

The transparency quotient

NANOPARTICLES CAN HELP PUT MESSAGES RIGHT ON TOP OF IMAGES THAT COME THROUGH A SCREEN, SAYS
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Adding comments, graphs and pictures in real time to images that are being viewed would be a good thing in many situations. This is useful, for instance, to project navigation information on an aircraft cockpit window or the windshield of a car, or messages or entertainment on to ordinary window glass or spectacle glass. What this kind of overlay amounts to is that the medium that displays the message is also transparent to the main images that are being viewed.

Chia Wei Hsu, Bo Zhen, Wenjun Qiu, Ofer Shapira, Brendan G DeLacy, John D Joannopoulos and Marin Soljacic at the Massachusetts Institute of Technology, Harvard and the US Army Chemical Biology Centre at Aberdeen in Maryland, announce in *Nature Communications* that they have developed a transparent display that faithfully adds messages and graphics to an existing projection with economy, efficiency and clarity, overcoming the deficiencies in existing methods. The display now developed relies on nanoparticles deposited within the transparent medium, which efficiently reflect light that is shone upon the medium in a wide cone, and yet do not interfere with the images that are passing through the medium.

The authors of the paper describe the existing devices. The simplest is the "head-up" display, where a pilot or driver can

see the message right on the windscreen before him/her — that is, with his/her head still "up" without having to look down. This display usually depends on a half silvered sheet at an angle, to reflect the message into the field and yet not block the view. The trouble with this design is that it could work only when the message needs to be seen from a narrow angle. The angle of view can be widened if there is scattering instead of reflection, but in this case making sure that the message is clear would reduce transparency and, hence, clarity of the original image. More complex arrangements have components that convert the message from Ultra Violet or Infra Red to visible, but these are difficult to implement in an efficient way.

There is even the idea of not shining the message on to the screen but generating the message in the screen, using transparent electronics. There is some success in this direction, but still not practical for a larger size of display.

Nanoparticles

The system now developed relies on a special property of particles whose dimensions are of the order of the wavelength of light to selectively reflect, but reflect strongly, light of a particular wavelength. The property of reflection is related to the presence of free electrons at the surface of

Optional particle size for different colours

Colour	Core radius	Shell radius
Blue	1.3 nm	30.8 nm
Green	22.2 nm	15.8 nm
Red	34.3 nm	11.0 nm

metals. Electrons, which are charged particles, interact with light waves, which consist of rapidly changing magnetic as well as electric fields. The surface electrons, thus, take up the energy of the wave, which they re-emit as the reflected wave. And as it is the electrons that carry out this action, metal surfaces are typically good reflectors.

But when the dimensions of the surface are very small, the to and fro motion of the electrons at the surface, which follows the rules of quantum mechanics, can match the frequency of waves of a particular colour of light. In such a case, it is said that there has been resonance and there is strong reflection. But with small particles, where there is no resonance, as in the case of light of other frequencies or colours, the wave just passes through. Very small particles can, thus, act as a selective but powerful reflector of just one particular colour of light, whose frequency matches that of the electrons on the surface. A screen embedded with such particles would then reflect light that is shone on it at a particular frequency, but allow all other light, of the main images, to pass through without being affected.

Chia Wei Hsu and others note in the paper that the metal, silver, is the most suitable, out of others, like gold, copper, aluminum, lithium, tantalum and so they used silver based nano-particles. The design requires silica cores with a shell of silver and the table shows the optimum radii of the core and shell for different colours of light. As the core suitable for blue light, which was chosen as test frequency, is small, silver nanoparticles were used. The particles were suspended in a vinyl-alcohol compound and poured on a glass sheet. When the plastic set, the sheet was covered with a transparent layer embedded with silver nanoparticles.

Proof of principle

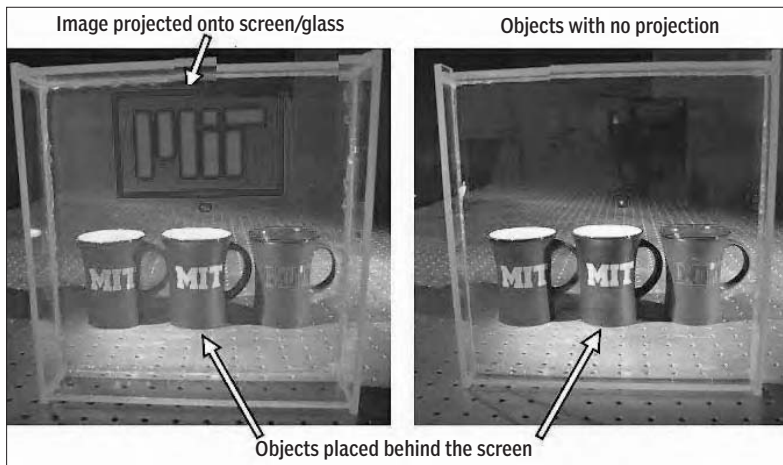
The trials with blue light showed that an image of "MIT" was effectively projected on a screen through which a trio of MIT

