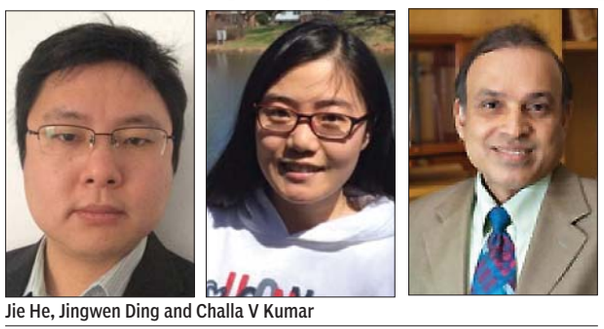
Doubling the mileage factor

BIODEGRADABLES ARE STEPPING IN TO RACK UP SOLAR CELLS, WRITES **S ANANTHANARAYANAN**

The crashing prices of solar panels held out the promise of affordable solar farms and, in tandem with growing wind power, of viable power generation without pollution. However, although mass manufacture has brought down the cost of solar cells, their energy conversion efficiency is low, not more than 15 per cent, in forms practically available. The use of solar cells is, hence, still not commercially economical. This apart, fabrication itself is power-intensive and, again, the material, at the end of the cells' life, is also a pollutant.

In this context, the development of a device that has been found to double the output of solar cells and which is also simple to fabricate as well as dispose of is doubly significant. Jie He, Jingwen Ding and Challa V Kumar at the University of Connecticut report — and have just presented at the 250th National Meeting and Exposition of the American Chemical Society, the world's largest scientific society — their success in testing an easily assembled film that helps solar cells get mileage out of previously inaccessible portions in the spectrum of sunlight.



Jie He, Jingwen Ding and Challa V Kumar

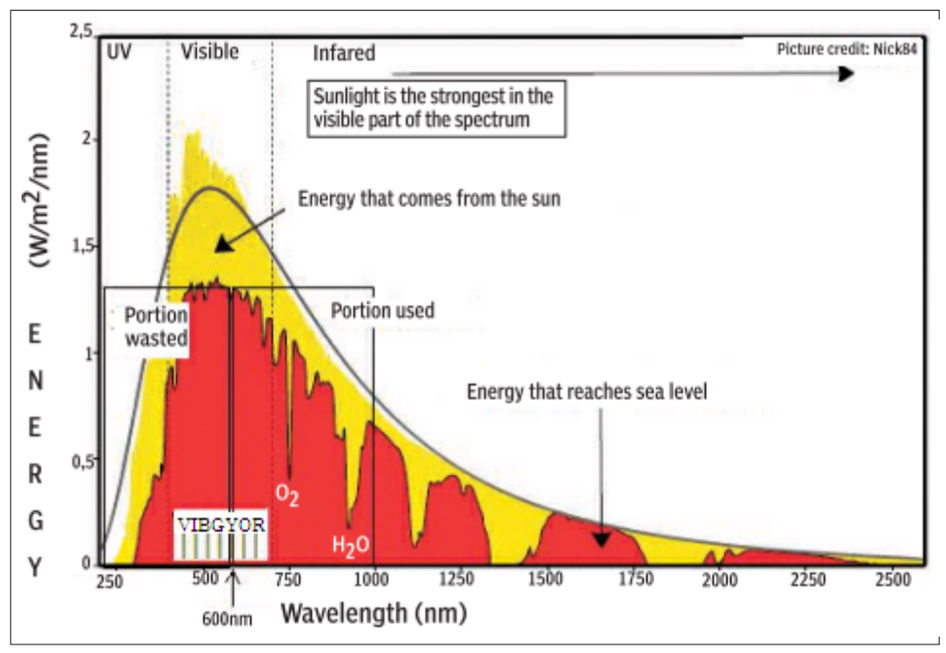
The reason the sun gives out heat and light is that it is fiercely hot. Hot things radiate energy because the atoms or other electrically charged components of which things are made up are in rapid vibration. The hotter they are, the more rapid the motion and the more they radiate. It has been observed and also worked out that while the photons, or particles of light, of which the radiation is composed are there at almost all wavelengths, there is central wavelength that represents a given energy of photons at which an object, at a given temperature, would radiate the most. And as the temperature is raised, the maximum radiation moves to higher energy, which is to say lower wavelength.

