Sniffing Savours

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A number of vertebrates and invertebrates have far superior olfactory prowess compared to humans. Recent years have witnessed remarkable progress in our ability to train dogs and rats, not only to sniff narcotics and landmines but also detect several infections, including tuberculosis and cancers. Molecular biology techniques are being currently employed to enhance specific olfaction genes and insect moths trained to drive tiny vehicles towards target smells.

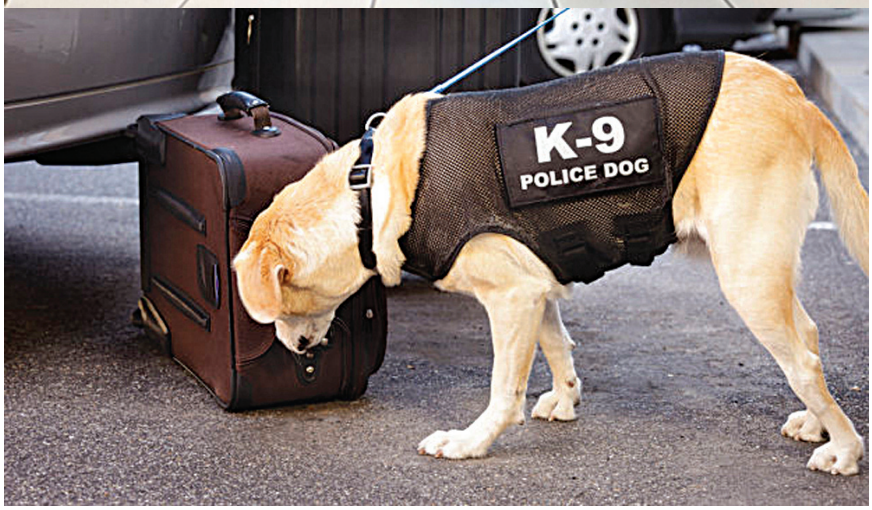
"Cleopatra's nose, had it been shorter, the whole face of the world would have been changed."

Blaise Pascal, seventeenth century mathematician

MAKING the countenance attractive may be not the primary function of the nose. It serves a more important role in humans and higher animals – housing the machinery responsible for smell recognition (olfaction).

With the exception of professional tasters of wine and gourmet foods, most people employ their nose for mundane activities like avoiding unhealthy surroundings or enjoying the fragrance of perfumes. For many animals, however, olfaction plays a seminal role in their very survival and they are therefore endowed with remarkably sophisticated and extremely sensitive olfactory systems. Their sniffing abilities help them locate food, find mates and escape predators.

African elephants have the highest



number of olfactory receptor genes known in mammals, twice as many as dogs and five times more than humans. In Kenya, elephants are known to locate and distinguish between the hunters belonging to the Maasai tribe and those from the friendly Kamba from a distance of a kilometre and respond accordingly.

According to Yoshihito Niimura of Tokyo University, "We don't really know how the number of olfactory receptor genes relates to olfactory ability. For example, dogs are known for their keen sense of smell – but we know that their number of genes is much smaller than that of mice, who we don't see with that same ability." The sense of smell of dogs is however known to be about 10,000 times more sensitive than that of a human.

Olfaction is a type of chemoreception that uses the molecular chemical compounds derived from various substances (odorants) to discern information about the environment. Odorants are generally small molecules showing greater solubility in water-insoluble media.

The practice of evaluating patients by the exhaled Volatile Organic Compounds (VOCs) dates back to 4000 BC, when stools and urine of infants from noble families were smelt daily by their physicians in order to detect any sign of disease. The basis was that the compendium of VOCs expresses change as a consequence of processes occurring and alterations in the body's metabolism.

Even today we do not unfortunately have sophisticated technology to augment olfaction (unlike vision that can be improved by lenses/microscopes and sound using hearing aids). At best, it is possible to tutor our noses to sniff desired odours with dexterity. Also, the success achieved in the development of electronic noses continues to be rather limited. Researchers consequently continue to look up to the highly sensitive olfactory systems of animals for sensitive detection of narcotic drugs, explosives as well as for diagnosis of various diseases.

Dogs and some other animals have a second smell system called the vomeronasal organ above the roof of their mouth and below the septum dividing the sides of the nose, which can detect the smell of molecules that have been absorbed in tissues. Dogs, being intelligent and amenable to training, are among the first animals employed to sniff explosives as well as a variety of other chemicals and they continue to be used globally for the purpose by the army, police and customs.

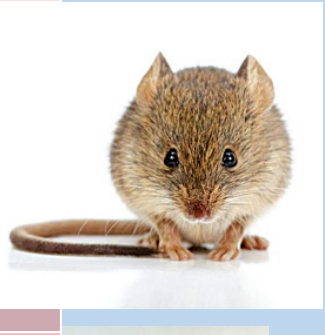
The Belgian Malinois breed of dogs that shot into fame following their role in sniffing out Osama bin Laden from his hideout in Pakistan by the US Navy Seals, is also assisting the Central Reserve Police Force in India. Unfortunately, two of the precious canines succumbed to IED blasts allegedly triggered by Naxals in January 2017.

Many reports, albeit some unsubstantiated, of pet dogs alerting their masters of some forms of cancer are available. The dog would whine or continuously nudge somewhere on the owners' bodies. The owners would dismiss the behaviour only to be diagnosed later with cancer.