mugs was viewed, as shown in the picture. The screen had effectively lost no transparency and the overlaid image was distinct. The trio of mugs could be replaced by any other display, or activity in progress, and the "MIT" image could be expert comments or announcements or even a video of a different part of the activity, related to the main display. If nanoparticles corresponding to green and red light are added to the particles embedded on the screen, the display would be in the three primary colours and, hence, could be in full colour.

The principle demonstrated is that the simple display could have clarity, be visible from a wide viewing angle and also readily scalable to large size of screen and display. The polymer used is inexpensive and the quantity of silver is negligible. The design of the nanoparticles could be improved for more accurate colour response so that true full colour rendition is possible.

Additional possibilities are of flexible screens and screens that can be rolled up and carried. Another attractive possibility is because the polymer film is only 0.46 mm thick. Most of the light, hence, undergoes only single scattering, as opposed to multiple scattering. The result is that a property called the polarisation, of the light that falls on the nanoparticles, is retained after reflection. Using the property, a pair of images or sets of images could be shone, using light in opposite directions of polarisation, to feed different images to the left and right eyes of viewers, for full 3-D effects.

Yet another useful feature is that a black cloth could be placed behind the transparent screen to convert it into a high contrast screen for the projected image alone. Placing a black background is found to improve the contrast, as opposed to a white background, which is necessary when we use conventional projection.



MOLECULAR MAGIC

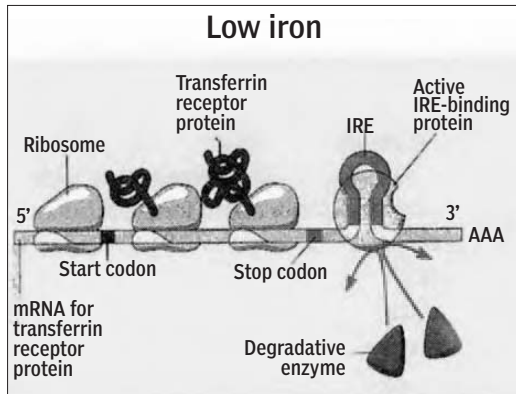
TRANSLATION CAN ALSO BE CONTROLLED BY REGULATION OF MRNA HALF-LIFE, WRITES TAPAN KUMAR MAITRA

Translation rates are also subject to control by alterations in mRNA stability — in other words, the more rapidly an mRNA molecule is degraded, the less time available for it to be translated. The half-life, or time required for 50 per cent of the initial amount of RNA to be degraded varies widely among eukaryotic mRNAs, ranging from 30 minutes or

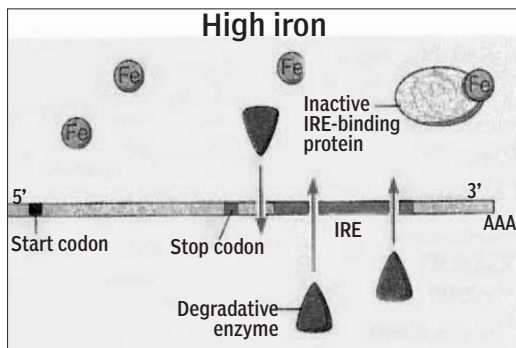
In some cases, mRNA stability is also influenced by specific features of the three-inch untranslated region. For example, short-lived mRNAs for several growth factors have a particular AU-rich sequence in this region. The AU-rich sequence triggers removal of the poly (A) tail by degradative enzymes. When the AU-rich sequence is transferred to the three-inch end of a normally stable globin message using recombinant DNA techniques, the hybrid mRNA acquires the short half-life typical of a growth factor mRNA.