Thus, objects that are only warm, like a cup of tea, radiate in the long wavelength, infrared region. A red-hot object radiates in the shorter wavelength of red light, while a white hot object radiates in even shorter wavelengths. The sun is at about 6,000° Celsius and the maximum radiation is in the region of yellow light, with almost as much in the other rainbow colours, and also energy in the shorter wavelength, ultraviolet, and the longer wavelength, infrared.

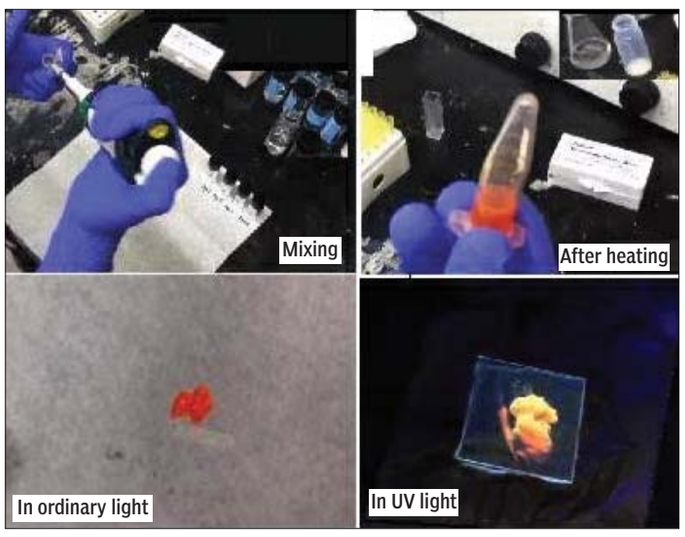
Living things, like plants, have adapted to use this region, from violet to red, for photosynthesis and also for vision so that they make the best use of the sun's radiation. And now that we are trying to tap the same radiation to power our high-energy lifestyle, it is fortunate that the available materials to build photo-voltaic devices also respond to nearly the same part of the spectrum.

Photo-cells

When photons of light of the appropriate energy strike certain metals, they surrender their energy to the metal by knocking one of the electrons in the atoms of the metal so that these pile up at the surface of the metal. Now if the pile of electrons is drained by a conductor leading from the surface to the body of the metal, this is an electric current that can heat things, drive machinery, charge batteries, etc. It is based on this principle that the photo-cell and, hence, the solar cell panels have been developed. The most suitable materials, dimensions and design have been worked out and the last decade has seen rapid improvement.



The limitation, however, is that metals have not evolved, like living things, to make the best use of sunlight and the suitable range of wavelengths for silicon, which is the most common metal used in solar cells, is from 1,000 to 600 nanometers. The radiation of shorter wavelength, 600-350 nm, which is also intense, is wasted. What is more, the radiation in this blue end of the spectrum and also in the ultraviolet is the more energetic and has the effect of causing damage to carefully constructed photo-voltaic cell material. There is, hence, interest, both in making use of the energy in short wavelength radiation as well as in protecting photo-cell material.



Green antenna

What the Connecticut researchers have done is to make use of a property, somewhat like one called *fluorescence*, of certain substances to absorb light at one wavelength and then emit part of the energy absorbed at a longer wavelength. Normal fluorescence is well known in the domestic fluorescent tube, where discharge of electricity through the gas in the tube gives off ultraviolet light. The tube itself is coated, in the inner surface, with fluorescent materials that absorb the UV light and emit light at wavelengths that approximate to white light.

