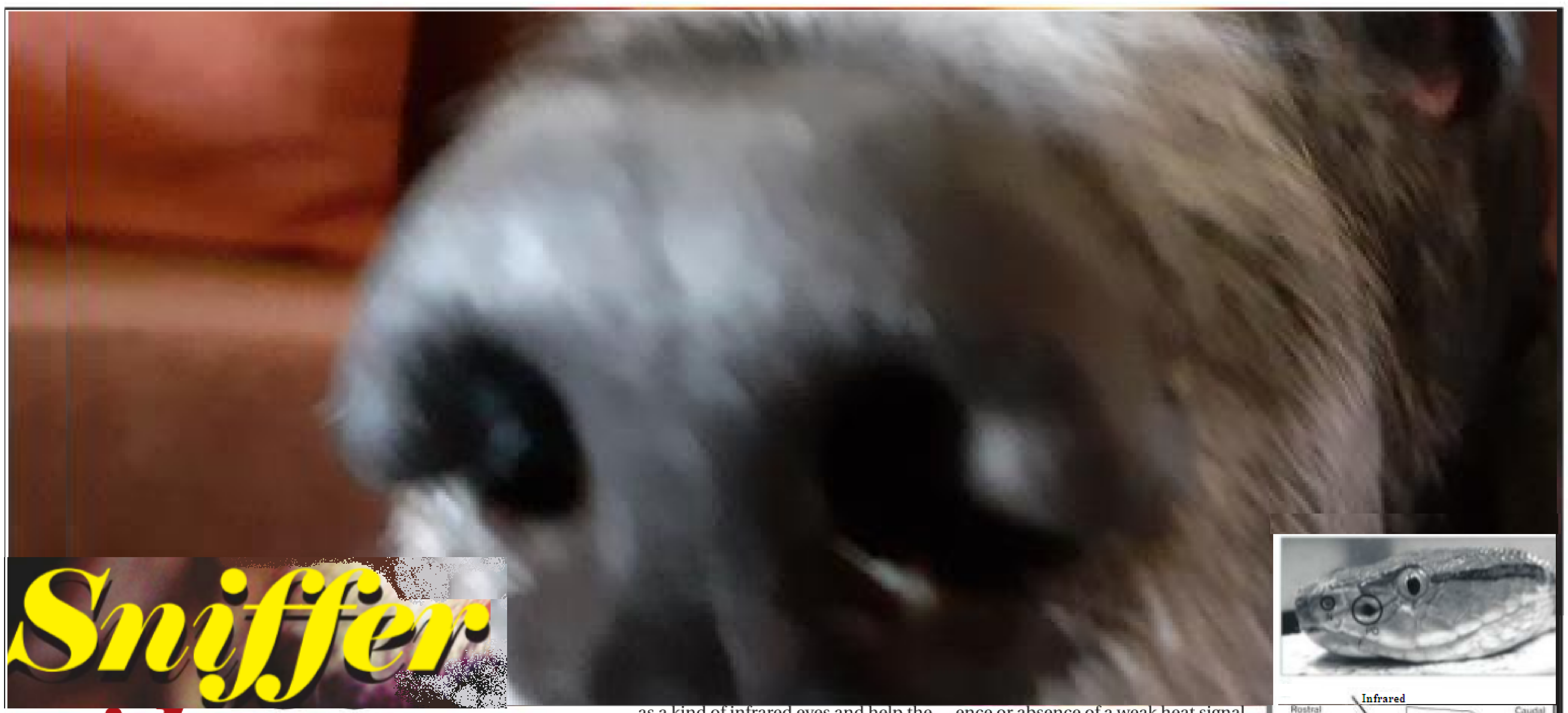


Sniffer widens range

The legendary nose of man's best friend can do more things than smell

S ANANTHANARAYANAN

Dogs, with their agility, pack loyalty and trainability, have stood by humans through recorded history. They have tended sheep, drawn sleds, been watchdogs, accompanied the hunt and led the blind. But they are best known for the acuity of their sense of smell — they are trackers, they can find lost persons or lost objects and their noses can detect firearms or contraband in sealed baggage.

Anna Bálint, Attila Andics, Márta Gácsi, Anna Gábor, Kálmán czeibert, Chelsey M Luce, Ádám Miklósi and Ronald HH Kröger, from Lund University, Sweden, Eötvös Loránd University, Hungary and the University of Bremen, Germany, write in the journal, *Scientific Reports*, that the dog's nose has yet another capability — it can detect heat from warm objects, like an infrared camera!