An alternative mechanism for regulating mRNA stability is illustrated by the action of iron, which, in addition to participating in translational control as just described, also plays a role in controlling mRNA degradation. The uptake of iron into mammalian cells is mediated by a plasma membrane receptor protein called the transferrin receptor. When iron is scarce, synthesis of the transferrin receptor is stimulated by a mechanism that protects transferrin mRNA from degradation, thereby making more mRNA molecules available for translation. This control mechanism involves an IRE (similar to the one in ferritin mRNA) located in the three-inch untranslated region of transferrin mRNA. When intracellular iron levels are low (left panel) and increased uptake of iron is necessary, the IRE-binding protein binds to this IRE and protects the mRNA from degradation.

When iron levels in the cell are high (right panel) and additional uptake is not necessary, the IRE-binding protein binds an iron atom and dissociates from the mRNA, allowing the mRNA to be degraded. As a result, synthesis of the transferrin receptor decreases, leading to a decreased rate of iron transport into the cell.



IRE-binding protein binds IRE; mRNA protected; transferrin receptor synthesis high. IRE-binding protein cannot bind IRE; mRNA degraded; transferrin receptor synthesis low.



less for some growth factor mRNAs to over 10 hours for the mRNA encoding b-globin. The length of the poly (A) tail is one factor that plays a role in controlling mRNA stability. Messenger RNAs with short poly (A) tails tend to be less stable than mRNAs with longer poly (A) tails.

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Stem cell breakthrough

EXPERTS SAY THE GROUND-BREAKING DISCOVERY COULD PAVE THE WAY FOR ROUTINE USE IN MEDICINE.
STEVE CONNOR REPORTS

A new way of creating stem cells that is cheaper, faster and more efficient than before could transform the ability of scientists to develop "personalised medicine" where a patient's own healthy skin or blood cells can be used to repair damaged tissues, such as heart disease or brain injury.

Japanese scientists have announced they had created stem cells — essential for bodily repair — by simply bathing blood cells in a weakly acidic solution for half an hour, triggering a remarkable reversion to the cells' original embryonic state.

Researchers in Britain said they were astonished by the ease with which their colleagues in Japan had created embryonic-like stem cells with the ability to develop into any of the dozens of highly specialised cells of the body, ranging from cardiac muscle cells to the nerve cells of the brain and spinal cord. It opens up the prospect of doctors taking small samples of skin or blood from a patient and using the tissue to create stem cells that could be injected back into the same patient as part of a "self-repair" kit to mend damaged organs without the risk of tissue rejection. The stunning breakthrough was even more striking in that it was made by a young Japanese researcher called Haruko Obokata of the Riken Centre for Developmental Biology in Kobe, who could not at first believe her own results — and when she did finally believe them she found it just as difficult to persuade her colleagues that they were not a mistake.

"I was really surprised the first time I saw (the stem cells)... Everyone said it was an artifact — there were some really hard days," Dr Obokata said. Although the research was carried out on mouse cells, it should also work with human cells, she said. "It's exciting to think of the new possibilities this finding provides us not only in areas like regenerative medicine but perhaps in the study of cell senescence (ageing) and cancer as well. As regards human cells, that project is underway," she added.

Previously, stem cells with the ability to develop into any specialised tissue — a phenomenon called pluripotency — could only be created either by extracting them from early embryos or by genetically manipulating adult cells to create so-called induced pluripotent stem (iPS) cells. However, creating and destroying human embryos raises ethical questions for many people and is fraught with practical difficulties, while using iPS cells in human medicine raises

safety concerns about using genetically modified cells. Both techniques are also costly, inefficient and time-consuming.

The new approach, based simply on bathing blood or skin cells in a weak solution of citric acid for 30 minutes, is not only much quicker and cheaper than the



An image of a mouse embryo with beating heart generated totally from stem cells. (Haruko Obokata; Nature.)

previous two techniques, it is also so simple that it could be carried out in labs without any particularly specialised knowledge or equipment.

To test that the cells were truly pluripotent, Dr Obokata and her colleagues labelled them with a green fluorescent gene, injected them into early mouse embryos and found that they colonised every tissue of the developing foetus, even its umbilical cord — which does not happen with classical embryonic stem cells and iPS cells.

The Japanese scientists, who collaborated with Charles Vacanti of Harvard Medical School in Boston, said that in addition to blood cells, they had also created stem cells from the brain, skin, muscle, fat, bone marrow, lung and liver tissues of newborn mice. They have called the technique Stimulus-Triggered Acquisition of Pluripotency and believe there may be other ways of "shocking" adult cells to revert to their embryonic condition other than bathing them in a weak acid solution.

