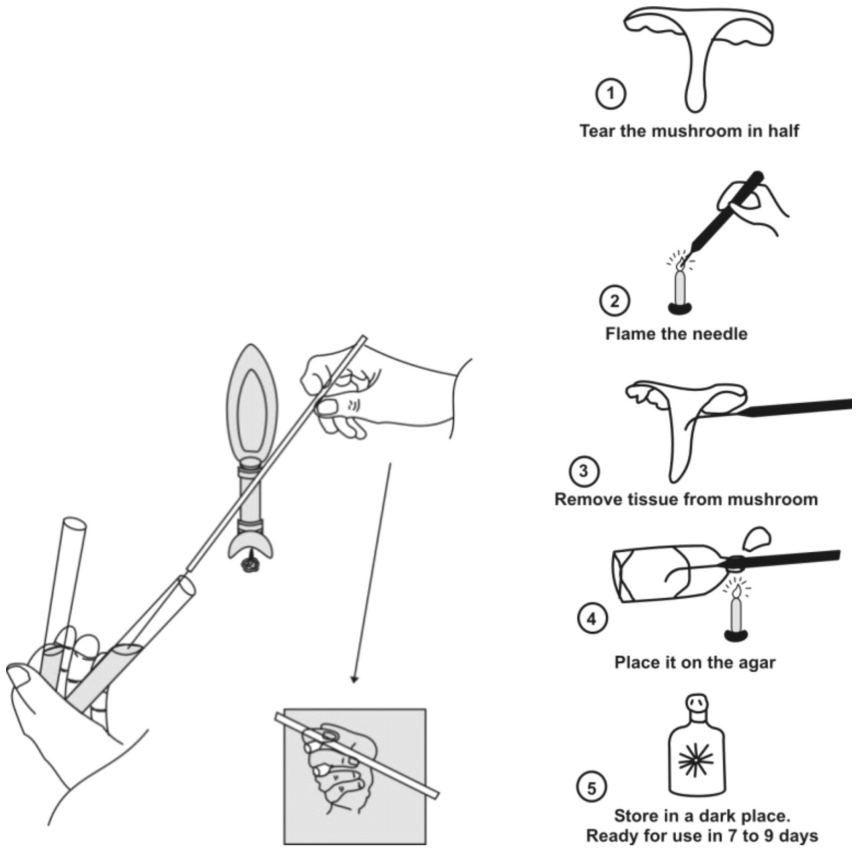

Figure 4: Isolation of mushroom culture.

Identification of Mushrooms by Spore Print Method

Several methods are used to identify mushroom and one of the most common method adopted is the spore colours. One of the generic feature of mushroom is the colour of spores which varies in different genera e.g. white, green, orange, brown, cream, etc. Though Agaricus and Amanita look alike from outer appearance, yet the spores of Agaricus are chocolate brown and that of Amanita white to pale. Spores are produced on basidia formed in gills of the basidiocarp.

The spore print is a simple method used for identification of gilled fungi. When the cap of mushroom is held stationary on a paper in a closed chamber for a long period, the impression of pattern of gills is printed, and the spores get accumulated onto the paper and invisible spores appear coloured (Table 3).

Method

1. Take a fresh mushroom for preparing the spore print for identification. Carefully cut the gill with the help of sharp knife.

