Tusker's multi-tasker trunk

The elephant's extra limb, which has no bones or joints, enjoys near-infinite flexibility

S ANANTHANARAYANAN

The elephant's bulk has worked against endowing the animal with delicate fingers. But it has a trunk that amply compensates.

Paule Dagenais, Sean Hensman, Valérie Haechler and Michel C Milinkovitch, from the University of Geneva, the Swiss Institute of Bioinformatics, and Adventures with Elephants, in Bela, South Africa, describe in the journal, *Current Biology*, how the elephant trunk has evolved, as they say in the paper, "to be a spectacular organ for delicate to heavy object manipulation as well as social and sensory functions." Understanding this evolution could point the way to doing something similar in the laboratory, the authors say.

The paper starts out by drawing attention to a specific feature of the elephant trunk. And what is it? It is that the elephant's trunk is not a limb with a skeleton, like an arm or fingers of the hand, but consists only of muscles. And the muscles work not by the action of levers, like limbs do, but by hydraulic forces exerted by liquid deformations. This method of working is found in many parts of the animal world — tentacles of the squid or arms of the octopus.

Closer home, this is the way we push food down to the stomach and through the intestines. A familiar organ like this, which has no bones and one that we consciously use, is the tongue. And as the tongue, muscles of the mouth, and in the throat, can produce complex speech, or the modulated tones of a trained singer, we can see that muscular control can be more refined than the fingers of a concert pianist, or the limbs of a gymnast.

And so it is with the trunk of the elephant. "It can manipulate a single blade of grass but also carry loads up to 270 kilograms," say the authors of the paper. American writer Herman Melville, in his novel, *Moby Dick*, in marvelling at the delicacy of touch that the sperm whale has in its tail, was reminded of the elephant. This is what he says, "What tenderness there is in that preliminary touch! Had this tail any prehensile power, I should straightway bethink me of Darmonodes' elephant that so frequented the flower-market, and with low salutations presented nosegays to damsels, and caressed..."

The elephant's trunk is a large organ, often over three metres long, and it is capable of great manipulation. The paper mentions functions like breathing, smelling, feeling by touch, vocalising, siphoning and spraying water, spraying dust, and handling things, pushing or carrying logs, or using suction to pick up the smallest of objects. The elephant needs to extend the trunk to its full length, to reach a distant object, or to draw in the trunk, to move things from side to side. It sometimes needs to create a bend, like an elbow, to mimic a skeletal joint.

The human-made, mechanical equivalent may be earth-moving equipment, which have a jib made of many sections. Control of this metal limb, however, needs sophisticated electronics and computing. And yet, the range of movement possible is hardly comparable. Animal limbs, of course, are capable of more complex movement, but the levers and joints through which they come about finally place limitations. Except that the elephant trunk, which has no bones or joints, enjoys near-infinite flexibility.

Except, again, the paper points out, that this flexibility arises out of a huge number of muscle fragments and associated nerve signals, which could lead to an overwhelming information load. Hence, as is done in the field of Artificial Intelligence systems, the paper says, a strategy is required to bring down the complexity of the tasks to be handled. The problem that arises in AI is because the task is to keep track of a huge number of factors on which a course of action to be decided may depend.

For instance, if the task before the AI system is to guide a car that is driving down a street, the method is to use a camera which feeds, say, a million pixels to the computer every second. The computer is first "trained", with the camera switched on and the car driven by a human driver. During this process, the computer "learns" to associate pixel-patterns that it "sees" with the kind of action the human driver takes. After this "learning", when the computer has to drive on its own, it is able to process the pixels that it "sees" and make the correct driving decisions.

The trouble with this, and other tasks that AI performs, is that there is a huge information processing load, and not all the information has the same importance. For instance, it is usually the space directly in the path of the moving car, rather than stationary things in the periphery, that are immediately important. In this and other applications, for instance forecasting market trends, it is possible to group many factors, as so-called "principal components", so that the total number of independent variables to consider is reduced — and hence reduce the complexity.

