A shade to see through

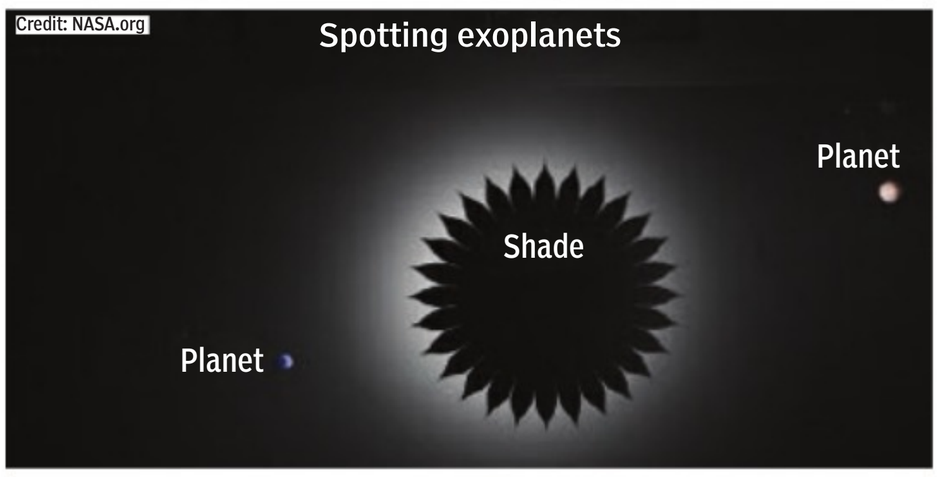
THE NEXT POWERFUL TELESCOPE TO BE LAUNCHED INTO SPACE MAY USE OPACITY IN PLACE OF TRANSPARENCY, WRITES **S ANANTHANARAYANAN**

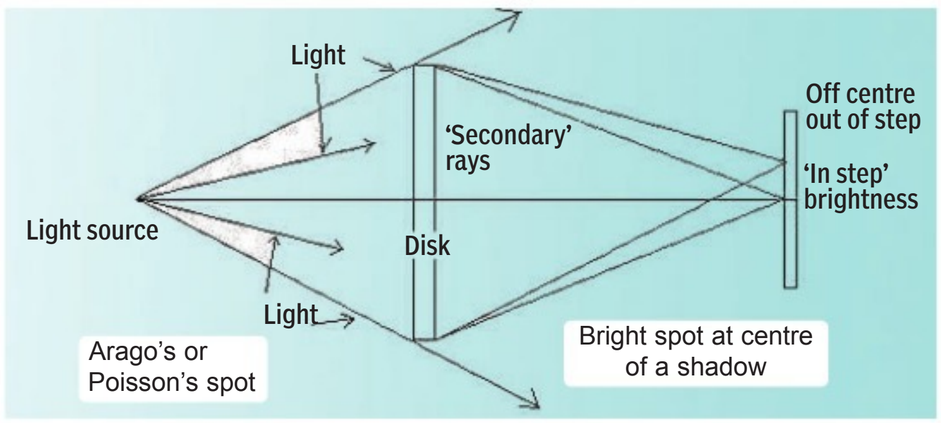
It is well known that the night sky we see is blurred by the atmosphere. Telescopes are hence located at mountaintops or even sent up in balloons, but the best viewing is completely outside the atmosphere — in orbit around the earth. Out in space, we not only escape the distortion of visible images but can also make use of emissions in the infrared, ultraviolet, X-Rays and even Gamma Rays that get absorbed before they reach the earth's surface.

The National Aeronautics and Space Administration's great space observatories — Hubble, launched in 1990; Compton (Gamma Ray) in 1991; Chandra (X-Ray) in 1999; and Spitzer (infra red) in 2003, marvels of engineering in themselves — have revealed images of the cosmos that were never seen before and which have transformed our understanding of the universe. But even these major research facilities that were built and launched with great effort and at great cost have their service life and would need replacement. Hubble is 25 years old and Spitzer, the most recent, has run out of liquid helium, which it needs to be cold enough to detect infra red. The quest is hence to find substitutes, ideally with simpler technology and of lower cost.