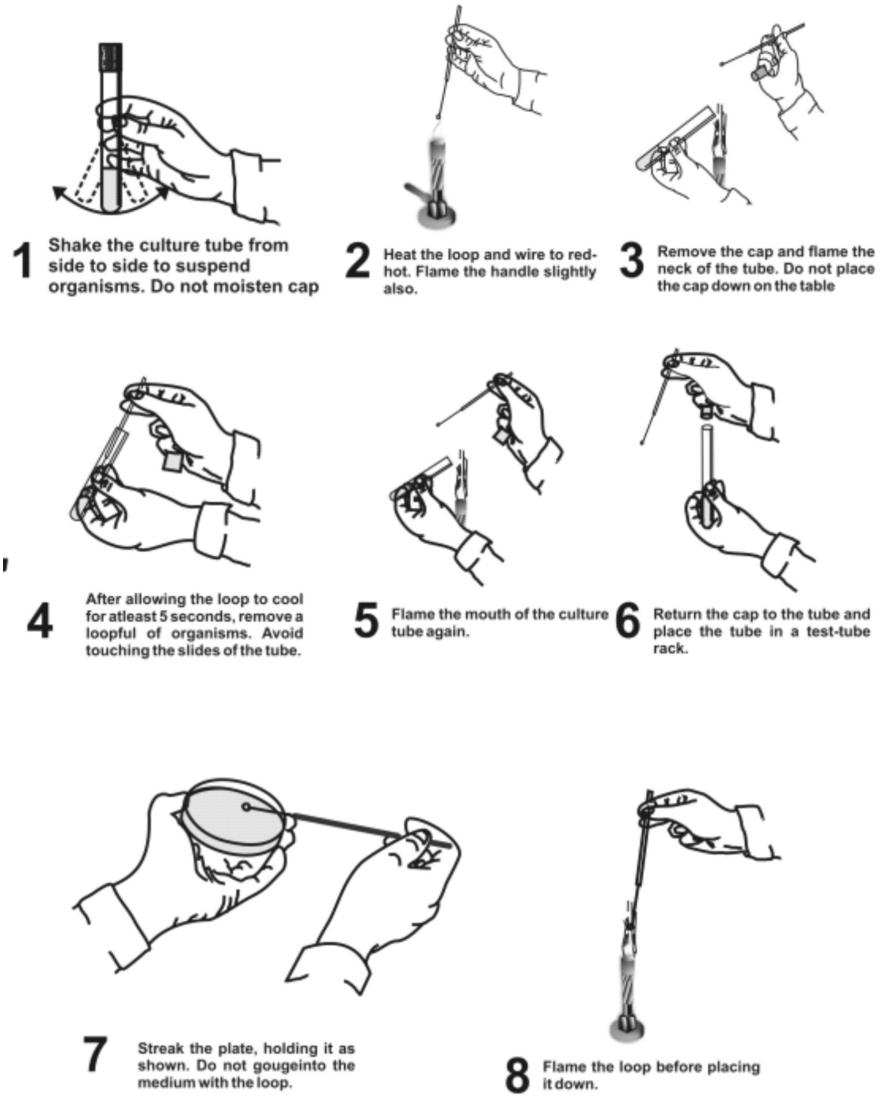

Figure 5: Isolation of mushroom culture.

2. Place gill side down of the cap on a half black and half white paper in such a way that half of gill should be towards black side and half towards white side.

3. Place a drop of water on the cap of mushroom and cover it by a glass bowl.

4. Leave this set up for about 8 hours or overnight undisturbed (Figure 3).

Gently remove the glass bowl and cap from the paper. This area shows the print of gills and spore deposits. Carefully study the gill pattern and spore colour and identify mushrooms studied by this method. Match colour with the colour dictionary and identify the mushroom.

Isolation and Maintenance of Mushroom culture

Method

1. Take a fresh mushroom for tissue culture, clean the surface with 70% aqueous ethyl alcohol, transfer a small piece with the help of inoculation needle under laminar air flow.

2. Clean both hands and bottles with alcohol and insert hands into the laminar air cabinet.

3. Hold needle with 2 fingers in a 45 degree angle, flame needle to disinfect until the needle turns red. Make sure it does not touch any surface after flaming.

4. While needle cools down (15-20 seconds - hold needle not to touch anything or place it on the clean surface of a glass).

5. Using other fingers, tear mushroom lengthwise (Do not use knife to cut).

6. With the needle, cut a small piece (2 mm x 2 mm) of fleshy tissue from inside the mushroom (in the middle between the cap and the stalk). Make sure that it is clean and did not touch the outside of the mushroom.

7. Flame around the PDA plate. Remove lid of PDA plate in front of flame to secure against contamination using other fingers. Inoculate the mushroom flesh on to the plates. Close the plate immediately near the flame (Figure 4).

8. Insert the needle in the bottle and inoculate by placing small piece of cut mushroom in the middle of the PDAs surface. Make sure the piece of mushroom does not touch anything before entering the PDA bottle close the mouth of the bottle before the flame with cotton plug. Label plates and indicate: Date, type of mushroom, culture.

9. Incubate plates and culture bottles at 28±20C in an incubator for 7 days and observe growth. Observe cottony radial growth on agar media.

Conclusion

Mushroom as a vegetable has become popular due to its food value in terms of protein and medicinal contents. They also show potential for use in waste management. Modem mushroom culture produces more protein per unit area of land than any other kind of agriculture and technology at present available. Mushroom farming is becoming successful because of its very low inputs. However, the successful operation of mushroom cultivation depends on the proper knowledge of laboratory techniques and practices involved in spawn production.

The DNA Technology (Use and Application) Regulation Bill, 2019

R L MAURYAN *

The **'DNA Technology (Use and Application) Regulation Bill, 2018'**[1] lays down the rules and the regulations for the use of DNA Technology in establishing the identity of certain persons in criminal and civil matters. It was first introduced in the Lok Sabha by the Minister for Science and Technology on August 9, 2018, and passed in the Lok Sabha on January 08, 2019, but it could not be cleared in the Rajya Sabha. Subsequently, its validity lapsed with the dissolution of the Lok Sabha, in view of the next General Election.

The Bill was again introduced in the Lok Sabha on July 08, 2019. It was then referred to the Standing Committee on Science and Technology, Environment and Forests for examination on Oct 19, 2019. The Chairman of the Standing Committee, Congress leader Jairam Ramesh has raised serious points on this Bill, which we shall discuss in this article, after giving a brief account of the actual provisions of the Bill.

It is no coincidence that the idea for the DNA Bill was first advanced by the Department of Biotechnology (DBT) in 2003 at the time of former Prime Minister Atal Behari Vajpayee. The present Bill is based on the draft submitted by the Law Commission- *'Human DNA Profiling – A Draft Bill for the Use and Regulation of DNA-Based Technology'* on 26th July, 2017 with its opinion that "discovery of DNA is considered as one of the most significant biological discoveries during the 20th century owing to its tremendous impact on science and medicine ··· It is acting as a very useful tool of forensic science that not only provides guidance in criminal investigation and civil disputes, but also supplies the courts with accurate information about all the relevant features of identification of criminals".

It further says, "DNA profiling technology is based on proven scientific principles, has been found to be very effective in the Criminal Justice Delivery System to identify the offenders. The DNA test has a 99.99% chance of correct conclusions and is perceived as an objective scientific test which may be difficult for an individual to refute, and outside of identical twins, no two people have the same DNA pattern".

