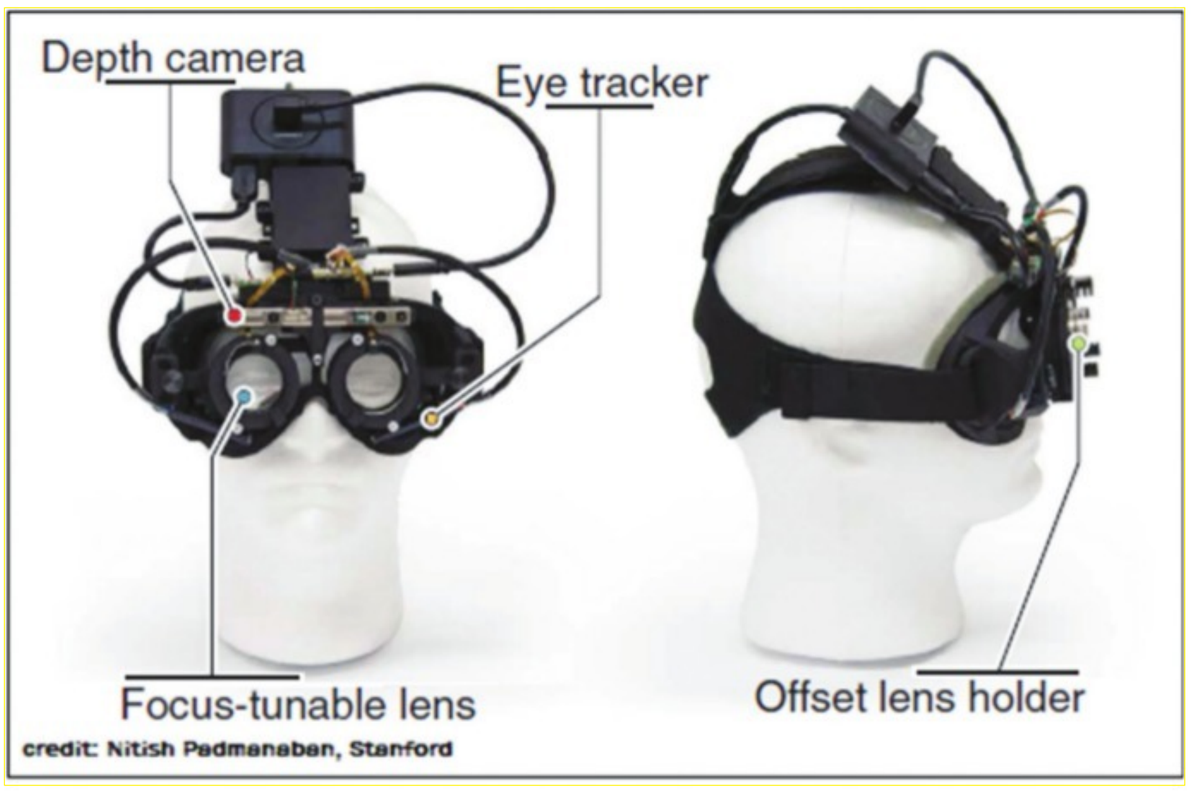
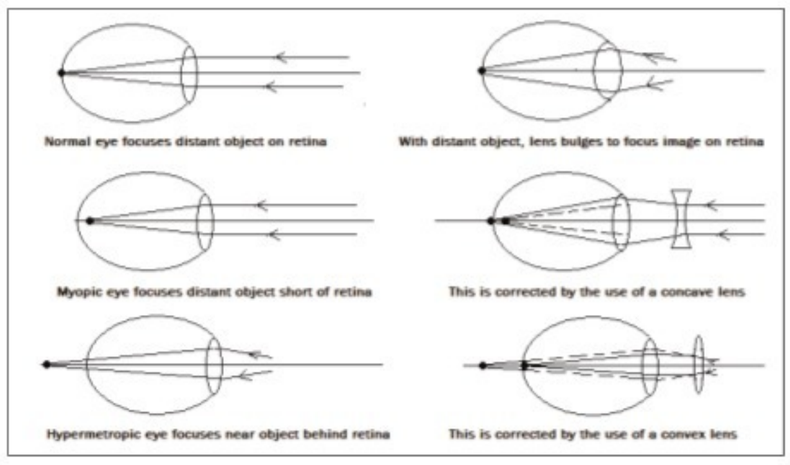
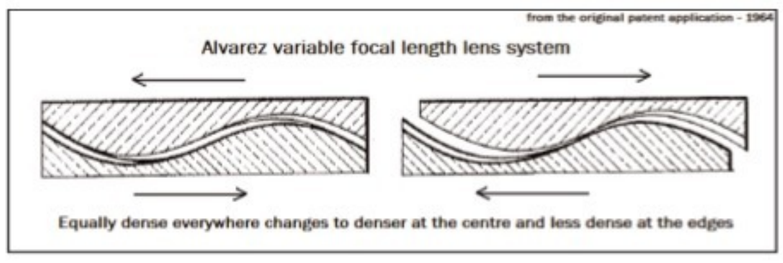
Focusing on smart vision

