Their eyes have it

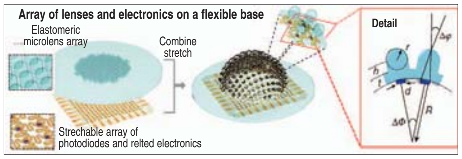
There is just more that meets an insect's eye, says s ananthanarayanan

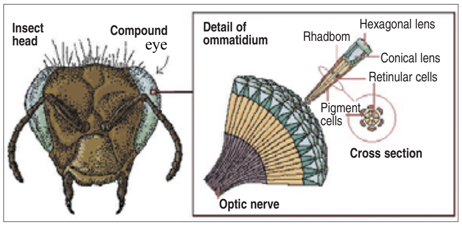
Who killed Cock Robin?
"I," said the sparrow, "with my bow and arrow."
Who saw him die?
"I," said the fly, "with my little eye."

INDEED, the little eye of the housefly is a remarkable instance of optical engineering. It is a *compound eye*, consisting of thousands of separate optical sensors, each pointed at a slightly different angle, which gives the fly a nearly 180° field of view. And each sensor can detect many colours that we cannot see and also a feature of reflected light, called polarisation, which helps the fly, the honey bee and many other species that have compound eyes to see detail which is invisible to us. And compound eyes are highly sensitive to movement, as most of us must know if we have tried to swat a fly!

Young Min Song, Yizhu Xie, Viktor Malyarchuk, Jianliang Xiao, Inhwa Jung, Ki-Joong Choi, Zhuangjian Liu, Hyunsung Park, Chaofeng Lu, Rak-Hwan Kim, Rui Li, Kenneth B Crozier, Yonggang Huang and John A Rogers, working at institutes in Illinois, Harvard, Colorado, South Korea, Singapore and China, report in the journal *Nature* that they have developed a laboratory, manmade copy, in function, complexity and size, of the insect eye.

The eyes of insects and many other creatures with segmented bodies are compound, or made up of hundreds or thousands of separate visual units, which are called *ommatidia*. The surface of the

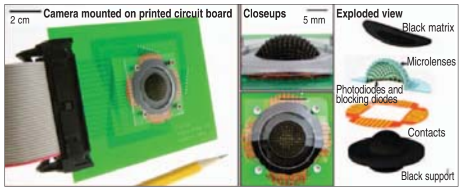


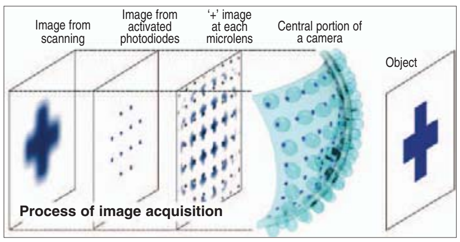


like the pixels that make up the picture in print — the more in number, the finer the detail. As the structures are at the cellular level, the insect eye has fairly good resolution even with the wide field of view. The other features are that as the lenses are of short focus, objects at all distances are in focus, which is to say there is good depth of field and the insect eye needs no muscles. And the eye is sensitive down to the ultra-violet. But the important feature is that movement of an object rapidly changes the ommatidia that are involved, and the eye is extremely sensitive to motion.

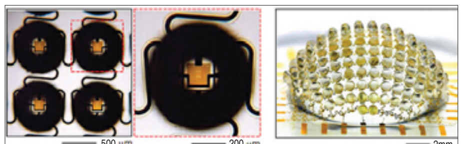
cylindrical supports. The second subsystem is a matching array of silicon photo-detectors, provided with filaments of deposited metal conductors, to carry away the electrical signals when the detectors are activated. A key feature of the materials used is that it can be bent and stretched to transform from a plane to a hemisphere. This kind of imager, shaped as a hemisphere, can then be mounted on further electronics for combining the images of the ommatidia to create the final, wide-angle view. The picture shows that the hemispherical array of 180 detectors, which matches the design of the eye of fire ants or bark beetles, is less than two centimetres across.

Working cameras constructed in this way have been found to give excellent characteristics and high yields. Individual ommatidia form images of the object in view according to the angle from which light is incident. The photoreceptors are activated only if the image falls on the sensitive area. The photodiodes stimulated like this create a sampled image of the object, as is shown in the picture. In living things, there is rapid motion of the eye, or combination of the images of a moving object, that work to





Process of image acquisition



Microscope picture of four adjacent ommatidia in a plane, with a magnified picture one of them.
After deformation into hemisphere.

ommatidium is a hexagonal lens, below which is a conical lens, and the combination focuses a narrow beam of light on to a retina-like structure of light sensitive cells called the *rhadbom*. Pigment, or colouring cells separate the ommatidia and optic nerve fibres transmit the signal at each rhadbom separately to the brain.

The ommatidia are positioned over almost a whole hemisphere and hence cover almost the complete view before the eye. As each unit focuses at a narrow angle, there is no overlap and the images that are formed act

These features of compound eyes make it attractive to mimic the design in the laboratory, to create similar camera lenses, for application in surveillance or endoscopy.

The limiting factor has been the absence of technology of lenses and detectors that can be bent to form a curved shape for wide coverage. The nearest approach has been with flat panels of compound lenses or curved shapes in largescale dimensions. Compact, full hemispherical shape with a good number of detectors has been out of reach.

In their paper in *Nature*, Young Min Song and colleagues have presented a scheme based on recent advances in flexible electronic components and hemispherical arrays of photo-detectors, which allow design features that were unachievable so far. Systematic experimental and theoretical studies of the mechanical and optical properties of working devices has led to a set of materials, layout and integration method for digital cameras which replicate biological compound eyes.