The answer, in the case of Hubble, at any rate, possibly lies in the innovative proposal, the Agaroscope, from the University of Colorado at Boulder. The Agaroscope, in place of the eight-foot diameter panel of mirrors that Hubble has for focusing the light from a distant star, uses a giant *starshade*, which would actually block out the star! The usual arrangement with lenses or mirrors contributes, in the first place, to large weight and hence the cost of the launch and then the mirror surface needs to be machined to nanometer accuracy, which presents its own difficulty as well as cost. The *starshade*, on the other hand, would be made of dark, opaque, plastic-like material that could be folded at the time of launch and then unfurled "like a parachute" once it is in the desired geostationary orbit above the earth.

Setting up such an arrangement, which could even be half a mile across, would be relatively easier to build and launch. Once this shade is in place — the innovative wonder of the arrangement — the starlight that falls on the entire periphery of the shade gets together at the focus to create the image of the star with far greater resolution and clarity than is possible with Hubble, says Anthony Harness, doctoral student at the university.





The Arago spot

The principle of this effect, of an opaque object throwing an image in place of a shadow, was discovered by French scientist François Arago, who studied how the wave nature of light allowed light to bend around a disc-shaped obstacle, as if it were passing through a lens, and meet at a central point. The way it works is that while the original light wave goes past the disc in the shape of a hollow cone, to throw a circular geometric shadow, the light striking the disc also gives rise to secondary light waves from all points on the periphery of the disc. The illumination of the edge of the disc thus becomes a circular source of light. As the source of all the secondary waves is the same original light wave, the secondary waves all set out at the same stage of wave motion and when they meet along the axis of the disc they have travelled the same distance and are at the same stage of wave motion and, hence, they combine and add. When the periphery is very large, as in the case of a disc that is half a mile across, the energy converging at the axis can be substantial and the image quite intense. The centre of the shadow of a disc is thus not in darkness but is a bright spot, which is called the *Arago spot* or the *Poisson spot*. It has been worked out that the clarity of an image formed in this way would be a thousand times clearer than Hubble's.

Using a disc to create an image was first suggested by astronomer Webster Cash of the University of Colorado in the course of the quest for satellites around distant stars. The main difficulty in viewing *exoplanets*, as such far off planet systems are called, is that their dim, reflected light cannot be made out in the glare of the light from the star itself. One way around would be to use a circular disc to cover the star and allow a surrounding planet system to come into view. But this does not work because of the Arago effect, where the disc does not, in fact, block out the image of the star. Cash proposed that just as a circular disc created waves that came together "in phase" at the centre, changing the shape of the disc could result in half the waves being "out of step" with the remaining waves and hence blank them out. Cash's 2006 paper in the journal, *Nature*, thus proposed a "sunflower"-shaped disc that could prevent the Arago's spot and hence the glare of the star.

The group at the University of Colorado Centre for Astrophysics and Space Astronomy has proposed the same concept, of a large but lightweight opaque circular body launched into orbit, without the sunflower periphery, as a possible alternative to the ageing Hubble telescope facility. The Nasa selection is as one of the proposals under its Innovative Advanced Concept programme in June 2014 and funded initial development. The Arago effect, barely noticeable at normal scales, becomes pronounced at the half-mile diameter proposed. Webster Cash believes this could allow scientists to image space objects like black hole "event horizons" and "plasma swaps" or streams of charged particles between stars, according to a news release from the university.

The orbiting "starshade and telescope" arrangement could even be turned around to point to the earth, when it would be able to make out objects the size of a rabbit, which could help find lost campers in the mountains, the news release reports Cash as saying.