Spectacles that change, like the lens of the eyes, is the next step in sight correction







S ANANTHANARAYANAN

Human sight is known to get less efficient with age. Perhaps this happens with animals as well, but humans have devised technology to correct deficiencies, and manage quite well for most of their lives. Current methods, however, are different for near vision and distant vision, and may need to be switched when we shift out gaze from one object to another.

Nitish Padmanaban, Robert Konrad and Gordon Wetzstein, from Stanford University, report in the journal, *Science Advances*, an arrangement that does better, it detects what a person is looking at and does an autofocus, or modifies the lenses of her spectacles to be just right for that distance. A large proportion of users who tried out the device found the result to be better than the best that we have so far, the paper says.

The sense of vision has its origin in the earliest organisms, which could just detect light or shade, and evolved, through the ages, to organs that could focus light as an image. The modern eye, with its high degree of clarity and acuity, consists of a lightproof chamber with a light-sensitive screen and a lens whose focus can be adjusted. The cavity of eyes in babies is a little shorter than that of adults. Babies, at the start, are not able to focus on near objects. But their eyes have flexible lenses and they soon learn to perceive, and grasp, near things. The problem recurs when a baby grows much older and the lens is less flexible. And at this stage, she needs a concave lens in her spectacles to be able to read the newspaper.

The picture shows the way the normal, young person's eyes function. The relaxed lens focuses the image of a distant object on the retina, the light-sensitive screen at the far end of the eye chamber. When the object moves closer, the same state of the lens would focus the image a little behind the retina and the image would be blurred. The muscles of the eye adjust for this by making the lens bulge a little more and bring the point of focus nearer, so that the image is again on the retina.

If the lens, in the relaxed position, focuses the image short of the retina, as in the second row in the picture (top right), distant objects appear blurred. With nearer objects, however, the image moves a little back and is seen clearly. A person with this condition, which is known as myopia, needs to strain the eye to reduce the bulge of the lens and move the point of focus closer to the retina. The condition is usually treated by placing a concave lens, one that makes light rays diverge, before the eyes.

The opposite of myopia is long sight, or hypermetropia, where distant objects are clear, but near objects are blurred. This happens with older people, where the crystalline material of the eye is not flexible and the lens cannot focus light on the retina, but forms the image behind the retina. The solution is then to place a convex lens, which makes the rays of light converge, in front of the eyes, so that the point of focus moves forward.

With advancing age, there is usually an element of both myopia as well as long sight. A person hence needs a pair of lenses for normal use and another pair for near-range work, such as reading. The inconvenience is avoided if we combine both kinds of lenses, as in the bifocal. This is a split lens — the upper part is concave, for seeing distant things, and the lower part is convex, for reading.

The disadvantage, however, is that the field of view is broken, there are double images and the user could misjudge heights, to trip and fall. An improvement of the bifocal was the progressive, where the concave and convex curvatures are built into a single lens, with a smooth changeover. The improvement, however, is partial.

"The common thread across these methods is that they use fixed focal elements to approximate vision that was once achieved by the flexible crystalline lenses in the wearer's eyes," the paper in *Science Advances* says. In the absence of a method to reverse the stiffening of the natural lens material with age, the creation of a "variable focus" lens, to be placed in front of the eyes just like the fixed focus lenses now used, was tried.

An early version of this lens was the Alvarez lens, where there are two thin lens elements, which can slide over each other, as shown in the picture (above). The patent application for the Alvarez lens said that a movement of 2.5 mm, could bring about a change in the power, by as much as 3 diopters (diopter is the "number" that opticians use). As a movement of 2.5 mm can be accommodated in normal spectacle frames, it said, the arrangement could easily change from distant to near settings in most cases.

