Let's keep it clean

It's better to keep microbes out in the first place, says s ananthanarayanan

An operation theatre in 1946 — and now.

THAT the tissue of living things had an unseen structure was unknown to the generations before the microscope, which was invented in the 17th century. And only later in that century was the invisible world of micro-organisms discovered by Leeuwenhoek. But it took till the 19th century and Frenchman Louis Pasteur for the role that microbes played in health and disease to be understood.

Yves Henon, another Frenchman and expert in the area of sterilisation of medical devices, presented the history and current status of sterilisation at a meeting of members of the Indo-French Technical Association in Mumbai last Sunday. He said Louis Pasteur was the father of microbiology, who invented the first devices for sterilisation using steam, the hot air oven and the autoclave. Joseph Lister, an Englishman, discovered that microbes caused wound sepsis and Enrst von Bergmann, a German surgeon, first sterilized OT equipment to keep germs out in the first place.

Henon displayed a photograph of a surgical operation in the 1846. The surgeons were in their town clothes and even the patient, who may have been anaesthetised, had his shoes on. It was common for visitors to come and go and at times even a pet dog, said Henon. Rarely, he said, did surgery end without the patient succumbing anyway to secondary infection.

In contrast, the modern operating theatre reflects attention to keeping the proceedings free of the least hint of infection. The table and other surfaces are in stainless steel, the walls and floor are devoid of cracks that could harbour organisms, the linen, the clothing of the doctors and nurses are freshly laundered and germ-free and the thoroughness of the surgeons scrubbing their hands is well known. But most of all, the instruments and materials used in the procedure itself are *perfectly sterilised*.

Yves Henon

Sterilisation

Traditionally, the method to sterilise articles like syringes, needles, scissors, forceps, scalpels and other specialised equipment was to keep these in boiling water. The great majority of bacteria and viruses cannot survive the temperature and the method is generally effective. But the difficulty was that the process takes some time and doing and the articles being sterilised also need to be of steel or glass.

With the increase in numbers and frequency of interventions, these materials and this method became impractical and uneconomical. The advent of plastics offered great saving in the cost of surgery and also permitted a regime of "use only once", which created great confidence in the article being sterile. It is regulation, in fact, that the articles be destroyed after use to make sure that they are not reused. Hence the market, which we see today, of "disposable" in the place of "reusable", whose value, Henon said, was *$42 billion every year* in the USA alone.

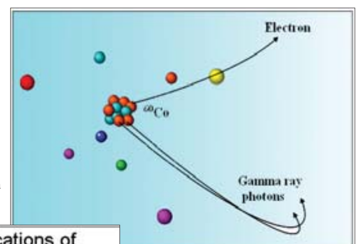
Yet, both for cost as well as availability, there are items that need to be sterilised and reused – and these occupy a considerable market share. The materials of choice are now plastics, PVC, polypropylene or polystyrene, but these are generally heat-sensitive. Stainless steel and glass are not just costlier, they need care and maintenance.

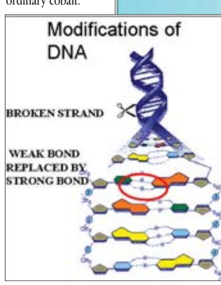
There is, hence, the need for "cold", low-temperature sterilisation, for which the two chief methods available were the radiation method and the chemical, ethylene oxide (or EtO) method. These are industrial methods and provide a high degree of safety and are more effective than hospital sterilisation.

Radiation

In the radiation method, the articles to be sterilised are exposed to high-energy gamma radiation from a radioactive source. Radiation acts by damaging the sensitive chemical bonds within the DNA in the cells of the organism – bacterial or viral. While humans and animals have large and complex DNA, the DNA of micro-organisms present small targets to gamma radiation. Microbes are, hence, hardier in surviving radiation and doses that would be very harmful to humans need to be used.

The radiation source is ^{60}Co or cobalt 60, which is a form of cobalt with one neutron more in its nucleus than ordinary cobalt.