Professor Kumar and team have made use of a related phenomenon in certain materials, where the lower energy emission is not in the form of a lower energy photon but a transfer, without any radiation, to a neighbouring atom and then radiation at an appropriate wavelength by the second atom. This phenomenon, which is called *Förster Resonance Energy Transfer*, is an effect seen only at very small dimensions, where the two systems are in coherence, and it requires the twin conditions of the two systems being close enough together and still not in contact, when FRET cannot take place.

Building on earlier work, reported in the journal of the *Royal Society of Chemistry*, where Kumar was a participant, the Connecticut team has identified a set of dye molecules that are able to act as "donor" and "acceptor" in FRET, as a cascade from light of wavelength at the blue end of the spectrum to emission at wavelengths at the red end. Work like this has been done in the past, but the medium has been in solution, and the participating dye molecules were often allowed to come in contact, inhibiting FRET. They have also been expensive to produce. The Connecticut team has employed a simple method of mixing a protein, albumin, derived from animal serum and fat from the common coconut, to create a gel that sets as a film when warmed. Proteins have a complex molecular structure that allows other molecules to attach to specific portions of their exterior, which is why specific proteins are able to act in specialised ways in living things. In this case, the team believes that the dye molecules are similarly trapped by the protein-fatty acid matrix and kept closely packed, but still held apart, so that Fret action can take place. And as the material sets as a film, it is in solid form and can be easily draped over a solar cell to filter the lower wavelength incident light and deliver it to the solar cell at the proper, longer wavelength.

"We can absorb solar light from 350 nm or blue region to 600 nm or the near red region. The photons absorbed in this wide colour window are then converted to red photons of about 600 nm," says a note from the research team. The fabrication of the film is a very simple process of mixing the components and then warming at some 80° Celsius for 20 minutes, when the film forms. "It can be done in the kitchen or in a remote village. That makes it inexpensive to produce," Kumar says.

The transparent film becomes a light pink or reddish when mixed with dyes, because of emission on the red side of the spectrum, or yellow-orange when seen in UV light. The effect can be destroyed if any one of the dyes is left out, which shows that they all take part in the cascade. Testing the film on actual solar cells has shown a positive increase in electrical output and the estimate is that there can be a doubling of the output of common solar cell types. And the doubling of output comes with the addition of natural materials that degrade without environmental damage — "They are even edible," says Kumar.

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PROTEIN TRANSLATION

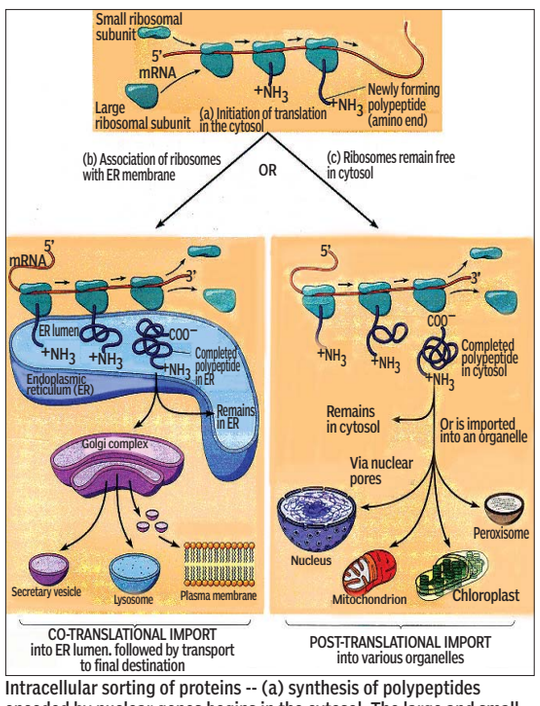
TAPAN KUMAR MAITRA EXPLAINS THE MECHANISMS BY WHICH POLYPEPTIDES ARE ROUTED TO APPROPIATE PLACES

When it comes to the mechanisms that route each newly made protein to its correct destination, think for a moment about a typical eukaryotic cell with its diversity of organelles, each containing its own unique set of proteins. Such a cell is likely to have billions of protein molecules, representing at least 10,000 different kinds of polypeptides, each of which must find its way either to the appropriate location within the cell or outside it. A limited number of these polypeptides are encoded by the genome of the mitochondrion (and for plant cells, by the chloroplast genome as well), but most are encoded by nuclear genes and are synthesised by a process that begins in the cytosol.