The Bill allows collection of DNA samples and creation of DNA profiles of persons by the National DNA Data Bank and Regional DNA Data Banks in every state, and the setting up of DNA Test laboratories for the purpose after due accreditation. There will be a DNA Regulatory Board at the National level with the Secretary, Department of Biotechnology, as the Chairperson, and 12 other members, including an eminent person in biological sciences as the Vice-Chairperson, and members from NIA & CBI, etc. The Board is required to ensure that all information relating to DNA profiles with the Data Banks, laboratories and other persons are kept confidential and will also

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be responsible for giving accreditation to DNA labs in the States and have complete control over their functioning.

However, the Board shall discharge of its functions and duties under this Act, but will be bound by directions given by the Central Government on policy matters and if any dispute arises between the Central Government and the Board, the decision of the Central Government thereon shall be final. The Central Government may amend the Schedule so as to include or exclude therefrom, or vary the description of, any entry in any Part thereof by issuing a notification which shall be laid before each House of Parliament. No court shall have jurisdiction to entertain any suit or proceeding in respect of any matter which the Board is empowered by or under this Act to determine.

The Bill allows that DNA materials or body substances of the individuals or at the crime sites to be collected for:

Firstly, offences covered under the Indian Penal Code (45 of 1860) where DNA testing is useful for investigation of offences testing;

Secondly, offences committed under special laws, like the:

1. Immoral Traffic (Prevention) Act, 1956 (104 of 1956);
2. Medical Termination of Pregnancy Act, 1971 (34 of 1971);
3. Pre-conception and Pre-natal Diagnostic Techniques (Prohibition of Sex Selection) Act, 1994 (57 of 1994);
4. Protection of Women from Domestic Violence Act, 2005 (43 of 2005);
5. The Protection of Civil Rights Act, 1955 (22 of 1955);
6. Scheduled Castes and the Scheduled Tribes (Prevention of Atrocities) Act, 1989 (33 of 1989);
7. The Motor Vehicles Act, 1988 (59 of 1988).

Thirdly, for civil disputes and other civil matters:

1. Parental dispute (maternity or paternity);
2. Issues relating to pedigree;
3. Issues relating to assisted reproductive technologies (surrogacy, in-vitro fertilization and intrauterine implantation or such other technologies);
4. Issues relating to transplantation of human organs (donor and recipient) under the Transplantation of Human Organs Act, 1994 (42 of 1994);
5. Issues relating to immigration or emigration;
6. Issues relating to establishment of individual identity.

Fourthly, for cases pertaining to:

1. Medical negligence;
2. Unidentified human remains;
3. Identification of abandoned or disputed children and related issues.

The Bill provides that no bodily substances for DNA samples shall be taken from a person who is arrested for an offence (other than the specified offenses) unless consent is given in writing. The consent of the individuals will be required in case of crimes involving punishment up to seven years, while no consent is needed in case of crimes with punishment exceeding seven years.

However, the police can collect DNA samples after obtaining the permission of the court in other cases also. The Bill is silent on grounds and reasons for which the

magistrate can override consent. The International Covenant on Civil and Political Rights, 1966 (ICCPR) has observed that "no one shall be subjected without his consent to medical or scientific treatment".

The Bill allows two categories of persons to have their DNA collected without consent. One is in case of serious offences and the second where an order is made by a magistrate. Now the question is whether in both cases the DNA profiles should be included in the Database or only in cases where a court has ordered it. In case the person is a victim, or relative of a missing person, or a minor or disabled person, the concerned authority is required to obtain the consent of the said victim, or relative, or parent or guardian of the minor or disabled person.

Samples for DNA testing can be collected from the following sources, namely (a) bodily substances; (b) scene of occurrence, or scene of the crime; (c) clothing and other objects; or (d) such other sources as may be specified by regulations. "Intimate bodily substance" means a sample of blood, semen or any other tissue, fluid, urine or pubic hair, nails, saliva or a swab taken from a person's body orifice other than the mouth; or skin or tissue from an internal organ or body part, taken from or of a person, living or dead; external examination of the genital or anal area, the buttocks.

Also, DNA samples can be taken by vacuum suction, by scraping or by lifting by tape from the external genital or anal area, the buttocks and breasts in the case of a female; and taking of a photograph or video recording of, or an impression or cast of a wound. In case of the sample collected from the person, or from the place of occurrence of crime, being found to be contaminated, the court may direct the taking of fresh bodily substances for re-examination.

As per the Bill, every DNA Data Bank shall maintain this DNA data in the four categories: (a) a crime scene index; (b) a suspects' index or undertrials' index; (c) an offenders' index; (d) a missing persons' index; and (e) unknown deceased persons' index.

In addition, every DNA Data Bank shall maintain, in relation to each DNA profile, the following information (a) in case of a profile in the suspects' index or undertrials' index or offenders' index, the identity of the person from whose bodily substances the profile was derived; and (b) in case of a profile, other than a profile in the suspects' index or undertrials' index or offenders' index, the case reference number of the investigation associated with the bodily substances from which the profile was derived.