In the same way, the authors say, the exceedingly great number of units to be considered when looking at how the elephant is able to control its trunk can be brought down by considering the movements of the trunk as composed of a lesser number of "building blocks" of movement. In order to show that this indeed is the case, the authors analysed the gamut of movements of the elephant trunk, their motivation, speed, purpose, and found that there existed a pattern, a method that underlay what the trunk achieved.

The method they employed was to assign specific tasks to two adult African elephants and to record their trunk movements with high speed cameras, followed by analysis using special software, software that had been successfully used in motion picture animation. The method, called "motion-capture", takes shots of real people or action and then develops animation. The technique, which trades creation of animation on the drawing board for adaptation of the real thing, was used with resounding success in films like *Lord of the Rings* and *Avatar*.

The same method was used to analyse elements of the trunk movements, and the result was that simple movements, for instance, of extending, bending and twisting, in a variety of tasks, could be broken down to just 17 primary behaviours. The findings were supplemented by anatomical studies and medical imaging, to demonstrate the relationship between muscle movement economy and the primary units of motion that were discovered.

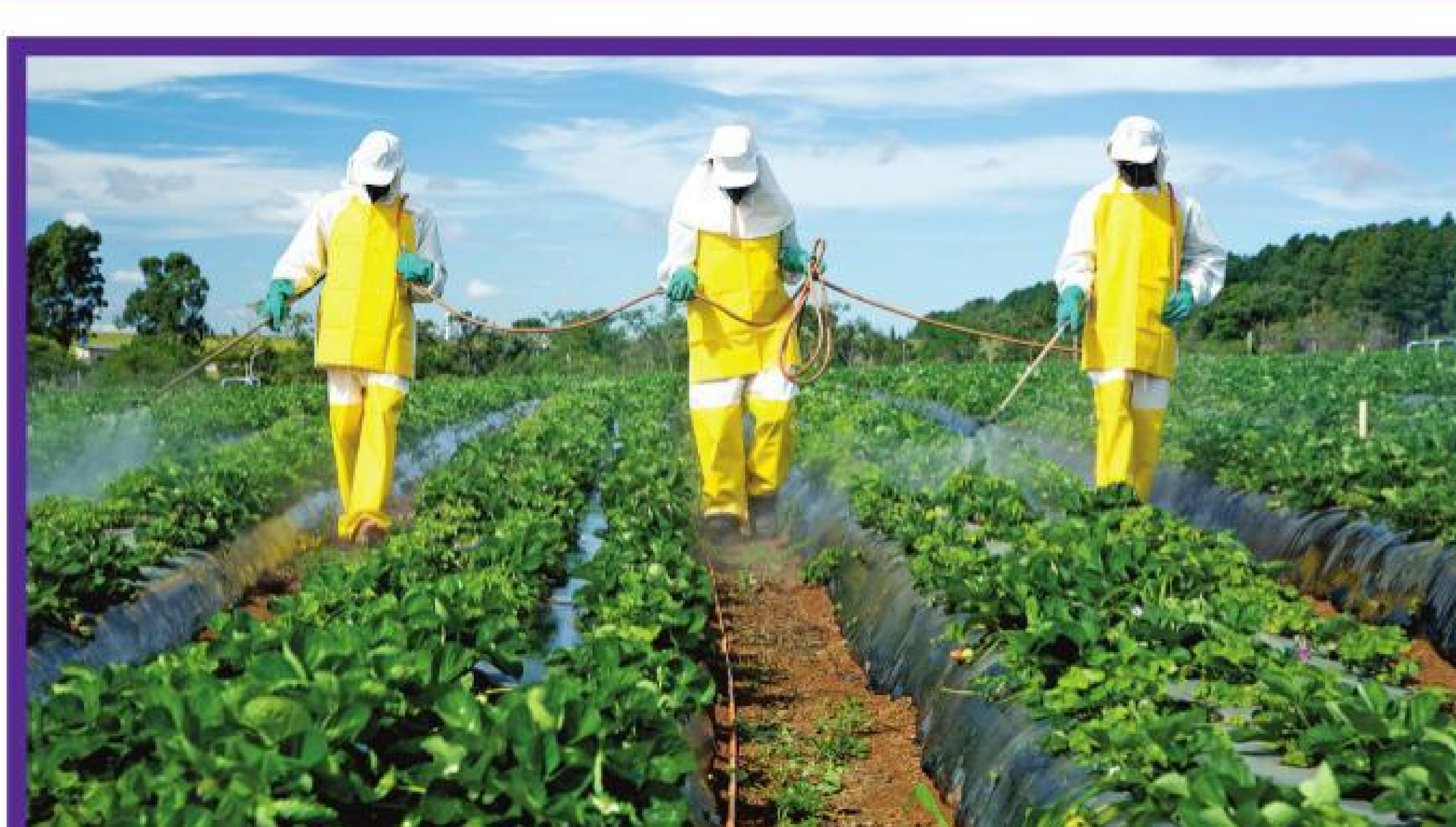
There is a striking similarity, the paper says, in the method of the elephant trunk and the way the arm of the octopus manages tasks and movements. As elephants and octopi are separated by a billion years of evolution and rely on widely different nervous systems, it is tempting, the paper says, to consider that the principles of breaking complexity down to primitives are basic to the mechanics and functioning of living things.

