Epidemics & the environment

Could Covid-19 be the unwitting saviour of the Earth?

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What we have been through during these last three months will leave an impression on young minds.

Scientists have been speaking of global warming and human destruction of the environment for several decades. In response, there have been international parleys and resolutions to cut emissions, campaigns, seminars, education programmes. Nobody, however, seems to have been convinced, as there is little change in lifestyles. And targets are not being met.

Covid-19, which has created the current crisis, is the chance evolution of a virulent pathogen, and it has no relationship with environmental damage – for there have been outbreaks before we heard of global warming. The crisis, however, is bringing general people face-to-face with natural phenomena, which need to be controlled individually, and with objective, scientific measures. Objects like the virus, molecular biology, RNA and DNA, are concepts of frontier sciences that have developed in recent decades. In a few quick weeks, common people have become familiar with these terms. Against an invisible enemy, we understand the need to use personal protection and the value of sanitisers. And hygiene is being practiced from a scientific perspective. This may be a turning point towards internalising what we learn in science. When corona is behind us, people may lend a more attentive ear to things said about the environment.

Speaking of the environment, the journal, *Nature*, has carried a report, by a group from institutes in Australia, with others from the US, Denmark, Sweden, Spain, Estonia, Belgium and Germany, that negates a belief that mature forests would soak in more carbon dioxide when the carbon dioxide content of the atmosphere increases. This finding suggests that it would be advantageous to replace old forests with new forest plantation, while the wood from old forests provides environment-friendly building material.

In the same context, of reducing the environment cost of construction activity, there is a paper by researchers at the Royal Melbourne Institute of Technology University, Melbourne, Australia, that proposes blast furnace slag as a material to help clean wastewater, a process that improves its value as aggregate in concrete. Even while wood may replace concrete in construction, this use of blast furnace slag would reduce the net footprint of steel and cement manufacture.

While carbon dioxide is the main greenhouse gas that causes global warming, it is also the "raw material" for photosynthesis by plants. The carbon dioxide reducing function of the Earth's green cover would hence get stronger when the carbon dioxide content rises. This has generally been found to be true, the paper in *Nature* says, and substantial increase in carbon dioxide uptake has been measured when the ambient carbon dioxide content increases, in the case of rapidly growing, young forest plantations. Whether this is true in the case of mature forests, which are viewed as the greatest carbon sinks, is of critical importance, the paper in *Nature* says.

Mature trees were also found to show increased carbon dioxide uptake, but it was not clear where the additional carbon extracted by these trees was stored. In the case of young trees, the sugar created by photosynthesis is used for the growth of the trees. But in a mature forest, growth has been found to be limited, as the tree needs nutrients from the ground below, in addition to sugars, to grow. A series of Free-Air CO2 Enrichment experiments were hence carried out in a warm-temperate, evergreen forest in Australia, which had not been disturbed for 90 years. The carbon transport, that is, absorption and end use, in plots where the carbon dioxide content had been increased by 150 parts per million, over a four year period, was collected and compared with control plots.

The study revealed that a good proportion of the carbon absorbed by mature trees ended up by being transferred to the Earth below, consumed by soil microbes and respired back into the atmosphere. The results call into question the predominant thinking that the capacity of forests to act as carbon sinks will be generally enhanced under increased carbon dioxide, the paper says.

Current civil construction is dominated by use of concrete and concrete reinforced by steel bars. As the manufacture, both of cement for concrete, and steel, is carbon intensive, civil construction has a large carbon footprint. The use of wood in place of concrete, so that buildings contain and preserve the carbon sequestered by forests, rather than pollute the atmosphere by energy intensive processes, is hence of interest. The finding that mature forests are not the great carbon sinks they were imagined to be during rising atmospheric carbon dioxide levels is to encourage use of wood from mature trees for construction, along with cultivation of equal, young tree populations.