If the DNA profile is derived from the bodily substances of a living person who is neither an offender nor a suspect nor an under trial, no comparison shall be made of it with the DNA profiles in the offenders' index or suspects' index or undertrials' index maintained in the DNA Data Bank. Any information relating to a person's DNA profile contained in the suspects' index or undertrials' index or offenders' index of the DNA Data shall be communicated only to the authorized persons.

But it is necessary that the DNA profiles of the people who are missing or minors, who died in accidents or natural calamities be separated from the DNA Database of the people who are involved in crimes and other illegal activities. DNA database of the persons who have submitted voluntarily must also be separated. In fact, the removal of such DNA records shall be automatic, to avoid misuse by the authorities.

The Bill specifies that National DNA Data Bank shall remove from the DNA Data Bank the DNA profile (i) of a suspect, after the filing of the police report under the

statutory provisions or as per the order of the court; (ii) of an undertrial, as per the order of the court, under intimation to him, in such manner, as may be specified by regulations. The National DNA Data Bank shall on receiving a written request of a person, who is neither an offender nor a suspect nor an undertrial, but whose DNA profile is entered in the crime scene index or missing persons' index of the DNA Data Bank, shall remove of his DNA profile from there under intimation to the person concerned, provided that where such a DNA profile is of a minor or a disabled person, then removal shall be made on receiving written request from a parent or the guardian of such minor or disabled person. In fact, in all such removals, shall be automatic even without the request from the person concerned.

All DNA data, including DNA profiles, DNA samples and records thereof, contained in any DNA laboratory and DNA Data Bank shall be used only (a) to facilitate the identification of persons in criminal cases by the law enforcement and investigating agencies; (b) in judicial proceedings, in accordance with the rules of admissibility of evidence; (c) in facilitating prosecution and adjudication of criminal cases; (d) in one's defence by an accused in the criminal case in which he is charged; (e) in investigations relating to civil disputes or other civil matters or offences or cases specified in the Schedule, with the approval of the court, or of the concerned authority; or (f) such other purposes as may be specified by regulations.

A person who is authorized to access an index of the DNA Data Bank, including information of DNA identification records or DNA profile in that index, may also access that index for the purposes of carrying out "One-time keyboard search" on information obtained from any DNA sample collected for the purpose of a criminal investigation, except for a DNA sample voluntarily submitted solely for elimination purposes. "One time keyboard search" means a search under which information obtained from a DNA sample is compared with the information in the index of the DNA Data Bank without resulting in the information obtained from the DNA sample being included in the index.

The Bill also specifies that the DNA profile will be used in civil and criminal proceedings and for investigation of crimes by law enforcement and other investigating agencies. The DNA laboratory, after deriving the DNA profile and depositing it with the DNA Data Bank, shall return the biological sample or remaining material for its preservation to the investigating officer in a criminal case till the disposal of the case or the order of the court; and in all other cases, destroy the biological sample or remaining material and intimate the person concerned.

However, the DNA profile itself may be retained in the Regional DNA Data banks and this will be against the interest of the person whose profile it is and an invasion of his right to privacy.

As per the Bill, anyone who willfully discloses and uses or accesses, or knowingly and intentionally, destroys, alters, contaminates or tampers with biological evidence of DNA information, or prevents the production or use of that evidence in a judicial proceeding is punishable under the law. But we also know the levels of corruption in the police department and other investigating agencies, and how FIRs are manipulated to support the rich and influential. So there is a high possibility of tampering with evidence like replacement of DNA samples collected from crime scenes, contamination of samples, or manipulation of DNA record, creating grounds for a

miscarriage or denial of justice, particularly when it comes to the poor and deprived sections of the society.

We know that most of the DNA labs would be under private ownership. Although they may be accredited, the chances of replacement of DNA samples or generation of false DNA reports taking place in exchange for money cannot be ruled out. Many reports have surfaced about diagnostic labs issuing bogus negative reports in case of tests for Covid-19. In the absence of properly trained manpower, any mistake in collection DNA samples or deliberate biased and manipulated reports could lead to wrongful charges against and conviction of innocent people.

While carrying out DNA profiling and creation of a database by the labs, there is a likelihood to capture the personal details of an individual, which are purely personal, pertaining to information like personal traits, physical features, color of skin, religion, caste, sexual propensity, illness and health profiles, political affiliation, social activism, information that has nothing to do with the investigation or crime. This is an intrusion into the personal and private life of the person concerned, a violation of an individual's right to privacy. Such information could be misused to specifically target and even blackmail individuals and their families to stifle their voices, suppress activities frowned on by the powers that be, and force them to take positions they would not normally do.

It is reported in the press that the Parliamentary Standing Committee has flagged concerns over provisions of the Bill:
(a) *Can reveal extremely sensitive information:* DNA profiles of an individual containing sensitive information such as pedigree, skin color, behavior, illness, etc, can be misused to specifically target individuals and their families with their own genetic data.
(b) *Can target a particular community:* This is particularly worrying as the sensitive information could be used to incorrectly link a particular caste/community to criminal activities.
(c) *The threat to an individual's privacy and other safeguards:* The Bill proposes to store DNA profiles of suspects, under trials, victims, and their relatives for future investigations, even if the conviction of the offender has been overturned. Independent scrutiny must be done of the proposals to destroy biological samples and remove DNA profiles from the database. Though this will help in identifying repeat offenders; there is no legal or moral justification for a database with high potential for misuse.
(d) *Premature legislation:* As in the absence of robust data protection legislation, the security of DNA profiles placed with the National DNA Data bank and its regional centers is questionable[3].