The writer can be contacted at response@simplescience.in

DEPENDENT ON VARIABLES

Here are the factors that determine the toxicity of pesticides

TAPAN KUMAR MAITRA



The toxicity of pesticides depends on the features of the chemical structure of the substance. Sometimes, even insignificant changes in the structure of a molecule lead either to the complete loss of toxicity or to a change in the spectrum of action.

Notwithstanding considerable achievements in the field of pesticide chemistry, to date no general theory of how pesticide properties depend on the chemical structure of a substance has been developed, although definite laws for separate classes of compounds have been established that allow the directed synthesis of pesticides with preset properties to be performed.

The toxicity of various chemical compounds is sharply increased by introducing into their structure toxophoric groups — chemical radicals or atoms that increase the toxicity of a substance. Toxo-phoric groups include the halogens (chlorine, bromine, iodine and fluorine), the nitro group, atoms of the heavy metals (mercury, tin and copper), and the rhodanic group.

The toxicity of chemical compounds often depends not on the composition of a substance, but on the structure of its molecule. Different isomers of the same substance have different activities. The thiolo derivatives of thiophosphoric acid are several times more toxic to mammals than the thiono ones.

The biological reaction of an organism (animal, insect, plant, fungus, etc.) acted upon by a poison is usually caused only by a small part of the total dose used in practice. This small amount of poison primarily blocks a vitally important function of the organism, after which secondary symptoms of poisoning develop that may lead to perishing of the entire organism. These considerations gave birth to the concept of the target (receptor).

This target can be imagined as a specific tissue or organ, a definite type of cells or intracellular structure, and in the long run as a molecular receptor, for example a specific section of an enzyme or reaction. The toxicity of a substance will depend on how quickly and in what amount the poison penetrates to the target and enters a reaction with it. Therefore, any factor affecting the processes of its reaction with the target causes a change in toxicity.

The toxicity of a pesticide also depends on several factors without account of which its proper appraisal and use are impossible. These factors can be divided into three groups -- factors affecting the duration of contact of the pesticide with a harmful organism; those affecting the penetration of the pesticide into an organism and those associated with the behaviour of the toxic substance in an organism.

Of great significance are properties of a pesticide such as adhesive-ness and wettability, which prolong its persistence on the surface being treated and the contact of the substance with the harmful organism. To improve such properties, auxiliary substances — adhesives (stickers) and wetting agents — are added to pesticides.

Among environmental conditions, temperature renders the greatest influence on the toxicity of pesticides. A change in the temperature may lead to both a change in the activity of the substance itself and a change in the reaction of an organism. With elevation of the temperature, the losses of a pesticide from the treated surface increase, but this may be attended by a growth in the toxicity, for example as a result of the formation of more toxic substances (the transformation of thiono isomers of phosphorothioates to thiolo ones).

Pesticides whose toxicity increases with elevation of the temperature are related to substances with a positive temperature coefficient, while those whose toxicity decreases with elevation of the temperature — to substances with a negative temperature coefficient. Most modern pesticides belong to the first group. Only a few of them have a negative temperature coefficient, but their presence in the assortment of chemical means of plant protection is exceedingly important for managing pests in the early spring.