While the dog's eyesight is less specialised than our own, the dog's nose, as an organ of smell, has adapted, to more than compensate. The insides of the canine nose consists of folds of skin, which contain 300 million smell-sensing nerve endings, compared to just the six million we have. Like some other animals, the dog's arsenal includes a special organ that detects trace chemicals, an ability that has disappeared in humans. The part of the dog's brain that is used for smells is 40 times larger than the part that we use.

The dog also separates the actions of sniffing and breathing, so that it can pass air continuously over the olfactory organs without disturbing respiration. Further, each nostril acts independently, to detect smells from different directions. By putting together the smells that come to each nostril, the dog can "smell in three dimensions", just like we can make out distance and depth with the help of our eyes. Overall, the dog's nose is considered 100,000 times more efficient at smelling than the human nose.

A marked feature of the canine nose is that it is damp and cold. Being damp would be useful to capture the chemicals that odours consist of. The feature of being cold, however, is not easy to understand, as lowering of temperature generally lowers nerve sensitivity. Except in the well-known case of the crotaline snake, which has cavities, the pit organs, which act like pinhole cameras, to focus infrared radiation from warm prey. These act as a kind of infrared eyes and help the animal hunt in complete darkness. The temperature of the pit organs, however, is kept low, with the help of a special arrangement to cause evaporative cooling.

The paper brings out that photons of the infrared radiation from objects, like prey animals, that are only moderately warm, are too feeble to activate the photo-pigments in the eye. An organ that could detect heat would hence depend on an arrangement to collect a good number of low energy, infrared photons and get warmed. That it would be important for such an organ to be colder than the emitter of the radiation to be detected is a reason to explain the feature of the pit organs being cool. The paper also says that a sensitive area in the nasal passage of the vampire bat, which is able to detect the warm spot, and hence the blood vessel, on the body of an animal it attacks, is kept a little cooler than its surroundings.

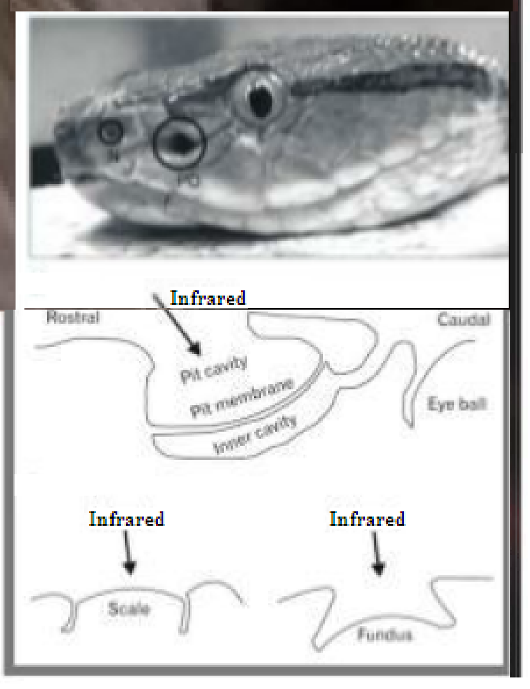
The discussion of the heat-sensing organs of species of snakes, insects and the bat being cool leads to the notion that the cold nose of the dog may also have a heat-sensing function. "The closest wild relative of domestic dogs, the grey wolf, preys predominantly on large endothermic preys and the ability to detect the radiation from warm bodies would be advantageous for such predators," the paper says.

To see if the domestic dog did have a heat sense, the authors of the paper carried out a series of experiments. The first series, at Lund University, Sweden, was to see if the dogs could make out a heat signal at all. Three dogs were trained to respond with one of two choices -- the presence or absence of a weak heat signal. The source of the signals was a pair of identical panels, approximately one square foot in size. One face of the panels was 11-13°C warmer than the surroundings, while the other face was almost at the temperature of the surroundings. At each trial, one warm face and one cool face was presented to the dog. Just below each panel was a bowl of food. The bowl below the warm panel could be opened, by working a lever, but not the bowl below the cool panel.

The dogs were first trained to work the lever when they chose the bowl below one of the panels. At the start, the lever below the warm panel was partially worked, so that the dogs could see the reward, and the trainer pointed to the warm panel. When the dogs had learnt the procedure, both bowls were fully closed and the trainer delayed pointing to the warm side, to allow the dogs to take in the heat signal from the panels.