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PLUS POINTS

Boosting crop growth

Researchers in Australia are seeking to build a prototype "Bubble-greenhouse" that could provide remote, arid places with a low-tech, low-maintenance way to turn salt water into fresh water to grow food. Engineers from Murdoch University, who published their study last month in the journal *Desalination*, estimate that a 150-square metre Bubble-greenhouse could produce around eight cubic metres of fresh water and up to 30 kg of crops each day. The sealed structure would protect crops from insects and disease, while the technology should be relatively simple to implement and use in isolated areas, they say.

The new approach moves the evaporation and condensation processes outside the greenhouse. Inside two water-filled "bubble columns", streams of thousands of tiny bubbles create a large surface for water to evaporate or condense. A unique property of seawater prevents the small bubbles joining to form big bubbles, thus maintaining a large surface area.

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Battling blackberries

Researchers and farmers in the Galapagos are waging a war against an invasive blackberry plant that is threatening the islands' food supply. The non-native plant, *Rubus niveus*, is spreading quickly and destroying the delicate ecosystem of the archipelago. This is causing problems for farming and food supply. On 25 August, two science organisations from the UK teamed up with the Galapagos National Park Directorate to work with farmers on weeding out the invader.

Their strategy is to find suitable biological control agents such as insects or diseas that would keep the plant in check. Once selected and introduced, these agents would make management of the blackberry easier and less expensive for farmers than weeding, helping to recover previously abandoned agricultural areas.

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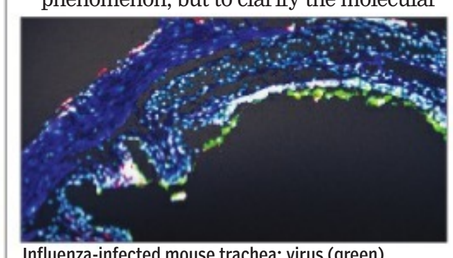
Neutrophil guides

Part of the innate immune system, white blood cells called neutrophils circulate in the blood and are the first responders to an influenza respiratory infection, guiding T cells — part of the adaptive immune response — to the site. Neutrophils create a physical trail of chemokines that allow T cells to home in on the infection site, according to a study published on 3 September in *Science*. Using two-photon microscopy, Minsoo Kim, an immunologist at the University of Rochester Medical Center in New York, and his colleagues visualised the mobilisation of immune cells in response to an influenza virus infection in the mouse trachea. The study is the first to track an immune system response to a flu virus *in vivo*.

"The paper goes very far, using an infection model to not only describe a phenomenon, but to clarify the molecular cascade of events in impressive detail," said Michael Sixt, who studies the activities of immune cells at the Institute of Science and Technology Austria in Klosterneuburg. He penned an accompanying perspective on the results, but was not involved in the research.



Influenza-infected mouse trachea: virus (green), neutrophils (red), collagen (blue).

"(The field) has appreciated that the adaptive immune system doesn't generate the right kind of response without instruction from the innate immune system," said Andrea Graham, an immunologist and evolutionary ecologist at Princeton University who was not involved in the work. "This study suggests that T cells also don't really know where to go without the help of key innate immune system cells like neutrophils. It is another example of how the innate immune system is absolutely indispensable to the function of the adaptive immune system."

In the current study, the researchers found that neutrophils were the first-responder cells, appearing in the trachea on day three or four of infection. Using immunofluorescence in live mice, Kim's team found that cytotoxic T-cells arrived in the trachea another few days later — about one week after the start of infection. Mice depleted of neutrophils had influenza-activated T cells. Yet these T cells did not efficiently home in on the virus-infected epithelial cells of the trachea, and cleared their infection less efficiently, suggesting that an early-mounted neutrophil response was necessary for T cells to reach the infection site.