Each of these polypeptides must then be directed to its proper destination and, therefore, have some sort of molecular "zip code" that ensures its delivery to the correct place. In this process of protein targeting and sorting, we can begin by grouping the various compartments of eukaryotic cells into three categories: the endo-membrane system — an interrelated system of membrane compartments that includes the endoplasmic reticulum, the Golgi complex, lysosomes, secretory vesicles, the nuclear envelope and the plasma membrane — the cytosol; and mitochondria, chloroplasts, peroxisomes (and related organelles) in the interior of the nucleus.

Polypeptides encoded by nuclear genes are routed to these compartments using different mechanisms. The process begins with transcription of the nuclear genes into RNAs that are processed in the nucleus and then transported through nuclear pores for translation in the cytoplasm, where most ribosomes occur. While mRNA translation is largely a cytoplasmic process, recent evidence suggests that as many as 10 per cent of a cell's ribosomes may actually reside in the nucleus, where they can translate newly synthesised RNAs. Nuclear translation appears to function mainly as a quality-control mechanism that checks new mRNAs for the presence of errors.

In spite of the existence of such functioning nuclear ribosomes, it is clear that most polypeptide synthesis occurs on cytoplasmic ribosomes after mRNAs have been exported through nuclear pores. Upon arrival in the cytoplasm, these mRNAs become associated with free ribosomes (those not attached to any membrane). Shortly after translation begins, two main pathways for routing the newly-formed polypeptide products begin to diverge. The first pathway is utilised by ribosomes synthesising polypeptides destined for the endomembrane system or for export from the cell.



Intracellular sorting of proteins -- (a) synthesis of polypeptides encoded by nuclear genes begins in the cytosol. The large and small ribosomal sub-units associate with each other and with the 5' end of an mRNA molecule, forming a functional ribosome that starts making the polypeptide. When the polypeptide is about 30 amino acids long, it enters one of two alternative pathways; (b) if destined for any of the compartments of the endomembrane system, or for export, the newly forming polypeptide becomes associated with the ER membrane and is transferred across the membrane into the lumen (cisternal space) of the ER as synthesis continues. This process is cotranslational import. The completed polypeptide then either remains in the ER or is transported via various vesicles and the Golgi complex to another final destination. (Integral membrane proteins are inserted into the ER membrane as they are made, rather than into the lumen.) (c) If the polypeptide is destined for the cytosol or for import into the nucleus, mitochondria, chloroplasts, or peroxisomes, its synthesis continues in the cytosol. When the polypeptide is complete, it is released from the ribosome and either remains in the cytosol or is transported into the appropriate organelle by posttranslational import. Polypeptide uptake by the nucleus occurs via the nuclear pores, using a mechanism different from that involved in post-translational uptake by other organelles.

Such ribosomes become attached to ER membranes early in the translational process, and the growing polypeptide chains are then transferred across (or, in the case of integral membrane proteins, inserted into) the ER membrane as the synthesis proceeds. This transfer into the ER is called co-translational import because movement of the polypeptide is directly coupled to the translational process. The subsequent conveyance of such proteins from the ER to their final destinations is carried out by various membrane vesicles and the Golgi complex.

An alternative pathway is employed for polypeptides destined for either the cytosol or for mitochondria, chloroplasts, peroxisomes, and the nuclear interior. Ribosomes synthesising these types of polypeptides remain free in the cytosol, unattached to any membrane. After translation is completed, the polypeptides are released from the ribosomes and either remain in the cytosol or are taken up by the appropriate organelle. The uptake by organelles of such completed polypeptides requires the presence of special targeting signals and is called post-translational import. In the case of the nucleus, polypeptides enter through the nuclear pores. Polypeptide entrance into mitochondria, chloroplasts and peroxisomes involves a different kind of mechanism.