Other methods have been to use liquid lenses that can change shape, and arrangements to discover the distance of objects in front of the person, to adjust the lens. Most of these methods, however, the *Scientific Advances* paper says, usually need some form of manual control and were never really as good as a young person's ability to effortlessly see clearly objects at different distances, as fast as she turns her head around. The use of the depth sensor, which could automate control of the shape of the lens, the paper notes, is an advance, but it requires the wearer to turn her head and face the object she wishes to see. The method also breaks down when viewing transparent or moving objects, or through a window, or when people pass in front of the object. Methods used in Virtual Reality, based on tracking eye movements have also shown promise, the paper says.

PROSPECTIVE BENEFITS

As age progresses, the sense of balance and sensations of pressure, pain or warmth deteriorate and humans need to rely more heavily on their sense of sight. It is unfortunate that in this sense too, the capacity of accommodation, or the capacity of the eye to view objects at different distances, reduces. Developing a device that automatically senses the distance of an object and compensates for the deficiency of the eyes in viewing it would go a long way in helping older people get around safely.

As an ideal solution is still not in sight, the Stanford University trio constructed a prototype wearable spectacles system that combines electronically controlled liquid lenses, a stereo camera to assess depth over a wide field of view and an arrangement to track the movement of the eyes, to know where they are looking. While the tracking system senses where the eyes are pointed, the stereo camera estimates the distance of the object being viewed and passes a signal to the lenses, which automatically adjust their focal power. All the major deficiencies of existing systems are thus addressed.The authors write that a large sample of users tried out the system and compared the results with other methods, starting from bifocals, progressives, or more sophisticated solutions. "We find that focus-tunable eyeglasses, on average, outperform traditional forms of correction across a range of metrics… users wearing autofocals express a notable preference for our eye-tracked autofocals over a previously proposed depth-tracked solution…" the authors note.

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Methods of discharge

Secretory pathways transport molecules to the exterior of the cell

TAPAN KUMAR MAITRA

Integral to the vesicular traffic are secretory pathways by which proteins move from the endoplasmic reticulum through the Golgi complex to secretory vesicles and secretory granules, which then discharge their contents to the exterior of the cell. The concerted roles of the ER and the Golgi complex in secretion were first demonstrated by Nobel Laureate George Emil Palade and his colleagues, who used autoradiography to trace the fate of radioactively labelled protein through cells in the salivary gland.

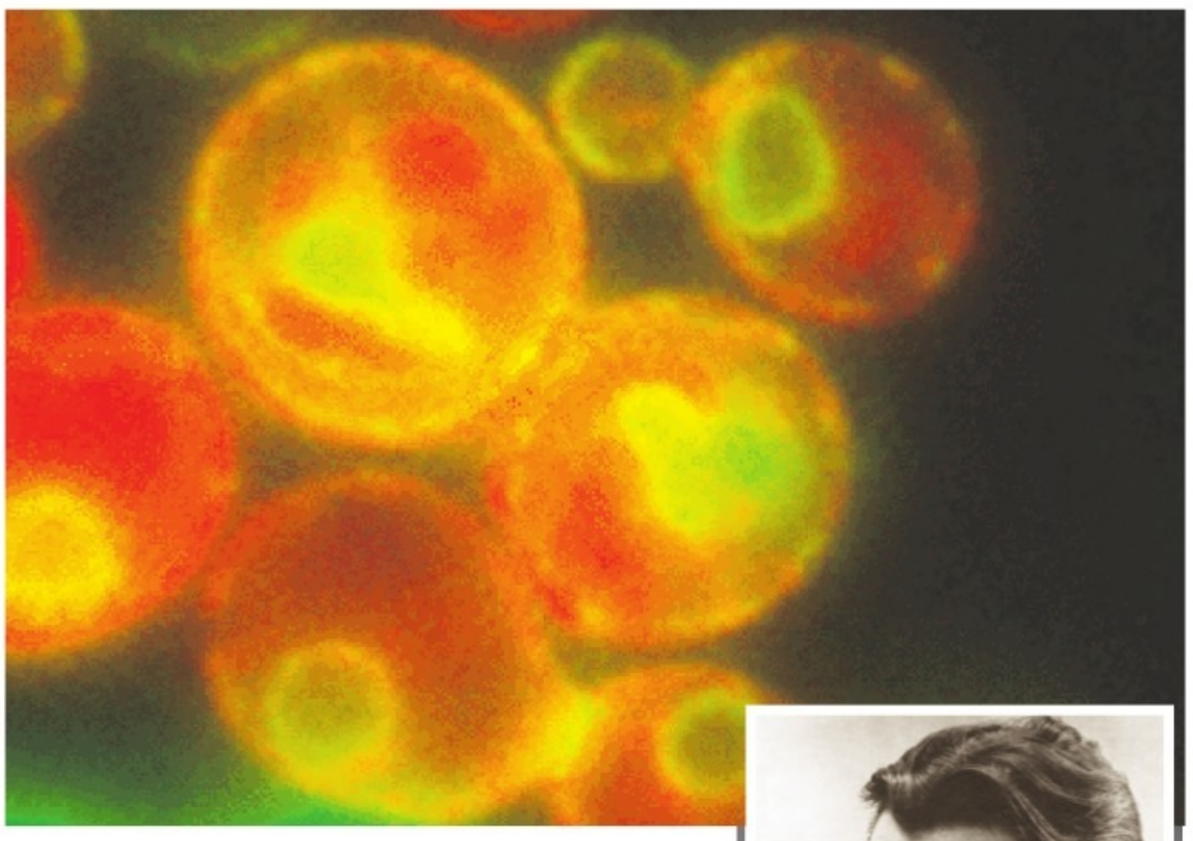
The results of one of Palade's experiments were that for the first few minutes after injection of a radioactive amino acid into rabbits, newly synthesised protein containing the radioactive amino acid was found only in the rough ER of the secretory tissue. Shortly thereafter, radioactivity began to appear in the Golgi complex, peaking at about 30-40 minutes. By 30 minutes, radioactively labelled protein could also be detected in vesicles budding from the Trans-Golgi Network, which Palade called condensing vacuoles. After 90 minutes, radioactivity began to accumulate in secretory granules, the vesicles that discharge secretory proteins to the exterior of the cell. Radioactively labelled protein eventually was released in the extracellular medium, demonstrating that the secretory granules actually release their contents beyond the plasma membrane.