When the dogs appeared to have learnt how to find the correct bowl most of the time, the extent of heat stimulus was reduced, by placing covers, with only a four-inch opening, before each panel. With a bit of help to get started, in case there had been a gap, there were several sessions of data collection, with 15 or less trials in each session. The results show that that the dogs were able to make out the weak heat signal in an efficiency range of 68 to 80 per cent.

The next series of tests, conducted in Hungary, was to investigate the excitation of different parts of the brain when the dogs were exposed to warm or neutral stimuli. Again, a pair of warm or neutral surfaces was used, and displayed to the dogs that had



been trained to lie motionless in the MRI scanner — the equipment that records activity of different parts of the brain.

The results, the paper says, were that the warm stimulus elicited a response in a specific area of the brain, the area that is associated with sensory information. The design of the experiment and elimination of signals other than the perception of heat, the paper says, identifies the response in the brain as related to the nasal region. "The location of the detected activation is clearly distinguishable from the auditory and olfactory cortical areas," the paper says.

Just how the low heat that strikes the small, furless, nostrils of the dog is translated into nerve signals is still unclear, the paper says. In the case of pit organs of the crotaline snake, there is a cavity that concentrates radiation and a lightweight structure that is warmed. The dog's nose, in contrast, has no cavities and the surface has only protuberances of nerve endings.

But the study shows that "sensing weak thermal radiation is within the abilities of the species *Canis familiaris*", or the domestic dog.

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PLUS POINTS

Killer cats

Domestic cats kill more prey in a given area than similar-sized wild predators, research suggests. According to a new study, hunting by pets can have a big impact on the local wildlife population.

Scientists say the effect is mostly concentrated around a cat's home, as most of their movement is within a 100-metre radius. This usually encompasses a few gardens on either side. The study indicates that pet cats kill two to 10 times more wildlife than the equivalent wild predator.

Researchers from North Carolina State University and the North Carolina Museum of Natural Sciences in the US worked with scientists from six countries to collect GPS cat-tracking data and prey-capture reports from 925 pet cats. Most of the animals came from the US, UK, Australia and New Zealand.

Lead author Roland Kays said, "Since they are fed cat food, pets kill fewer prey per day than wild predators, but their home ranges were so small that this effect on local prey ends up getting really concentrated. Add to this the unnaturally high density of pet cats in some areas, and the risk to bird and small mammal populations gets even worse."

Researchers asked pet owners to track their cats to see where they went and report on the number of prey they brought home. GPS trackers measured the distances travelled by the house cats, which spent their days both indoors and outdoors.

In the study, published in the *Animal Conservation* journal, scientists calculated the amount of prey killed per year by house cats and divided the number by the area in which the cats hunted. Some adjustments were made to the prey count as the animals do not necessarily take all their kills home.

According to the study, house cats killed an average of 14.2 to 38.9 prey per 100 acres, or hectare, per year. The study also showed that cats do much of their damage to wildlife in disturbed habitats, like housing developments.

The Independent

Repairing DNA

A new "toolkit" to repair damaged DNA that can lead to ageing, cancer and motor neurone disease has been discovered by scientists at the Universities of Sheffield and Oxford in the UK.

Published in *Nature Communications*, the research shows that a protein called TEX264, together with other enzymes, is able to recognise and "eat" toxic proteins that can stick to DNA and cause it to become damaged. An accumulation of broken, damaged DNA can cause cellular ageing, cancer and neurological diseases such as MND.

Until now, ways of repairing this sort of DNA damage have been poorly understood, but scientists hope to exploit this novel repair toolkit of proteins to protect us from ageing, cancer and neurological disease. The findings could also have implications for chemotherapy, which deliberately causes breaks in DNA when trying to kill cancerous cells.

Professor Sherif El-Khamisy, co-founder and deputy director of the Healthy Lifespan Institute at the University of Sheffield and a professor from the department of molecular biology and biotechnology and the Neuroscience Institute at the University of Sheffield, who co-led the research said, "We hope that by understanding how our cells fix DNA breaks, we can help meet some of these challenges, as well as explore new ways of treating cancer in the future." The next step of the research will be to test if the behaviour and properties of protein TEX264 is altered in ageing and in neurological disorders such as MND.