Countries like the UK, USA, China, and Argentina have well-established laws for DNA sampling and profiling of the persons. In countries such as Holland, Germany, France and Austria, only individuals who have committed certain serious crimes are included in the DNA profiling. A Court order is necessary to obtain a tissue sample. Some countries allow retention of DNA samples for a period of time, whereas in most countries, DNA samples are destroyed upon acquittal.

"International evidence shows that the success of a DNA database is driven primarily by the number of crime scene DNA profiles loaded on to it, not by the number of DNA profiles from individuals, so proper crime scene analysis should be the top priority" [4]. As such, there is no need to collect DNA samples of the people who are not involved in any criminal activities and civil disputes.

In fact, DNA testing is presently permitted as per "The Code of Criminal Procedure (Amendment) Act, 2005 which came into force on 23rd June 2006, added to Sections 53, 53A and 54 to clarify the scope of medical examination and the extraction of the bodily substances, which includes the examination of blood, bloodstains, semen, swabs in case of sexual offences, sputum and sweat, hair samples and fingernail clippings by scientific techniques including DNA Profiling."[2]

Normally, "DNA fingerprinting is utilized as a tool for criminal investigation, to establish blood relations and trace medical history. Investigators would find "anonymous DNA" at the crime scene and compare it with the DNA of suspects for possible matches. Prior to the use of DNA, identification was heavily based on fingerprints, footprints, blood, or other evidence that a suspect may have left behind after committing a crime."

"When the DNA analysis of evidence found at the crime scene (for example blood, hair, saliva, sperm, etc.) is compared with the analysis of samples which make up the database, the investigators can locate the possible perpetrator of the crime"[2].

DNA technology can be used even on decomposed human remains to identify the victims. At the same time "all evidence and/or circumstances should be checked in making an identification, even if DNA provides the primary or sole evidentiary factor and DNA should not be considered the sole tool for identification, as many circumstances will allow for faster identification of the victims using dental records or fingerprint characteristics" [2].

Our different courts have taken different positions on a compulsary collection of DNA materials or samples. One of the courts concluded that "compulsory administration of the impugned techniques violates the right against self-incrimination. Article 20[3] aims to prevent the forcible conveyance of personal knowledge that is relevant to the facts in issue. The results obtained from each of the impugned tests bear a testimonial character and they cannot be categorized as material evidence such as bodily substances and other physical object"[2].

The Supreme Court held that: "The right to privacy is implicit in the right to life and liberty guaranteed to the citizens of this country by Article 21. It is a "right to be let alone". A citizen has a right to safeguard the privacy of his own, his family, marriage, procreation, motherhood, child-bearing and education among other matters" and "when there is an apparent conflict between the right to the privacy of a person not to submit himself forcibly to a medical examination and duty of the court to reach the truth, the court must exercise its discretion only after balancing the interests of the parties and on due consideration whether for a just decision in the matter, a DNA test is eminently needed"[2].

Whereas the Delhi High Court, in one of the cases, held that DNA testing does not amount to a violation of any of the rights. So there are no clear cut rulings of the courts on this issue. They also decide on merit, looking at the necessity of DNA tests on case to case basis.

On the issue of determining the paternity of a child, the courts have upheld that DNA testing should be made permissible only on the direction of the court, as no person can be forced to give his blood without such direction. The Supreme Court, in paternity cases, had rejected the prayer for permitting DNA evidence and has relied solely on the non-access principle.

As pointed out in the beginning of the article, that Central Government will have

complete control over the National Board of DNA and can amend anytime the schedules or portions of the Bill, and Courts will have no jurisdiction to entertain any suit or proceeding in respect of any matter which the Board is empowered to determine by or under this Act. Here lies the danger for misuse and manipulation of the Bill by the Government.

DNA technology has proved its effectiveness when it comes to identification and investigation, and deciding on civil disputes and determining paternity cases. However, on one hand, the fact is mistakes can arise from lack of proper training in handling of DNA material & blood samples. On the other, given the rampant corruption pervading society and institutions from Police Departments to Judiciary, fears exist that evidence can be tampered with at will, and deliberate disappearance, replacement & contamination of DNA samples can take place, all for the right price. The possibility of denial, subversion or miscarriage of justice is very real. It would be poor and deprived section of society who would suffer the most even with this new technology. One example is the way diagnostic labs have been found to be unconscionably willing to falsify reports in case of Covid-19 tests, just to make quick money.

How far will these DNA labs, Regional data banks that are to be set up in under this Bill be able to ensure the correctness of DNA test results? Will they keep secure and safe vital and confidential personal information, and ensure that it is not misused in any way against any individual? These are questions of grave concern. Simply by making laws, it does not follow they will be properly and conscionably implemented in the general interest of society and the common man, particularly in a capitalist social system like ours, where profit-making is the sole business and the raison d'être of the propertied class, and where deep-rooted corruption has become institutionalized in the bureaucracy and administration. The apprehensions about the misuse of DNA technology are not misplaced, given our present circumstances.

References

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[2] The Law Commission Report No 271, "Human DNA Profiling A draft Bill for the Use and Regulation of DNA-Based Technology", 26 July, 2017.