Using waste

The study at RMIT University, Melbourne, is relevant to the manufacture of cement and steel. Concrete consists of finer particles of sand and larger particles of crushed stone, bound together by cement. The material can bear very high crushing loads and has been a traditional construction material. The use of steel rods to reinforce concrete adds the capacity to bear bending loads and reinforced concrete dominates civil construction.

Manufacture of both cement and steel consumes energy, and their use has a heavy carbon footprint. In the manufacture of steel, ores of iron are reduced to the metal by the use of high temperature, and carbon, to draw away the oxygen from oxides of iron. What is left is a rocky material, the slag, which has use for road building and as the aggregate or the coarse material in concrete. Another use of blast furnace slag is to absorb chemicals from wastewater, before the water is allowed to mix with streams or to soak into the ground.

Municipal wastewater contains significant quantities of phosphorus, which would affect the plant and animal life in water bodies. Blast furnace slag is found to be effective in removing most of the phosphorus contaminant. This is apart from the granules of slag filtering out iron and manganese that wastewater contains. Now, the study shows that apart from cleaning waste water, blast furnace slag also undergoes changes, in the process, that improve its performance as aggregate in concrete. Concrete with blast furnace slag is 17 per cent stronger than with ordinary aggregate and again, eight per cent stronger when the slag has been treated with wastewater, the study shows. This creates a circular economy, with a by-product of manufacture of steel, which is used to strengthen concrete, finding another use, which again, improves its value in concrete. The use of concrete could be reduced, with two-fold benefit to the environment, by the use of wood in civil construction. Next, the use of reinforced concrete itself can be made more environment friendly when blast furnace slag helps purify wastewater before release into the environment. And then, the very process leading to less use of concrete.

The world has taken many steps to reduce the load on the atmosphere – generating electricity without burning fossil fuels, improving industrial processes, limiting the use of plastics and fertilisers and the use of biotechnology. The impact, however, has not been felt, and lifestyles encourage waste, power consumption and travel. The short periods of shutdown that Covid-19 has imposed on the world however, has that it is possible to live without much that we considered indispensable. Could living grow sensible when things normalise? Could Covid-19 be the unwitting saviour of the Earth?

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PLUS POINTS

Important innovations

A team of researchers at the Indian Institute of Technology-Guwahati has developed affordable antimicrobial (antiviral/antibacterial) spray-based coating for personal protective equipment and 3D printed ear guard for comfortable use of face masks by healthcare workers. Both concepts have been developed by Biman B Mandal, professor, department of biosciences and bioengineering, IIT-Guwahati, along with his PhD scholars, Bibhas K Bhunia and Ashutosh Bandyopadhyay. The PPE that are being used presently are designed to protect the wearer from infectious microbes/aqueous virus droplets acting as a barrier. However, these PPE, generally, do not have the ability to prevent the spread of microbes as the surface of the fabric readily allows adherence and accumulation of microbes with time. This leads to further spread of the microbes due to negligent handling of PPE and wrong disposal protocols.

In an attempt to safeguard healthcare workers and citizens from the current coronavirus crisis and other infectious diseases, the research group has developed an affordable antimicrobial (antiviral/antibacterial) spray-based coating for PPE kits to kill and prevent the spread of microbes once they come in contact with the coated PPE surface.

The strategic association of metal nanoparticle cocktail, such as copper, silver and other active ingredients, present in the spray acts as an antimicrobial agent. This ensures limited penetration and accumulation of microbial contaminants on PPE. Thus, the coating has the potential to reduce the risk of secondary infection by limiting the transmission of the microbes. The innovation is affordable and readily deployable using existing infrastructure available with PPE manufacturers. It can be spray/dip-coated onto any kind of surface including textiles and other medical device surfaces to get rid of microbial load. This will allow reusability of PPEs and easy containment of the microbes.