Cobalt 60 is created in a nuclear reactor by exposing ordinary cobalt to radiation and, thanks to the extra neutron, is an unstable nucleus. ^{60}Co hence spontaneously decays into nickel 60 by emitting one electron and two high-energy gamma ray photons. It is this gamma radiation that is useful in killing micro-organisms. Cobalt 60 is created in nuclear reactors and formed into rods that are sealed into stainless steel tubes and deployed in irradiation units, which are positioned behind concrete walls to prevent the escape of radiation.

The material to be irradiated is passed through the facility with the help of conveyor belts and the radioactive rods are lowered underwater and into concrete pits, or bunkers, when humans need to enter for maintenance or repair. The arrangement is simple and safe, with a record of not more than a dozen casualties in nearly 100 years of use.

Chemical sterilisation

In the chemical route to sterilization, the material of choice is ethylene oxide (EtO), a chemical of great industrial use, apart from this medical application. The chemical was first used for chemical warfare as it is lethal in small doses to humans. The US army, in the course of investigating military uses, developed the application for sterilisation. EtO works in the same way as radiation, by denaturing the chemical bonds within DNA.

Unlike radiation, however, it does not need a nuclear reactor to create the active substances and it, hence, needs less capital to set up. Ordinary, low-cost plastics that are damaged by radiation, can also be used with EtO. But EtO is a hazardous chemical and its use calls for elaborate precautions against leakage, or accident, and the facilities need to be stationed away from cities or places that are frequented. The process itself is complex and needs arrangements for correct levels of temperature, humidity and concentration to be effective. And after sterilisation, the gas needs to be "rinsed out" to allow the sterilised articles to be safely used.

But given its lower cost of installation, this is the method most frequently used in India and in the developing world. Its use is also about the same as radiation in Europe, while radiation is more used in USA.

Level of assurance

Any method of sterilisation needs to ensure freedom of the device from the "bioburden" or the level of contamination with which it starts. While radiation means rapidly reducing the numbers of organisms, by some factor every minute, the elimination of the last survivors cannot be completely assured. Hence, what is attempted is an acceptable *Sterility Assurance Level*. The Sal in current use is 10^{-6}, or an assurance that there is at most one non-sterile item out of one million. The industry is now pushing for a more stringent standard of one non-sterile item in one billion.

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Seven Milky Way planets could harbour life

The Habitable Exoplanets Catalogue says it has far exceeded expectations in search for a new earth. john hall **reports**

AN ambitious project to catalogue every habitable planet has discovered seven worlds inside the Milky Way that could possibly harbour life. Marking its first anniversary, the Habitable Exoplanets Catalogue say it has far exceeded its expectation of adding one or two new planets this year in its search for a new earth.

In recent years, scientists from the Puerto Rico-based Planetary Habitability Laboratory that runs the catalogue have sharpened their techniques for finding new planets outside our solar system. Chile's High Accuracy Radial Veolocity Planet Searcher and the orbiting Kepler Space Telescope are two of the many tools that have increased the pace of discoveries. The Planetary Habitability Laboratory launched the Habitable Exoplanets Catalogue last year to measure the suitability for life of these emerging worlds and as a way to organise them for the public.

It has found nearly 80 confirmed exoplanets with a similar size to earth but only a few of those have the right distance from their star to support liquid surface water — the presence of which is considered essential to sustain life. Seven potentially habitable exoplanets are now listed by the Habitable Exoplanets Catalogue, including the disputed Gliese 581g, plus some 27 more from National Aeronautics and Space Administration-Kepler candidates awaiting confirmation. Although all these exoplanets are superterrans considered potentially habitable, scientists have not yet found a true earth analogue.

Montage of the High Accuracy Radial Velocity Planet Searcher spectrograph and the 3.6m telescope at the La Silla Observatory in Chile. The upper left shows the dome of the telescope, while the upper right illustrates the telescope itself. The spectrograph is shown in the lower image.

Over the next year, the Habitable Exoplanets Catalogue will go further in its analysis of the planets that could possibly harbour life, offering new visualisations and habitability assessments. However, the team says the biggest impact over the next 12 months will come from new discoveries rather than deeper analysis of planets it has already found. A spokesperson says, "A true earth analogue or a potentially habitable exomoon would be big discoveries. Certainly, this was the right time to start mapping the habitable universe around us."