The three pictures explain how the arrangement works. The first is a moulded elastic sheet of a polymer, which acts like glass and is shaped into 16x16 lenses. Of these 256 lenses, 180 participate in the camera and are mounted on matching

improve the resolution, or the level of detail. Similar effects were created and modelled by scanning the images of different ommatidia, to improve the images formed. Special software, computing algorithms and data acquisition methods help the camera adapt to changing conditions of lighting or speed of movement.

The key features, of being scalable to large numbers of ommatidia, different layouts and dimensions, and compatibility with silicon electronics suggest that commercial compound lens cameras could equal or better the biological templates by which they have been inspired.

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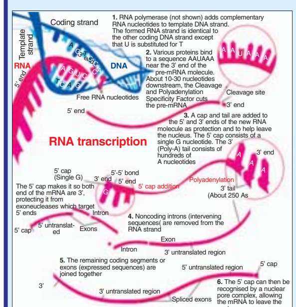
Differential activity

tapan kumar maitra **explains genetic control at the level of transcription**

SINCE the genome remains constant throughout development, the differences between cells must be due to differential gene activity; that is, some genes must be expressed at a higher rate than others. This could be explained by differential translation (protein synthesis) of genes. One possibility is that cells may have mechanisms by which some mRNAs are translated in a given cell type but not in others. Experiments in which mRNA is injected into living cells argue strongly against this possibility.

When purified mRNA coding for rabbit globin protein, a large number of mRNAs of animal and plant origin are efficiently translated in oocytes (including those coding for immunoglobulins, interferon, collagen, viral coat proteins and many others). This shows that oocytes do not have a mechanism that excludes the translation of certain mRNAs. Thus, protein synthesis does not seem to be regulated in the way required to explain the expression of, for example, haemoglobin in red blood cells but not in other tissues.

Several lines of evidence suggest that eukaryotic gene expression is regulated at the level of RNA synthesis. The clearest example is provided by polytene chromosomes, in which transcription of genes can be visualised in the form of puffs. Specialised cells have distinct patterns of puffing (and therefore of transcription) which differ in different tissues.



Although many mRNAs are different between tissues, many others are shared by different cell types. The shared sequences represent the so called housekeeping genes required for the survival of all cells, such as, for example, genes coding for membrane proteins, glycolytic enzymes, ribosomal and mitochondrial proteins and so on. The unshared sequences represent the so called luxury functions, which are characteristics of specialised cells, for example, haemoglobin in red blood cells, ovalbumin in the oviduct and keratin in skin.

The abundance of transcripts for individual genes such as globin, ovalbumin and so forth can be measured by nucleic acid hybridisation studies, and for all differentiated genes that have been examined, the experimental evidence is consistent that the view that production of specialised proteins is due to differential gene transcription.

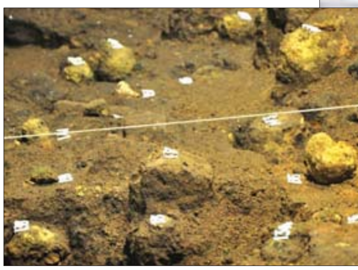
The writer is associate professor and head, Department of Botany, Ananda Mohan College, Kolkata

'Yellow spheres... but we don't know their meaning'

matilda battersby **reports on a mysterious find beneath Mexico's Temple of the Feathered Serpent**

ARCHAEOLOGISTS excavating beneath Mexico's Temple of the Feathered Serpent have discovered hundreds of mysterious yellow orbs in tunnels near what is the third largest pyramid in the pre-Hispanic city of Teotihuacan, which have been the focus of study ever since they were discovered in 2003.

The yellow spheres were uncovered when a remote-controlled robot — Tlaloc II-TC — carrying camera equipment was deployed to explore a series of winding and largely

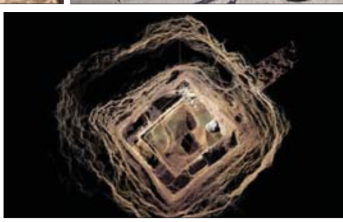


inaccessible chambers within the ancient pyramid ruins that are characterised by statues of strange serpent-like creatures.

"They look like yellow spheres, but we do not know their meaning," Jorge Zavala, an archaeologist at Mexico's National Anthropology and History Institute, told *ABC* news of the find.

"It's an unprecedented discovery."

The orbs measure between 1.5 and five inches and are believed to be covered in a yellow material called jarosite, and to contain a core of clay. The World Heritage Site, a city of pyramids located just 30 miles from Mexico City, is thought to have been established around 100 BC and was inhabited by around 100,000 people at its peak before being mysteriously abandoned around 700 AD.



Tlaloc II-TC sent to explore the tunnels carries an infrared camera and a laser scanner that generates 3-D visualisation of the spaces beneath the temple, allowing it to access parts of the ruins that have not yet been excavated. "A few months ago we found two side chambers at 72 and 74 metres from the entrance. We called them North Chamber and South Chamber," archaeologist Sergio Gómez Chávez, director of the Tlalocan Project, told *Discovery News*. "The robot was able to enter the part of the tunnel which has not yet been excavated yet and found three chambers… We believe that high-ranking people, priests or even rulers, went down to the tunnel to perform rituals."

George Cowgill, professor emeritus at Arizona State University, told *Discovery News* the find was "unique". He said, "Pyrite was certainly used by the Teotihuacanos and other ancient Mesoamerican societies. Originally the spheres would have shown brilliantly. They are, indeed, unique, but I have no idea what they mean."

The walls of the tunnels are covered in a mineral powder made up of magnetite, pyrite and hematite. Gomez believes the tunnels were sealed twice by the Teotihuacan people and access was blocked nearly two millennia ago in order to project something very important in the central chamber. He believes the tunnels might contain the remains of those who ruled Teotihuacan and that the site is possibly one of the most significant archaeological finds in the region.

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