The penetration of poisonous substances depends to a great extent on the anatomical and morphological features of organisms. The entry of pesticides into organisms coated with a wax layer diminishes quite noticeably. Adult specimens of scale insects protected by a wax scale do not perish after treatment with aqueous suspensions or emulsions of organophosphorus insecticides that are toxic upon internal injection. The explanation is that aqueous solutions do not virtually penetrate under the scale of these insects. The eggs of insects, the spores of fungi, and the cysts of nematodes are highly resistant to pesticides owing to the low permeability of their protective shells.

The toxicity of a poisonous substance is also noticeably affected by processes taking place inside an organism. The toxicity of a poison to a given organism, in addition to other factors, depends on the rate of passive or active diffusion of the substances through various tissues. The higher the rate of penetra-tion, the greater is the toxicity of a compound because the possibil-ity of it being deposited and detoxified diminishes.

Finally, the toxicity of a poison penetrating to the place of its action depends on the degree of affinity of a molecule of the poison to a molecule of the target. Although the target of most pesticides has not been established exactly, the necessity of such affinity of the molecules is confirmed by the fact that the toxicity of many substances depends on the structure of a molecule and the spatial arrangement of its atoms.

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

PLUS POINTS

Lesser risk

Individuals with mentally stimulating jobs have less risk of dementia in later life than those who have non-stimulating employment, research suggests.

Scientists looked at over 100,000 participants across studies which were focused on connections between work-related factors and chronic disease, disability and mortality, from the United States, Europe and the United Kingdom.

The study examined those in a range of different occupations, from forestry workers to civil servants and public sector employees, while the lead author suggested that the findings support the idea that being mentally stimulated in adulthood may delay the onset of dementia. It is already thought that cognitive stimulation can postpone or prevent the onset of dementia. These assumptions, however, have been based on small sample sizes and short term-interventions, with inconsistent results produced, said researchers.

A possible explanation for the results of the large study is that cognitive stimulation is associated with lower levels of certain proteins which may inhibit some processes in the brain. Those involved were tracked for an average of 17 years to see whether or not they developed dementia. Their cognitive stimulation at work was previously measured at the beginning of the study.

Lead author professor Mika Kivimaki, from University College London's Institute of Epidemiology and Healthcare, said, "Our findings support the hypothesis that mental stimulation in adulthood may postpone the onset of dementia. The levels of dementia at age 80 seen in people who experienced high levels of mental stimulation was observed at age 78.3 in those who had experienced low mental stimulation.

"This suggests the average delay in disease onset is about one and half years, but there is probably considerable variation in the effect between people."

Cognitively stimulating jobs were defined by researchers as including demanding tasks and having a high job decision latitude or job control, for example senior government officers, production and operations managers, directors and chief executives. Non-stimulating occupations were considered to be those with a lack of job control and with low demands such as cashiers, agricultural, fishery and related labourers, transport labourers and mobile-plant operators.

Due to longer hours spent at work, it is thought that exposure to cognitive stimulation lasts "considerably longer" than cognitive interventions or cognitively stimulating hobbies, said scientists. The study found that, having taken influential factors into account, the incidence of dementia was 4.8 per 10,000 people in the high stimulation group, while it was 7.3 in the low stimulation group. Potentially influential factors included age, sex, educational attainment and lifestyle.

It appeared that there was no difference between genders or those younger or older than 60. There was an indication, however, that the association was stronger for Alzheimer's disease compared to other types of dementia.

Sara Imarisio, head of research at Alzheimer's Research UK, said, "This large, robust study adds to a body of evidence suggesting that staying mentally active is important for helping reduce the risk of dementia.

"Previous research has suggested that keeping the brain active can help build cognitive reserve, a type of resilience that helps the brain 'rewire' its connections more easily and keep working for longer when diseases like Alzheimer's take hold. This new research also identified proteins in people's blood plasma that may be connected to this process, and further research should investigate this finding in more detail."

She said, "Not everyone is able to choose the type of work they do, but studies like this highlight the importance of finding activities that help keep the brain active, whether it's through work or hobbies."

— The independent/agencies