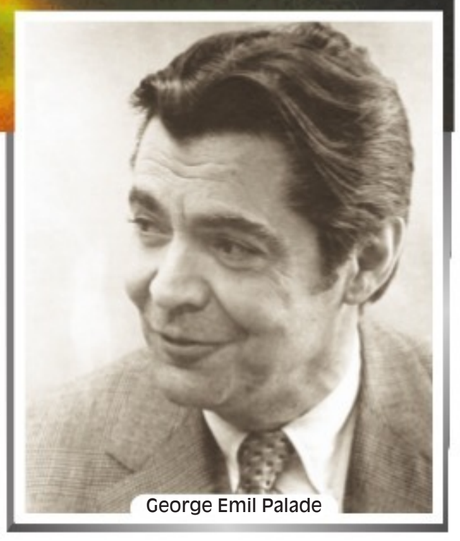
Based on Palade's initial experiments and numerous similar studies since then, the secretory pathways are now understood in considerable detail. Moreover, there are two different modes of secretion by eukaryotic cells. Constitutive secretion involves the continuous discharge of vesicles at the plasma membrane surface, whereas regulated secretion entails controlled rapid releases that are usually in response to an extracellular signal.

After budding from the TGN, some secretory vesicles move directly to the cell surface, where they immediately fuse with the plasma membrane and release their contents. This process, which is continuous and independent of specific extracellular signals, occurs in most eukaryotic cells and is called constitutive secretion. Examples include the continuous release of mucus by cells that line your intestine and the secretion of the glycoproteins of the extracellular matrix.

Constitutive secretion was once assumed to be a default pathway for proteins synthesised by ribosomes attached to the rough ER. According to this model, all proteins destined for transport from the ER to the Golgi complex must have a tag that diverts them from constitutive secretion. Unless an amino acid sequence or oligosaccharide chain identifies a protein for retention in, or transport to, a specific organelle, the protein moves through the endomembrane system and is released outside the cell by default. Support for this model came from studies in which the retrieval tags on ER-specific proteins were removed and the fates of the proteins were traced. Removal of the sequence from resident proteins of the ER generally led to secretion of the protein. More recent evidence, however, points to a variety of short amino acid sequences that identify proteins for constitutive secretion by one of several distinct pathways for this process.

While vesicles containing constitutively secreted proteins move continuously and directly from the TGN to the plasma membrane, secretory vesicles involved in regulated secretion accumulate in the cell and then fuse with the plasma membrane only in response to specific extracellular signals. An important example is the release of neurotransmitters. Two additional examples of regulated secretion are the release of insulin from the ? cells of the pancreatic islets of Langerhans and the release of digestive enzymes from acinar cells of the pancreas.




George Emil Palade

Regulated secretory vesicles form by budding from the TGN as immature secretory vesicles, which lose their clathrin coats and undergo a maturation process. Maturation involves concentration of the proteins — referred to as condensation — and frequently also the proteolytic processing of secretory proteins. The mature secretory vesicles then move close to the site of secretion and remain near the plasma membrane, until receiving the signal that triggers release of their content by exocytosis.