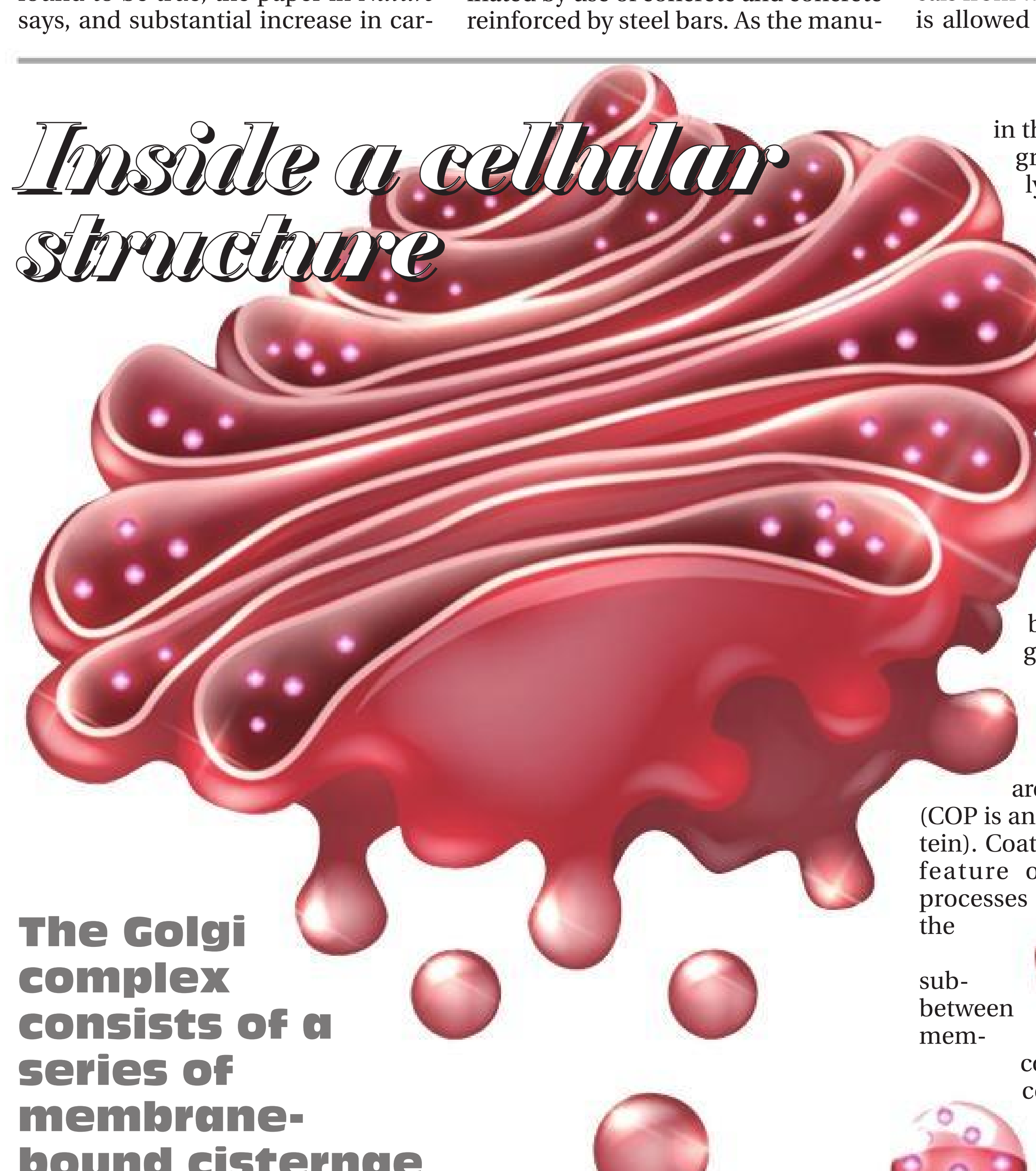
The research team has developed the prototype of the technology. Further validation of product safety is ongoing and antimicrobial action specifically against the novel coronavirus will be done at a government facility. The team has filed for a provisional patent for the innovation. The technology has several advantages,

- Killing of microbes will allow reusability of masks and other PPEs. Hence, less burden will be on the manufactures for making millions of masks, which are generally thrown away after single use.
- Restrict spreading of microbes to fingers and other individuals due to negligent usage of masks where users tend to touch them while removing.
- Reduce bio-burden and transmission after disposal.
- The affordable technology can be implemented through a one-step facile spray/dip method using existing industry infrastructure to coat fabric materials, which are commonly used for mask/bodysuits.