The Independent, London

The greatness of gravitational lensing

The discovery of a galaxy estimated to date back to when the universe was only three per cent of its present age would not have been possible but for a little help from nature and the ingenuity of space photography, writes debameeta bhattacharya

A TEAM of astronomers using the National Aeronautics and Space Administration's Hubble and Spitzer space telescopes has managed to spot the most distant object ever seen in the universe — a star cluster (named MACS0647-JD) located about 13.3 billion light years away from earth. The cluster is tiny in comparison to our own Milky Way as it is still in the first stages of formation but it is estimated to date back to a time when the universe was only three per cent of its present age. The faint light from the cluster's stars has taken almost all of the history of space and time to travel to us.

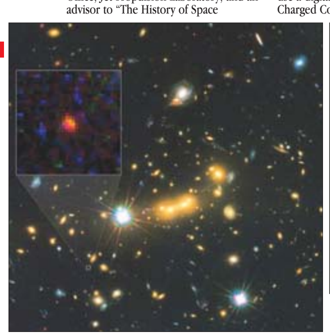
The discovery was made by astronomers grouped under the joint American-European Clash Project. Team leader Marc Postman of the Space Telescope Science Institute in Baltimore said, "We see the newly discovered galaxy, named MACS0647-JD, as it was 420 million years after the Big Bang." The team, however, wouldn't have been able to make this record discovery without a special hint from Mother Nature. The cluster's light is so faint that it could never have been detected with any manmade telescope.

Luckily, a massive galaxy cluster located between earth and the newly found distant object caused its light to take detour along multiple paths as it travelled towards earth. The phenomenon creates a naturally occurring cosmic zoom lens, allowing distant galaxies to be greatly magnified in appearance.

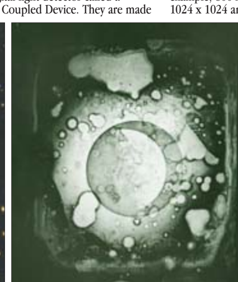
Postman explained that this gravitational lensing, "…does what no manmade telescope can do", and that "without the magnification, it would have required a Herculean effort to observe the newly found distant galaxy".

In this context, Randi R Wessen, deputy manager of the Project Formulation Office, Jet Propulsion Laboratory, and an advisor to "The History of Space Photography" exhibition explained the mechanism employed.

These days all scientific instruments collect data in digital format and dismiss the use of photographic plates or film. Telescopes, whether on earth or in space, use a digital light detector called a Charged Coupled Device. They are made up of rows and columns of light collection cells known as "picture elements" or "pixels" for short. The number of rows and columns are called arrays with specific CCD — for example, 800 x 800 array, or a 1024 x 1024 array, etc.



A composite image of the galaxy cluster that helped reveal the newly discovered galaxy – MACS0647-JD. The inset at left shows a close up of the young dwarf galaxy.

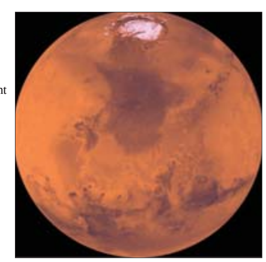


John W Draper captured this first known photograph of the moon, launching the age of astronomical photography. It is believed to have been taken on 26 March 1840 from his rooftop observatory at New York University.

When an image is focused on CCD, each pixel measures a brightness level that is usually assigned between 0 for black and 255 for white. As a pixel increases, the gray level lightens. When an image is ready to be taken, the brightness level in each pixel is read out as a string of numbers (for example, row 1column 1 is a 186, row 1 column 2 is a 187, etc).

On earth, the string of numbers is reassembled and reconstructed into an image. Colour images are obtained by taking three images of the same subject – a red, blue, and green filter – and then recombining them.

A fancier and newer way, according to Jay Belloli, curator of the California/International Arts Foundation, is to take colour images with CCD and Mars Science Laboratory cameras through a Bayer filter — a checkerboard of red, blue and green filters, after which a graphic designer takes over and uses various software to give us the finished product.



Mars as captured by the Viking spacecraft. The north polar residual ice cap, which is cut by spiral-patterned troughs, is located at the top. The central part has a large, dark depression – Chryse basin – where the large outflow of several large channels terminate. The lower left corner is marked by a vast system of canyons – Valles Marineris – that extends eastward for 2,500 miles.