Looking inside a cell

Cell organelles perform diverse functions in both plants and animals

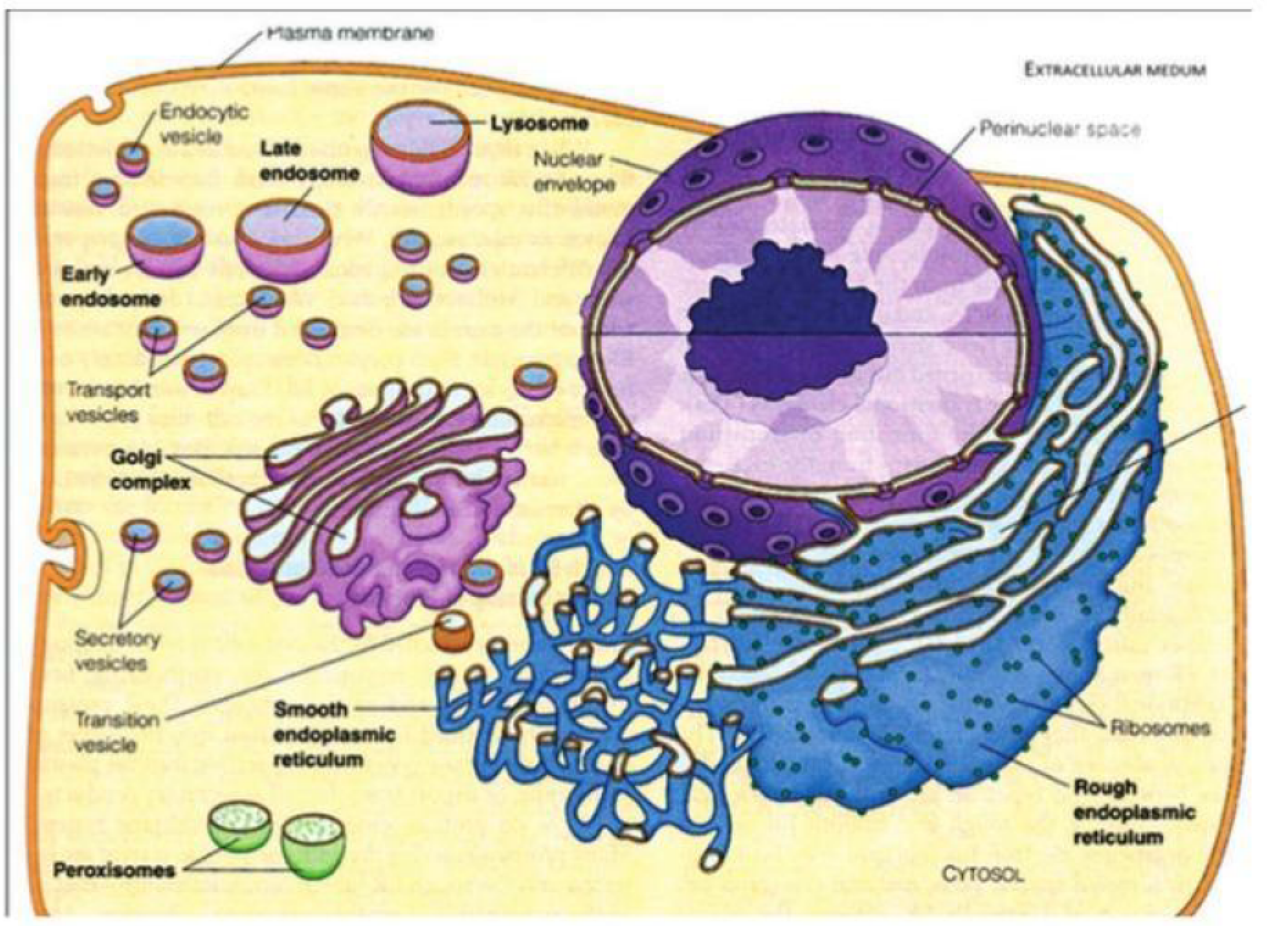
TAPAN KUMAR MAITRA

The study of eukaryotic cells requires understanding of an elaborate array of organelles — intracellular membrane-bound compartments that house various cellular activities. Whether it be the storage and transcription of genetic information, biosynthesis of secretory proteins, breakdown of long-chain fatty acids, or any of the myriad other metabolic processes occurring within eukaryotic cells, many reactions of a particular pathway occur within a distinct type of organelle.