On the other hand, long-time usage of strapped and tight-fitting face masks is painful to the ears. This has been a major concern with healthcare workers who have to wear these masks for hours during a duty cycle. Even for commoners during the corona crisis, masks are to be worn constantly. To address this critical issue, the research team has a 3D printed "ear guard" prototype.

The ergonomical design of the guard holds the face mask strap in a place without giving pressure to the ear. Therefore, masks can be worn effortlessly for hours without pain or discomfort to the wearer. Using 3D printers, these "ear guards" are being made in a free size to fit all. They are being printed at the Biomaterial and Tissue Engineering Laboratory of IIT-Guwahati using polymer resins. The ear guards are affordable, long-lasting and designed to give comfortable wearing experience. Presently, the team is printing thousands of these ear guards to be distributed to hospitals across the North-east region and if needed, across India.

Inside a cellular structure



The Golgi complex consists of a series of membrane-bound cisternae

TAPAN KUMAR MAITRA

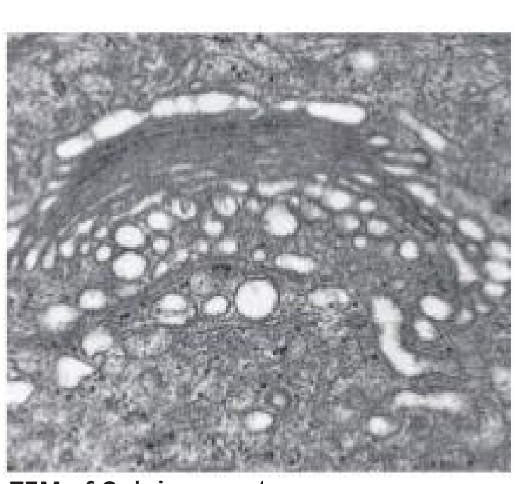
The Golgi complex or Golgi apparatus consists of a series of flattened membrane-bound cisternae, which are disk-shaped sacs stacked together. The series of such cisternae is called a Golgi stack and can be readily visualised by electron microscopy. Usually, there are three to eight cisternae per stack, though the Golgi stacks of some organisms can include several dozen cisternae. The number and size of Golgi stacks vary with cell type and with the metabolic activity of the cell. Some cells have one large stack, whereas others -- especially those that are highly active in secretion -- have hundreds or even thousands of Golgi stacks. The Golgi complex lumen, or intracisternal space, is part of the endomembrane system's network of internal spaces.

The static view of the endoplasmic reticulum and Golgi complex presented by electron micrographs can be misleading; these organelles are actually very dynamic structures. Both the ER and Golgi complex are typically surrounded by numerous transport vesicles, which bud off membranes in one region of the cell and fuse with other membranes. Such vesicles convey lipids and proteins from the transitional elements of the ER to the Golgi complex, between the Golgi stack cisternae, and from the Golgi complex to various destinations in the cell, including secretory granules, endosomes, and lysosomes.

Most of the vesicles involved in lipid and protein transfer are also referred to as coated vesicles because of the characteristic coats, or layers, of proteins covering their cytosolic surfaces as they form. These coats promote membrane curvature, which allows vesicle formation, and are removed from the vesicle before fusion with the target membrane. The coat's precise composition depends on the role of the vesicle in the cell. The most studied coat proteins are clathrin, COPI, and COPII (COP is an abbreviation for coat protein). Coated vesicles are a common feature of most cellular processes that involve the transfer or exchange of substances between specific membrane-bounded compartments of eukaryotic cells or between the inside and the outside of a cell. Each Golgi stack has two distinct sides, or faces?