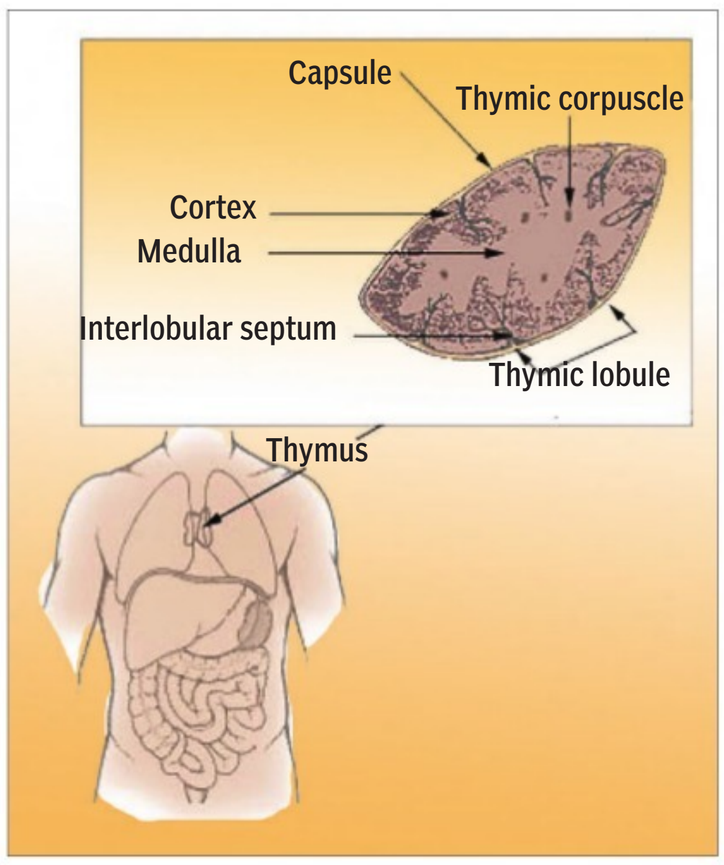
ANNA AZVOLINSKY/THE SCIENTIST

NATURAL DEFENCE SYSTEMS

TAPAN KUMAR MAITRA EXPLAINS ANTI-TUMOUR AND ANTI-PARASITIC IMMUNITY

Humans have a high-tension natural immunity to cancer and other malignant tumours but the regression of cancer cells, as opposed to normal ones, is encountered in some cases. Anti-tumour immunity is displayed in two forms — humoral, with the production of antibodies, and cellular, with the participation of T-lymphocytes. Antibodies are produced under the effect of the antigens of DNA or RNA containing oncogenic viruses, antigens of tumours induced by carcinogens, antigens of transplants, embryonal antigens (a_1-fetoproteins), etc. In some cases, anti-tumour antibodies provide protection; in others they intensify growth of the tumour.

The thymus is an important organ in anti-tumour immunity and ensures the elimination of cancer cells because of its ability to suppress the synthesis of nucleic acids and proteins. As distinct from transplantation immunity, in this type of immunity the forming foreign tumour tissue is not rejected. The task of oncological immunology consists of removing the organism's tolerance to malignant neoplasms.



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Many types of cancer cells possess specific antigens capable of accomplishing a defence without the participation of antibodies. They resemble protective antigens occurring in some infectious diseases of bacterial aetiology (anthrax, plague, etc). Tumour growth is inhibited by chalones. Their content in cancer cells is one tenth that in normal cells. Interferon possesses a defence effect against leucoses and cancer. Leucosis develops when there is a high concentration of the virus and, as the result of hereditary predisposition, a low level of immunity and active effect of the inducing agents. Natural immunity is more intense in adults than in children. Children two to four years of age are most susceptible.

Insusceptibility to leucoses is associated with humoral immunity. A high antibody titre promotes a decrease in the concentration of viruses in the blood. There is a correlation between the antibody titre and insusceptibility.

Methods are studied for specific therapy and prophylaxis of malignant tumours, the production of active antigens and the isolation of viruses that induce tumours in humans. Insusceptibility to pathogenic parasites is characterised by a variety of mechanisms. The production of immunity depends on the character of the localisation of the parasite. Some of these localise in the tissues (trypanosomes, leishmaniae, malarial Plasmodia), others in the lumen of the intestine (*Entamoeba histolytica)* and yet others in the lumen of the intestine and the tissues (intestinal balanti-dia, coccidia, helminths).