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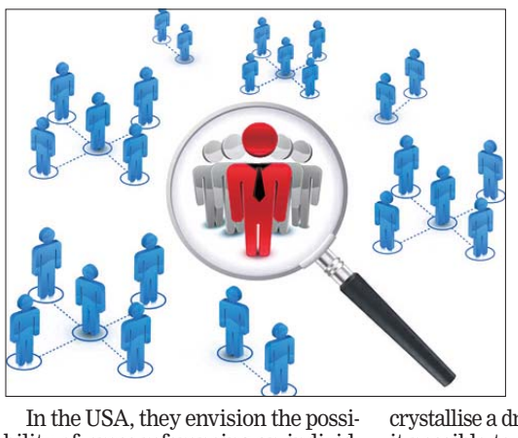
Expediting precise therapy

ONE MORE 'COLOUR' HAS APPEARED THROUGH MEDICAL SCIENCE'S METAPHORICAL WHITE LIGHT SPECTRUM, WRITES **DEEPAK RIKHYE**, AND IT'S CALLED PRECISION MEDICINE

When sunlight, or white light, passes through a glass prism, it cannot be seen on the other side. Instead, what is observed are all the colours of a rainbow, ranging from red to orange, yellow, green, blue, indigo and violet. This is known as the white light spectrum because sunlight comprises all these colours.

Isaac Newton wrote about this phenomenon 300 years ago in a work titled *Optiks*. If we imagine medical science as a ray of white light passing through a glass prism then as a subject it can symbolised by the different colours observed on the other side, each representing a specific branch of medical science. Given the subject's many branches, however, a lot more imaginary shades would need to pass through the prism and, indeed, one more "colour" has appeared through medical science's metaphorical white light spectrum — Precision Medicine.

Imagine undergoing a simple blood test and the doctor meeting you fully prepared with a diagnosis wherein the ideal medicines would have already been identified based on your genetic make-up. This form of treatment will avoid any side effects you may be vulnerable to and genetic data from every patient can improve insights into variations. It would also expedite creating precise therapies faster and at less expense, in which regard an estimated seven billion people across the world would benefit.



In the USA, they envision the possibility of cross-referencing an individual's medical history and biology with patterns found worldwide and utilising the knowledge to deliver effective treatment. The role and study of genes is virtually integral to PM given that genes are catalysts of all cellular processes and determine physical traits.

Again, there are many diseases with no proven means of prevention or treatment and this is where PM provides a new approach. While significant advances in this practice have been made for certain types of cancer, most other diseases don't figure, which is why efforts are in progress to make PM the norm rather than the exception. Plans are underway to move this concept into everyday practice, to formulate a module that will be suited to a particular patient. The tools for this practice are essentially the individual's genetic content or cellular analysis that will also help diagnostic imaging.

However, this does not imply creating drugs specific to any one person but, rather, the ability to classify individuals that differ in their being susceptible to a particular disease and how they could respond to a particular treatment. Rather than interpreting PM as "individual treatment", it would more relevantly involve a category of individuals with genetic similarities. At the molecular level, the cause of an individual's disease could, through analysis, be identified — thus facilitating treatment.

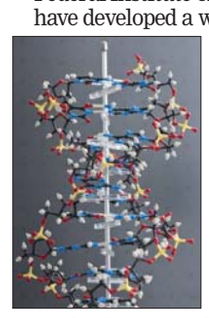
The PM roadmap involves building a comprehensive database of scientists who will embark on the study of one million Americans to expand the understanding of health and disease. One of the priorities will be to focus on an integrated policy of better prevention and treatment of more types of cancers. The branch of PM that addresses cancer is "precision oncology".

This new branch of medical science could crystallise a dream into reality: to make it possible to prevent or treat or cure one of humankind's most frightening diseases — cancer.