[3] https://www.jatinverma.org/the-parliamentary-committee-flags-concerns-over-dna-bill-summary

[4] The Hindu August 09, 2018

Organisational News

National programmes

Book release

The second edition of the book 'A Brief History of Science' was released online on Oct 6 by Prof S G Dani, Former President, National Board of Higher Mathematics. On the occasion, Prof Bikas Sinha, Former Director of Saha Institute of Nuclear Physics spoke on the life and work of Prof. Meghnath Saha. The program can be viewed on Breakthrough Science Society Youtube channel https://www.youtube.com/watch?v=wDwRejqh47Q.

A screen-shot of the book release programme

Nobel Prize lecture

Breakthrough Science Society organised a webinar on the Nobel Prize in Physics 2020, titled 'On Black Holes and Singularities' on November 1, 2020. The lecture was delivered by Prof. Jasjeet Singh Bagla, Dean, Academics, and Professor of Physics, Indian Institute of Science Education and Research (IISER), Mohali. The program can be viewed at https://www.youtube.com/watch?v=kGuJ4LqktNI.

A screen-shot of the talk by Prof Bagla

Hindi Science Magazine 'Vigyan Chetna'

The online edition of the Hindi Science Magazine 'Vigyan Chetna' published by the All India Committee of Breakthrough Science Society was unveiled and inaugurated by Dr. Soma Marla (Principal Scientist, Bioinformatics, ICAR, NBPGR, New Delhi) on 15 September 2020. A discussion was also held on the 'Role of science magazine in spreading scientific thoughts'. Dr. K N Jha (Principal, Government Polytechnic College, Ashoknagar, Madhya Pradesh) and Mr. Debashish Roy (Vice President, All India Committee, Breakthrough Science Society) were the main speakers. The program was broadcast live on the 'Vigyan Chetna' Facebook page.

Bihar

Breakthrough Science Society, Jamalpur, Bihar, organized a viewing program of the

Jupiter-Saturn Conjunction on 21 Dec, 2020 using a reflecting-type telescope. Many teachers, students and local people watched the event with enthusiasm. Later, a short quiz on astronomy was also organized.

Chattisgarh

9th Aug 2020: An online poster demonstration was organised on the occasion of the India March for Science on Aug 9, 2020. Students held placards with the demands of IMFS and circulated on social media.

A webinar was also organised in which Dr. D S V G K Kaladhar (HoD, Microbiology Dept., Atal Bihari Bajpeyee Vishwavidyalaya, Bilaspur) and Dr. Renu Nayar (HOD, Chemistry Dept., DP Vipra College, Bilaspur) spoke on the issues raised by the March for Science movement.

15 Sept 2020: BSS Dhamtari Chapter in Chhattisgarh organized a webinar on the occasion of 53rd Engineer's Day on the topic "The role of engineering in the development of society and civilization". Mr. Yogesh Dewangan (Principal, Govt ITI Kurud) and Miss Pooja Sharma (State convener, BSS Chhattisgarh chapter) were the main speakers.

30 July 2020: BSS Chhattisgarh Chapter organised a webinar on July 30, 2020 to commemorate the 129th death anniversary (29 July) of the great humanist Ishwar Chandra Vidyasagar. Mr. Debashish Roy (Vice president All India BSS) was the main speaker.

25 June 2020: BSS Chattisgarh Chapter organized a webinar on "Covid-19, its social impact and the role of science activists". Mr. Debashish Roy, All India Vice President of Breakthrough Science Society was the main speaker. Dr. D S V G K Kaladhar (HOD of Microbiology Dept., Atal Bihari Bajpeyee Vishwavidyalaya, Bilaspur) made a detailed presentation on Corona Virus. Mr. Sharad Kokas, science activist, spoke about the misinformation on the Corona virus prevalent in the society.

Delhi

An online seminar on the topic 'How humans evolved' was organized on July 3, 2020. Dr Soumitro Banerjee, General Secretary, Breakthrough Science Society and Professor, IISER Kolkata, was the main speaker. Dr. Vinay Kumar (In-charge, BSS, Delhi chapter) coordinated the program.

Gujarat

Universe Science Forum (USF) and ASTRONOMICA organized a lecture series on the Nobel Prizes. Dr. Durgesh Modi delivered a lecture on "Nobel Prize in Medicine/Physiology" on 11 Oct 2020. The lecture on "Nobel Prize in Physics-2020" was on 25 Oct, 2020. Shri Arnav Chaturvedi and Shri Jatin Tekani were the speakers.

Jharkhand

At Ghatshila, a sky-watching program was organized on the occasion of the Jupiter-Saturn conjunction on Dec 21. Students and their guardians numbering more than 200 participated in the program. The local newspapers covered the program.

The Hazaribag and Bokaro chapters jointly organized a webinar on 21 December, 2020 at 4.30 PM. The speakers Mr Rajesh Kumar and Mr Manoranjan Kumar explained the astronomical phenomenon of Jupiter–Saturn conjunction.

Karnataka

State Level Online Science Festival: The festival conducted in the months of May and June 2020 drew about 400 plus registrations across various age groups from

various districts of Karnataka. The events included Poster Making, Cartooning and Science Poetry.