Anti-parasitic immunity is brought about by the defence action of antibodies IgE and an increased activity of phagocytes. Under the influence of antibodies, the life processes in parasites are deeply disturbed and then the parasites are dissolved. Phagocytes, under the influence of opsonins, absorb and digest minute parasites, while large parasites are immobilised in the tissues by the mutual action of many cells.

Usually, at first an active effect is manifested by the microphages, then the macrophage that has a more effective action enters into combat with the parasite. The number of defence cells greatly increases and, in some cases, is an index of the infection of the body by one or another species of parasite.

In spite of the common character of natural immune reactions during parasitic and bacterial infections, the problem of prophylactic vaccination against diseases caused by parasites has not yet been worked out.

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A first blood test tell-all

SCIENTISTS HAVE COME UP WITH THE MEANS THAT CAN ESTIMATE HOW QUICKLY PEOPLE AGE ~ AND THEIR RISK OF ALZHEIMER'S. **STEVE CONNOR** REPORTS

Scientists have developed a blood test they believe could be used to predict a person's risk of developing Alzheimer's disease as well as the "youthfulness" of donated organs for transplant operations. The test measures the vitality of certain genes that the researchers believe is an accurate indication of a person's "biological age", which may be younger or older than their actual chronological age.

A study has shown that the test can distinguish between healthy individuals and patients with Alzheimer's and so might also be used it to identify people in the early stages of the brain disease who have not yet developed symptoms. The "ageing test" could also be used on organs donated for transplant operations to assess their biological age and hence the risk of them failing once they have been transferred into a recipient, said James Timmons, professor of precision medicine at King's College London.

"We use birth year, or chronological age, to judge everything from insurance premiums to whether you get a medical procedure or not. Most people accept that all 60-year-olds are not the same, but there has been no reliable test for underlying biological age," he said. "Our discovery provides the first robust molecular 'signature' of biological age in humans and should be able to transform the way that age is used to make medical decisions. This includes identifying those more likely to be at risk of Alzheimer's, as catching those at early risk is key to evaluating potential treatments.

"There was a very strong difference between people with mild cognitive impairment and (healthy people), so it seems as if it could be developed into a test, particularly when combined with relevant clinical variables. However, most likely it represents a way to spot 'at risk' people and guide them toward clinical trials for prevention."

In addition to the possibility of applying the test to dementia, the researchers hope to develop it as a way of assessing the suitability of organs donated for transplant operations from elderly donors. "For kidney transplantation, older organs are being used more and more, and the older the donor the more likely the transplantation will fail and it would be valuable to know the biological age of the organ before using it," Professor Timmons said. It may also be possible to use the test to screen elderly people who had a young biological age so that they could be considered for organ donation if they died of other causes, such as traffic accidents, he added.

The research, published in the online journal *Genome Biology*, analysed the activity levels of a panel of key genes of healthy 65-year-old subjects by measuring the levels of RNA — a close cousin of DNA — in their blood. The scientists used this information on gene activity as a marker of biological ageing. They then studied the RNA of healthy 70-year-olds and analysed their health records over two decades and found that a high gene-activity score was associated with better cognitive health and kidney function across a 12-year period — both predict the risk of an early death.

An important finding from the research was that this gene activity was the same in the brain and the blood for people with Alzheimer's disease, giving scientists a way of quickly and easily diagnosing what was happening in the brain just by looking at a blood sample. "This is the first blood test of its kind and has shown that the same set of molecules are regulated in both the blood and the brain regions associated with dementia, and it can help contribute to a dementia diagnosis," Professor Timmons said.

"This is very novel. It suggests we can use the gene-signature to better understand Alzheimer's disease and also as a screen for looking at drugs in human cells — an early step in drug discovery."

THE INDEPENDENT