PLUS POINTS

Data storage

Robert Grass and colleagues **at** the Swiss Federal Institute of Technology in Zurich have developed a way of storing vast quantities of information for up to a million years in a single molecule of DNA. The breakthrough could lead to digital archives of everything from ancient texts to Wikipedia changes surviving for hundreds of thousands of years without any loss of data. They have pioneered a process of encapsulated DNA in glass that is equivalent to creating a fossilised form of data storage.



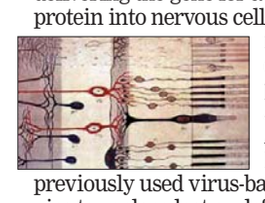
They have also developed a mathematical algorithm normally used in long-distance radio transmissions to eliminate any errors when deciphering the data written in the digital genetic code of DNA. "We will show how we can use modern chemical and information engineering tools for the safeguarding of actual digital information in the form of DNA," the researchers told the American Chemical Society meeting in Boston. Dr Grass said his team had converted 83 kilobytes of text from the medieval Swiss Federal Charter of 1291 and the Methods of Archimedes from the 10th century into the digital code of DNA based on sequences of four chemical building blocks, the nucleotides A, C, T and G. "A little after the discovery of the double helix architecture of DNA, people figured out that the coding language of nature is very similar to the binary language we use in computers," he said. "On a hard drive, we use zeros and ones to represent data, and in DNA we have four nucleotides, A, C, T and G."

The DNA molecules were synthesised by machine and heated to 71° Celsius for a week, which is equivalent to being stored at 50° Celsius for 2,000 years, after which it was decoded back into the original text without any errors. DNA has the advantage over hard drives in that it is an extremely dense form of data storage with the potential to survive for long periods of time. An ounce of DNA could fit on a penny, store 300,000 terabytes of memory and palaeontologists have shown the data stored in DNA recovered from fossils can survive for up to a million years.

STEVE CONNOR/THE INDEPENDENT

Restoring sight

A team of researchers at the University of Manchester has enabled blind mice with advanced retinal degeneration to see by delivering the gene for a light-sensing protein into nervous cells within their retinas, according to a study published on 30 July in *Current Biology*.



Researchers have previously used virus-based gene therapies to replace lost or defective genes in rods and cones, the photoreceptor cells of the retina. But for the present study, the team set its sights on ganglion and bipolar cells, which transduce signals from rods and cones into electrical signals sent to the brain. By delivering the gene for the light-sensing pigment, rhodopsin, to these cells they bypassed the need for rods and cones. Doing so enabled the treated mice to respond to visual stimuli, such as a video of an owl swooping.

"The treated mice could discriminate black and white bars, but only ones that were 10 times thicker than what sighted mice could see," Robert Lucas, study coauthor and geneticist at the University of Manchester told *New Scientist*. He added that the virus they used to deliver the gene was approved for use in humans, which means people could figure in trials in the next five years.

AMANDA B KEENER/THE SCIENTIST

Dream scenes

The stage of sleep in which we dream is characterised by flickering eye movements but whether that activity beneath the eyelids correlates to what is happening in our dreams has been tough to work out. Using *in vivo* neural recordings from human participants, scientists have now shown that immediately after an eye movement, activity in a brain region related to processing images spikes.

"We are intimately familiar with the activity of these neurons. We know they are active every time you look at an image, or when you imagine that image. And now we see them active in a similar way when you move your eyes in Rapid Eye Movement sleep, so it becomes very probable that these movements represent some type of reset, or 'moving onto the next dream frame,'" Yuval Nir of Tel-Aviv University told the *BBC News*. He and his colleagues published their results on 11 August in *Nature Communications*.

Nir's team enrolled epilepsy patients who had electrodes implanted to monitor seizures. They tracked the neural performance of the medial temporal lobe in 19 patients during sleep and wakefulness. They found that a fraction of a second after eye movement, the neurons had a burst of excitement.

KERRY GRENS/THE SCIENTIST