Professor Vacanti said, "It may not be necessary to create an embryo to acquire embryonic stem cells. Our research findings demonstrate that the creation of an autologous pluripotent stem cell — a stem cell from an individual that has the potential to be used for therapeutic purpose — without an embryo, is possible."

PLUS POINTS

Resistant to fluorosis

A scientist from a government college in Udaipur, Rajasthan, has found that compared to other animals, including humans, camels are less prone to fluorosis — a medical condition caused by excessive intake of fluoride. It is characterised by discolouration of the teeth and, in severe cases, by dark brown stains. Understanding what protects camels from the disease could help find ways to protect other animals. Young adults of most species are susceptible to fluorosis.

It occurs mainly due to continuous intake of fluoride through water and diet. "Fluoride content in groundwater is relatively high in Rajasthan," says the author of the study, SL Choubisa, professor and head of the zoology department of Government Meera Girls College, Udaipur. He says fluoride levels in groundwater in Rajasthan are between 2-5.7 parts per million. Choubisa carried out a comparative fluoride study in animals and humans



Fluoride content in groundwater is relatively high in Rajasthan. Since camels can live for days without water, their intake of fluoride-rich drinking water is less.

from 2011 to 2012. House-to-house surveys were carried out in nine villages of the Thar desert for examining fluorosis symptoms.

Signs for dental and skeletal fluorosis were observed in 194 adult camels (over five years old) and 43 juvenile/sub-adult camels (less than five years old). Apart from camels, 210 adult and young bovines and 218 residents, including children, were examined for fluoride symptoms in the surveyed regions.

The results showed that 13.8 per cent of adult camels and 9.3 per cent of sub-adult camels were afflicted with mild to moderate forms of dental fluorosis, while the incidence of moderate forms of skeletal fluorosis was found to be 10.2-2.3 per cent, respectively. However, the prevalence of dental fluorosis was found to be much higher and severe in bovines (61.9 per cent) and humans (58.6 per cent) than in camels, says Choubisa. He also found a difference in the manifestation of fluorosis in camels and bovines. In cattle, the enamel of the anterior teeth was striated with deep brown stains, whereas in camels it was non-striated and vertical, with light brown stains.

Choubisa says that since camels are adapted to arid environments and can live for days without water, their intake of fluoride-rich drinking water is comparatively less. He concludes that the severity of fluorosis is directly proportional to the frequency of fluoride intake.

Devendra Swarup, former director of the Central Institute for Research on Goats, Mathura, Uttar Pradesh, cites a few reasons for the difference in fluoride susceptibility in animals. He says that unlike cattle and horses, which are grazers, camels and goats are browsers and eat plants and herbs rich in calcium and vitamin C. Grazers primarily eat grass while the diet of browsers includes mostly leaves and twigs.

The study was published in *Current Science* on 25 December 2013.

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Pollution biomonitors

Seaweeds (algae) are good indicators of heavy metal levels in marine environments and could be used for monitoring such pollutants in seas. According to a new study in the Gulf of Kutch, which receives discharges containing heavy metals from several industries, various species of brown, red and green algae accumulate heavy metals from seawater and sediments.

Heavy metals enter various organisms and trigger tissue damage. They generate reactive oxygen species, such as hydrogen peroxide, which break down proteins and lipids, degrade DNA, and cause cell deaths.

The study was conducted at Vadinar and Sikka in the Gulf of Kutch. In recent years, such coastal regions have seen rapid industrialisation. The researchers measured the levels of heavy metals in various species of red, brown and green algae, in seawater and sediments and found that iron, manganese and zinc concentrations were generally high in all the algae species. Large amounts of cadmium and zinc were also found.

The highest concentrations of iron and zinc were found in green algae (*Ulva lactuca*) and the lowest iron concentration was recorded in red algae (*Gracilaria*



Iron, manganese and zinc concentrations were high in all the algae species studied in the Gulf of Kutch.

verrucosa) at Vadinar. Green algae (*Caulerpa scalpelliformis*) accumulated considerable amounts of

manganese at Vadinar. At Sikka, it was found accumulated with large quantities of cadmium and chromium. The highest and lowest concentrations of lead were found in the green algae. The study also found that cadmium was accumulated most by brown algae (*Padina gymnospora*).

The results have been published in the February issue of *Eco toxicology and Environmental Safety*.