Last year, Philip and Paula of Brotton North Yorks were baffled by the strange behaviour of their pet dog border collie Bessie. Having heard earlier that dogs can sniff diseases; the young couple took the toddler to the family doctor who diagnosed that she was suffering from lymphoblastic leukemia. Early diagnosis according to the physician vastly increased the chances of Philippa's recovery and she

Animals with the largest number of genes devoted to smell detection

Animals	Olfactory receptor genes
African Elephant	1948
Rat	1207
Opossum	1188
Cow	1186
Chinese soft-shelled turtle	1137
Mouse	1130
Horse	1066
Western clawed frog	824
Dog	811
Guinea pig	796
Rabbit	768
Tree shrew	563
Man	396



The Champion sniffers

is currently undergoing chemotherapy.

Taking clues from such reports some organizations have taken up the task of training dogs to detect specific diseases. At the Pen Vet Working Dog Centre (PVWDC) in Philadelphia, smart dogs are identified at an early age and made to go through a rigorous training to detect specific odours for saving human lives.

One dog, named Tsunami, is being trained to detect the deadly ovarian cancer. Ovarian cancer like some other forms of the disease is asymptomatic till it spreads in the body and the patient experiences pain only after the disease reaches an almost incurable stage. Blood from the patients of cancer has a signature odour and within a year of training at PVWDC, Tsunami is able to detect blood samples from ovarian cancer patients with over ninety percent accuracy.

A two-year old English springer spaniel Angus is similarly helping a hospital in Canada currently to sniff the bacterium that causes one of the most difficult-to-treat gut infection – *Clostridium difficile*. Interestingly, the dog is being trained to detect the bug in the hospital environment rather than in the patient, to avoid dog-related sensitivities or allergies in the patients.

Rats however seem to surpass dogs in sniffing endeavours. Their ingenuity in detecting smells prompted the Belgian product designer Bart Weetjens to zero in on them to clear landmines. The NGO founded by him in 1997, the Anti-personnel Landmines Removal Product or APOPO, has successfully trained several African giant pouched rats for clearance of land mines.

The pouched rats are remarkably intelligent social creatures with a keen sense of smell. The rodent measures almost three feet in length, weighs about four pounds, is resistant to tropical diseases and lives up to eight years. Thanks to the teams of trained giant pouched rats, rightly designated heroRATs, 270 square miles of Mozambique farmlands are once again available to farmers dislocated since the 1980s. APOPO reported in their 2016 report that heroRats have thus far

Sniffer dogs: The Belgian Malino (left) and Baby Phillipa with her saviour Bessie (right)

exposed 13,826 mines, 29,031 small arms and ammunitions, and 39,601 leftover unexploded munitions. The rats offer advantage over dogs in their smaller body weight that overcomes the risk of the mines going off accidentally due to pressure and the ability to work without an accompanying trainer. The heroRats have successfully helped clear landmines also in Angola and Cambodia.

APOPO is also training the giant rats to diagnose tuberculosis, which continues to be endemic in some parts of Africa. Sputum samples to be tested are kept in a line and the trained heroRats made to pass along. The rats stop for a short while when they come across a sample from a TB patient. Remarkably the rats act fast and can screen 100 samples of sputum in 20 minutes with barely any error.

APOPO presently has fifty trained TB-detecting heroRats and a dedicated TB detection facility employing the rodents in Mozambique, where patients can get reliable test results at very little cost in just 24 hours.

Paul Feinstein of the Hunter College in New York city who researches on odorant receptors claimed last year that mice, which again are powerful sniffers, can be tuned to sniff out the signature chemical of diseases like Parkinson and Alzheimer's, for which simple diagnostic procedures are not currently available. Feinstein's group accomplished "upgradation" of the mouse's olfactory system by making some of the chosen odorant receptors more numerous with the help of molecular biology techniques.

His group synthesised a string of DNA, which when injected into the fertilised mouse eggs, enhanced by an order of magnitude, the number of olfactory neurons bearing the receptor M71 that detects acetophenone with smell of jasmine. The treated mice were able to detect acetophenone at far lower concentration in drinking water compared to untreated mice. His team was also successful in enhancing the ability of mice to detect peppermint like smell over 100-fold using the same strategy. Feinstein is optimistic that the technique can help tailor-make him mice with the desired sniffing activities and even help decode the 'black box' of the human olfactory system.

The olfactory system of several invertebrates, particularly that of the insects, is also highly developed and certainly far superior than the human nose. While training invertebrates is a big challenge, their small size and possibility of economically rearing and employing them in large numbers offers big advantages. Researchers at the University of St. Louis at Missouri, USA are currently harnessing the olfactory prowess of antennae to convert ordinary locusts to bomb detectors. They plan to link powerful sensors, carried in the backpacks of volunteers, to detect brain activity of the locusts after detecting explosives and analyze the information for further action.

A more recent study further underscores the potential of insect olfactory system to come to the rescue of man in detecting specific odours and design of robots that can detect bombs, drugs, etc. In the study published in December 2016 in the *Journal of Visualized Medicine,* scientists have made a silkworm moth pilot a tiny car while housed in a minute cockpit of the vehicle. The moth was free to move its legs on a mini ball, which propelled the vehicle in the direction in which the moth intended to reach the source of smell, which in this case was a female sex pheromone. An optical sensor facilitated the movement of the vehicle in the direction prompted by the insect leg movement.

The researchers claim that their findings could help roboticists integrate biologically inspired odour detection systems into their robots and possibly to develop more powerful and maneuverable versions of the robot car that could be driven by genetically modified silkworm moth to sniff the desired smells.

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