Online Webinars during the COVID-19 :

- 'Life without water' by Prof T.V Ramachandra (IISc Bangalore)
- 'How scientific thinking can help tackle misinformation' by Ms. G. Satish Kumar
- 'Life and works of Marie Curie' by Ms. Rajani K.S
- 'Deciphering the Universe with Gravitational waves' by Prof Bala Iyer
- Discussion on 'Why should we study History of Science'

Dharwad District: Weekly webinars were held on the following topics.
1. Life and relevance of Ishwarchandra Vidyasagar;
2. Life of Meghanad Saha;
3. Advent of agriculture – Two part series;
4. Relevance of studying history of medicine in the background of the pandemic COVID-19;
5. Some interesting stories of invention and the anatomy of heart;
6. Life of Sir C V Raman;
7. Life of Prof. J C Bose.

Jupiter–Saturn Conjunction, 21 Dec. Viewing programs were organized in localities with limited numbers at residential areas in Bangalore. Gulbarga chapter organized viewing programs with two telescopes. Children, students, teachers and common people numbering more than 90 attended the viewing programs. A state-level study class on 'History of Science' has been initiated with a participation of 75 members on Google Meet.

Kerala

Ernakulam

Learning Science through Experiments: Online live demonstration and discussion on Oxidation Reduction Reactions by Sri Sajeevkumar P P and a presentation on Michael Faraday by Mr Harikumar K S on 19 Sept, 2020. An experiment on electricity by Anand George on 3 Oct, 2020.

A talk on 'How stars are formed' was organized by Galileo Galilee Science Club, Aluva on 13 Dec 2020. Ms. Sandra made the presentation and Mr Harikumar K S conducted a discussion on the topic.

Kottayam

June 5, 2020: Observed World Environment Day by conducting social media campaign on the theme 'Celebrate Biodiversity'.
17 June 2020: Webinar on Landslides in Kerala by Dr Sajinkumar, Asst. Prof. Dept of Geology, University of Kerala.
6 August, 2020: Observed Hiroshima–Nagasaki day by children making Sadako cranes and taking part in drawing and painting competition.
23 August 2020: Webinar on 'Growing environmental problems and the EIA 2020 Draft' by Dr T V Sajeev, Scientist, Kerala Forest research Institute (KFRI)

Trivandrum

May 13, 2020: Webinar on 'Lightning – Science and Safety' by Dr. V. Sasikumar, Former Scientist, CESS Thiruvananthapuram. Participation – 100
June 7, 2020: World Environment Day Webinar – 'Tropical Cyclone and Climate Change' by Dr. M. Govindan Kutty, Associate Professor, Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, Trivandrum. Participation – 160

July 5, 2020: Webinar on 'Viruses, Vaccines and the Race for a SARS-Cov-2 Vaccine' by Dr. Subramani M (Former Professor, Vanderbilt University, USA). Participation – 200.

July 11, 2020: Webinar on 'Madam Curie: A life dedicated for science and humanity', for school students. Participation – 60.

July 25, 2020: Webinar on 'NASA's Mars 2020 Mission' by Surbhi Baghotia, Scientist, VSSC, ISRO, Trivandrum. Participation – 1500.

Sept 13, 2020: Webinar on 'Exoplanets and the Search For Habitable Worlds' by Dr. Anand Narayanan, Associate Professor, Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, Trivandrum. Participation – 500.

August 15, 2020: Panel discussion on 'Pandemics and Science'. Panelists: Dr. Anish T S, Department of Community Medicine, Government Medical College Thiruvananthapuram and Dr. Babu P S, President, Breakthrough Science Society Kerala chapter. The program was organised by India March for Science, Trivandrum Organising Committee. Participation – 300.

October 17, 2020: 'A brief history of Exoplanets: from their discovery to present' by Dr. Manoj Puravankara, Associate Professor, Dept. of Astronomy & Astrophysics, Tata Institute of Fundamental Research, Mumbai. Participation – 600.

13 December 2020: 'Story of Telescope' by Sri. Arul Jerald Prakash (Former Director, KSSTM). Participation – 100.

Madhya Pradesh

The Indore chapter of BSS organised a science experiment demonstration program on 27 Dec 2020. Children demonstrated several science experiments and projects and explained the principles behind them. Mr. Ajit Singh Panwar and Mrs. Arshi Agarwal discussed about the need to cultivate scientific outlook, particularly in children. Around 50 students participated in the program.

On the occasion of the 200th birth anniversary of the great humanist Ishwar Chandra Vidyasagar, a webinar was organized on 'Life struggle of Vidyasagar' on 27 Sept, 2020. Dr. Dipti Gaud (teacher) was one of the speakers. Similar programs were organised in Guna, Indore and Ashoknagar. In Guna the main Speaker was Mr. Sachin Logariya (Fd. Safety officer). The program was conducted by Mr. Vikas Bansal. In Ashoknagar the main speaker was Dr. K N Jha (Principal, Govt Polytechnic College Ashoknagar, M P). The program was moderated by Mr. Krishna Bairagi. A good number of students attended the webinars. An online Science competition was organised by Breakthrough Science Society, Gwalior chapter, on the occasion.

Telangana

A competition on science experiments called 'Let's do some Science', was organized on the occasion of the Engineer's Day on 15 Sept 2020. A good number of students participated.

Jupiter – Saturn Conjunction 21 Dec 2020: Discussion cum visit to Birla Science museum: Mr Devarshi Gangaji, President, BSS, Hyderabad explained about the phenomenon of Jupiter-Saturn conjunction to a group of BSS activists and children. Later the group visited the Birla Science museum and viewed the sky watch show on Jupiter-Saturn conjunction.