Mature regulated secretory vesicles are usually quite large and contain much more highly concentrated proteins than do constitutive secretory vesicles. Such large dense vesicles are often called secretory or zymogen granules to distinguish them from other secretory vesicles. Zymogen granules are con-centrated in the region of the cell between the Golgi stacks from which they arise and the portion of the plasma membrane bordering the lumen into which the contents of the granules are eventually discharged.

The information needed to direct a protein to a regulated secretory vesicle is presumably inherent in the amino acid sequence of the protein, though the precise signals and mechanisms for sorting proteins to secretory vesicles are not clear. Current evidence suggests that high concentrations of secretory proteins in secretory granules promote the formation of large protein aggregates that exclude non-secretory proteins.

This could occur in the TGN, where only aggregates would be packaged in vesicles destined for secretory granules, or it could occur in the secretory granule itself. The pH of the TGN and the secretory granule lumens may serve as a trigger favouring aggregation as material leaves the TGN. The soluble proteins that do not become part of an aggregate in the TGN or a secretory granule would be carried by transport vesicles to other locations.

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PLUS POINTS

Smoking kills

Smoking increases both men's and women's risk of a major heart attack at all ages, but women smokers have a significantly higher increased risk compared to men, especially those aged under 50, according to new research. The findings, published in the *Journal of the American College of Cardiology*, showed that despite the increased risk, smokers can reduce their risk to that of someone who has never smoked in as little as a month after quitting.

Smoking is a risk factor for heart disease and researchers have previously identified smoking as the cause of ST-Elevation Myocardial Infarction, one of the most acute forms of life-threatening heart diseases, in nearly 50 per cent of all cases. However, none have quantified and compared the incidence of Stemi associated with smoking between genders and within different age groups.

In the research, the authors sought to assess smoking as an independent risk factor for Stemi and determine the differences in risk between age groups and genders. They found that smoking increases Stemi risk in all patients, regardless of age or gender, but the risk is higher in females compared to males at all ages. The largest relative risk difference between men and women smokers was in the 50-64 years old group, but the highest risk increase in both genders was in the 18-49 years group — the youngest group. Female smokers in this age group had a greater than 13 times higher risk of Stemi compared to their non-smoking female contemporaries. Young male smokers had an 8.6 times increased risk.

"Our study found that smoking cessation, regardless of age or gender, reduces Stemi risk to that of a never smoker, possibly within a month. Patients who smoke merit encouragement to give up their habit, and this study adds quantitative evidence to the massive benefits of doing so," said Dr Ever Grech, from the University of Sheffield's Department of Infection, Immunity and Cardiovascular Disease and consultant interventional cardiologist at Sheffield Teaching Hospitals NHS Foundation Trust.

Improved solar cells

Researchers have developed a novel process to improve the performance of third generation solar cells. Working with dye sensitised solar cells, they have shown that the incorporation of magnetic nanoparticles in the anode can enhance light-to-power conversion efficiencies. Their most recent work has been published in the journal *Solar Energy*, a peer-reviewed journal.

There is much promise for dye sensitised solar cells because of costs and the possible environmental benefits and it is expected that with improvements in performance, DSSCs could outdo mature silicon-based solar cells. The worldwide DSSC market is projected to reach US $60 million by 2023, but such a market can be tapped only with efficiency improvements. Research like this, which is headed by the Indian Institute of Technology-Hyderabad, can contribute towards global efforts to bring DSSCs into real-life applications.

The research is being led by Jammalamadaka Suryanarayana, associate professor, magnetic materials and device physics laboratory, department of physics, IIT-Hyderabad, with his student Kannan UM in collaboration with L Giribabu, senior scientist, Indian Institute of Chemical Technology, Hyderabad.

Speaking about his research, Suryanarayana said, "Photovoltaic or solar cell technology has been around since the19th century and we are now seeing the third generation of cells. The first-generation silicon-based cells, with energy harvesting efficiency of about 26 per cent, continues to be costly. Second-generation thin film solar cells based on semiconductors have comparable efficiencies, and not much lower costs. The third generation DSSCs can significantly lower costs of solar cells while being environmentally friendlier than earlier generations, but their efficiencies need improvement to translate to practical products."

The efficiency of these cells, also known in the scientific community as the Grätzel cell, after its inventor Michael Grätzel, continues to hover around 13 per cent and there is considerable research all over the world to improve its performance.