The cis (or forming) face is oriented toward the transitional elements of the ER. The Golgi compartment closest to the transitional elements is a network of membrane-bounded tubules referred to as the cis-Golgi network. Coated transition vesicles containing newly synthesised lipids and proteins from transitional elements of the ER continuously arrive at the CGN, where they fuse with the CGN membrane.

The opposite side of the Golgi complex is called the trans (or maturing) face. The compartment on this side of the Golgi complex, like the CGN, is a network of membrane-bounded tubules. This structure is referred to as the trans-Golgi network.



TEM of Golgi apparatus

Coated transport vesicles continuously bud from the tips of TGN cisternae, carrying processed proteins from the Golgi complex to secretory granules, endosomes, lysosomes, and the plasma membrane. The central sacs between the CGN and TGN comprise the medial cisternae of the Golgi stack, in which much of the processing of proteins occurs.

The CGN, TGN, and medial cisternae of the Golgi complex are biochemically and functionally distinct, each compartment containing enzymes necessary for specific steps in protein and membrane processing. Immunological and cytochemical staining techniques have shown that specific receptor proteins and enzymes are concentrated within the CGN, whereas other proteins are found pri-marily in medial cisternae or in the TGN. Staining to detect N-acetylglucosamine transferase I, an enzyme that adds N-acetylglucosamine to carbohydrate side chains of glycoproteins, shows that the enzyme is concentrated in medial cisternae of the Golgi complex.

The CGN, TGN, and medial cisternae of the Golgi complex also differ in the kinds of coated vesicles associated with each compartment. Vesicles that bud from the ER for transport of proteins and lipids to the CGN are coated with COPII proteins, while vesicles that bud from the CGN or medial cisternae of the Golgi stack are coated with COPI proteins. Vesicles that bud from the TGN can be coated with COPI or clathrin.

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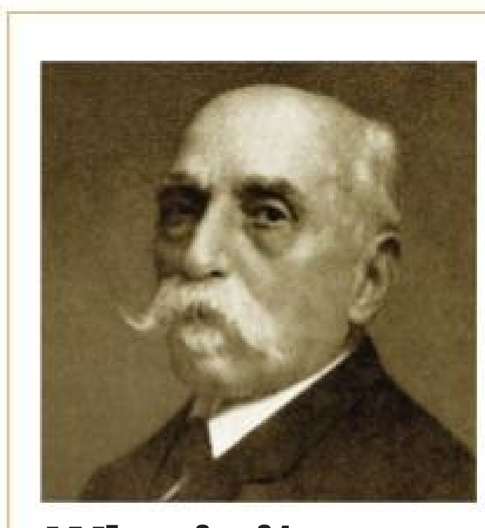

Why is it named so?

The Golgi complex is named after Italian scientist Camillo Golgi. Although an established clinician and histopathologist, Golgi had to leave research due to financial constraints and joined the Hospital of the Chronically Ill near Milan as chief medical officer in 1867. But he was undeterred. To continue with his research, he set up a make-shift laboratory in one of the hospital's kitchens and some of his most notable discoveries took place there.

On 16 February 1873, Golgi wrote to a friend, "I am delighted that I have found a new reaction to demonstrate, even to the blind, the structure of the interstitial stroma of the cerebral cortex." His research was published in the *Gazzeta Medica Italiani* on 2 August 1873.

Initially called the "black reaction", Golgi's discovery of a silver straining method to visualise nervous tissue under light microscopy was a game-changer for neuroscience. Thereafter, it has been christened Golgi's method and several structures and phenomena in anatomy and physiology have been named after him. Golgi was jointly awarded the Nobel Prize in Physiology or Medicine with Spanish biologist Santiago Ramon y Cajal in 1906.