Webinars held:

'How did Humans evolve?' by Dr Soumitro Banerjee, Gen Secretary, Breakthrough Science Society and professor, IISER Kolkata on 17 June 2020.

'Role of immunity fighting against COVID-19' by Dr.Bakthair Choudary.

'Nobel Prize in Physics – Black Holes' by Dr.Rukmimi Jagirdar, HOD, Dept of Physics, Osmania University.

Two part lecture series on 'COVID-19' by Dr.Vikas Sharma, Asst.Professor, University College of Science, Osmania University.

Tamil Nadu

History of Science lecture Series:

Breakthrough Science Society, Tamil Nadu chapter organized an online series of talk cum discussions every week on Fridays on the history of science based on the chapters in the book "A Brief History of Science" published by the Breakthrough Science Society. The series began on 12 June, 2020 and ended on 18 Dec 2020 after completing a total of 21 sessions. A good number of participants attended the sessions regularly and enthusiastically took part in the discussions. The recordings of the talks are available on the Facebook page of BSS Tamilnadu.

June 20: Webinar on 'COVID-19: The source of origin and types of Indian SARS-Cov-2'. The speaker was Dr Kumar Sundaram, Professor, Microbiology and Cell Biology, IISc, Bangalore.

June 5: As part of observance of World Environment Day a webinar was organized. Prof K Palanivel, Centre for Environmental Studies, Anna University was the main speaker. Students from Govt High School, Puzhal, D Kirthika and R Kumaravel also made presentations.

May 30: Webinar on 'Mountains on Moon: How to see and measure their heights'. Prof Joseph Prabagar, Dept of Physics, Loyola College, Chennai, gave the presentation.

Tripura

Jupiter- Saturn conjunction: On 21 December, 2020, BSS Tripura Chapter organised a sky watch program at Arundhati Nagar H. S. School ground where participants viewed the rare cosmological event 'Jupiter-Saturn Conjunction'. The participants also viewed moon and its craters. More than 50 students participated in the viewing program and the discussion on astronomy.

West Bengal

Lecture program on Nobel Prize in Chemistry: BSS, West Bengal Chapter organized a webinar titled "CRISPR/CAS: Cut your gene where you want" on 20 Dec, 2020. The speaker was Prof. Parimal Mishra, Chief Scientist and Professor, Dr. Reddy's Institute of Life Science, Hyderabad. Prof. Mishra elaborately discussed the fundamentals of CISPR/CAS based genetic engineering tools and its diverse applications in medical science particularly in drug design system. The talk was followed by a Questions-answer session in which many participated actively.

A webinar on 'Materialism in ancient India and its influence on the cultivation of science' was organised on 12 July, 2020. The speaker was Mr. Subrata Gouri, eminent science writer and Vice President, BSS.

Science for Society Science for Man Science in Thinking

BREAKTHROUGH SCIENCE SOCIETY

A Voluntary Organization Committed to the Cause of Science, Culture and Scientific Outlook

The science organization BREAKTHROUGH SCIENCE SOCIETY (BSS) was started in West Bengal in the year 1995 as a platform to create a new science movement in the country. Since then it has been functioning as a non-profit social welfare organization registered under the West Bengal Societies Registration Act, 1961 with the Registration No. S/86180 of 1996-97. It has now taken the form of an all-India organization, through the All India Science Conference held in Bangalore, 17-19 October 2014.

AIMS AND OBJECTIVES

1. To cultivate and promote scientific outlook and logical faculty of mind to establish a scientific culture in the society; 2. To explain, disseminate and popularize different discoveries and advancements of science; 3. To foster consciousness against unscientific notions, superstitions, fanaticism, communalism, untouchability, casteism and such other orthodoxy; 4. To cultivate the study of history and philosophy of science; 5. To inculcate ethical values and social responsibility in all fields of scientific endeavour; 6. To work towards a scientific education system through devising and introducing correct method of teaching and learning; 7. To fight against the application of science that would cause harm to the society and destruction of humanity. 8. To conduct campaign and movement for a secular, scientific and democratic education policy; 9. To mobilize opinion and to move for the introduction of correct and pro-people government policies in regard to research, development and application of science and technology; 10. To build up movements for the preservation and socialization of natural resources and for protection of environment; and 11. To stand by the people and to provide relief at the time of natural calamities.

ACTIVITIES

We function through Science Clubs, Societies, and Chapters of BSS created in different localities and educational institutions. They take up a variety of activities to pursue the above objectives. Some of these are: (1) Popularization of astronomy and counterposing it against beliefs in astrology (we organized large-scale programmes on the occasion of the Total Solar Eclipse of 1995, 1999, and 2009, the arrival of the Comet Hale-Bopp 1997, Leonid Meteor Shower 1998, Transit of Venus 2004, 2012, etc.); (2) Comprehensive science education through experiments at the school level; (3) Anti-superstition campaigns; (4) Cultivation of the life and struggle of great scientists; (5) Relief works for people affected by natural calamities like flood, earthquake, super-cyclone, tsunami etc.; (6) Scientific agriculture; etc.

Our central office is open every Monday, Wednesday and Saturday from 5 p.m. to 8 p.m. at
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