Also, the movement of molecules between organelles, known as trafficking, must be tightly regulated to ensure that each organelle has the correct component for its proper structure and function. Therefore, a full appreciation of eukaryotic cells depends on an understanding of the prominent role of intracellular membranes and the compartmentalisation of function such membranes make possible.

Let us consider several individual organelles in more detail. First are the rough and smooth endoplasmic reticulum and the Golgi complex, which are sites for protein synthesis, processing and sorting. Next are endosomes and lysosomes. Early and late endosomes are important for carrying and sorting materials brought into the cell by endocytosis and for helping to form lysosomes, organelles responsible for digestion of both extracellular material brought into the cell and unwanted or damaged intracellular components. Last is the diverse function of peroxisomes, which house peroxide-generating reactions and have an essential role in the oxidation of fatty acids and the biosynthesis of certain membrane lipids.

The endoplasmic reticulum, Golgi complex, endosomes and lysosomes are all components of the eukaryotic cell's endomembrane system. The nuclear envelope is also a



part of this system. The outer membrane of the nuclear envelope is continuous with the surrounding membrane of the endoplasmic reticulum, and the perinuclear space between the two membranes of the nuclear envelope is continuous with the interior of the endoplasmic reticulum, a space known as the ER lumen. As a result, molecules can diffuse freely from either one of these compartments to the other.

Material can also flow from the endoplasmic reticulum to the Golgi complex, endosomes, and lysosomes by means of transport vesicles that shuttle between the various organelles. Such vesicles convey membrane lipids and membrane-bound proteins, as well as soluble cargo. Thus, these organelles and the vesicles connecting them make up a single system of surrounding membranes and internal spaces. This intimate association has important consequences for cellular metabolism.

Plant cells contain acidic membrane-enclosed compartments called vacuoles that resemble the lysosomes found in most animal cells, but generally serve additional roles. The biogenesis of a vacuole parallels that of a lysosome. Most of the components are synthesised in the ER and transferred to the Golgi complex, where proteins undergo further processing. Coated vesicles then convey lipids and proteins destined for the vacuole to a provacuole, which is analogous to an endosome. The provacuole eventually matures to form a functional vacuole that can fill as much as 90 per cent of the volume of a plant cell.

In addition to confining hydrolytic enzymes, plant vacuoles have a variety of other functions essential to the health of plant cells. Most functions reflect the plant's lack of mobility and consequent susceptibility to changes in the surrounding environment. A major role of the vacuole lies in maintenance of turgor pressure, the osmotic pressure that prevents plant cells from collapsing. Not only does turgor pressure prevent a plant from wilting, it can also drive the expansion of cells. During development, softening of the cell wall — accompanied by higher turgor pressure — allows the cell to expand. The direction of expansion can be controlled by selective softening of specific segments of the cell wall.

Maintenance of turgor pressure is closely connected to another role of plant vacuoles — regulation of the concentrations of various solutes in the cytoplasm. An important example is the control of cytosolic pH. ATP-dependent proton pumps in the vacuolar membrane can compensate for a decline in cytosolic pH (perhaps due to a change in the extracellular environment) by transferring protons from the cytosol to the lumen of the vacuole.

The vacuole also serves as a storage compartment. Seed storage proteins are generally synthesised by ribosomes attached to the rough ER and co-translationally inserted into the ER lumen. Some of the storage proteins remain in the ER while others are transferred to vacuoles, either by autophagy of vesicles budding from the ER or by way of the Golgi. When the seeds germinate, the storage proteins are available for hydrolysis by vacuolar proteases, thereby releasing amino acids for the biosynthesis of new proteins.

Other substances stored in vacuoles include malate stored in CAM plants, the anthocyanins that impart colour to flowers and attract pollinating insects and birds, toxic substances that deter predators, inorganic and organic nutrients, compounds that shield cells from ultraviolet light, and residual indigestible waste.

Storage of soluble as well as insoluble waste is an important function of plant vacuoles. Unlike animals, most plants do not have a mechanism for excreting soluble waste. The large vacuoles found in plant cells enable the cells to accumulate solutes to a degree that would inhibit or restrict metabolic processes if the material were to remain in the cytosol.

The writer is associate professor and head, department of botany, Ananda Mohan College, Kolkata