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Cat Tips

The Remarkable Feline Sense of Smell: Better Than Dogs'?

Up until recently, we knew a lot about a cat's vision and hearing, but little about the workings of the feline nose. This in-depth study reveals how a unique dual-function nose helps cats adapt to their surroundings 100 times faster than some other types of noses.

Analysis by Dr. Karen Shaw Becker

STORY AT-A-GLANCE

- A recently published study sheds new light on the remarkable feline sense of smell
- The study title lays it out: "Domestic cat nose functions as a highly efficient coiled parallel gas chromatograph"
- Interestingly, it seems the size and shape of the feline head may have resulted in the evolution of an intricate airway structure that not only fits inside that small space, but also helps cats adapt to a variety of environments
- The researchers suggest that convoluted turbinate structures in the domestic cat nose may significantly increase odor delivery speed and chromatography efficiency at a rate > 100 times that of the straight nasal channels of amphibians

Recently, an article appeared in the journal PLOS Computational Biology with the intriguing title "Domestic cat nose functions as a highly efficient coiled parallel gas chromatograph."[1]

Parallel gas chromatographs are laboratory equipment used for highly efficient analysis of the chemical makeup of substances.[2] According to the PLOS online magazine Tech Explorist:

> "*Vertebrates use their noses for both breathing and smelling, with receptors inside the nose detecting odors in inhaled air. Some prior studies suggest that odor detection in vertebrates may function similarly to basic gas chromatography, in which, essentially, the substance being analyzed is vaporized and carried by a steady flow of gas through a tube. Different chemical components of the substance interact with the tube in distinct ways along its length, enabling identification of each component.*"[3]

Cats Have Dual-Function Noses

To perform the first-ever detailed analysis of the nasal airway of the domestic cat, the researchers created a feline nose using a 3D computer model, and simulated the flow of inhaled air containing common cat food odors through the coiled structures.

They discovered that inside the nose of cats, inhaled air separates into two flow streams. One stream is cleansed and humidified while the other carries the odorant quickly and efficiently to the olfactory region (smell center).

The researchers liken the function of the cat nose to a highly efficient, dual-purpose gas chromatograph, a lab tool designed to detect and separate chemicals in vaporized form. In fact, say the scientists, the feline nose is so efficient at this that its complex collection of tightly coiled bony airway structures might just inspire design improvements in the gas chromatographs in use today!

Two Different Flow Zones With Two Different Purposes

Another creature whose (quite long) nose has also been found to operate similar to a gas chromatograph is the alligator. Interestingly, the researchers believe the compact size of the feline head perhaps resulted in the evolution of an intricate airway structure that not only fits inside the head, but also helps cats adapt to a variety of environments.

If a cat's nose, like an alligator's or other amphibian's, had only one straight tube for odor detection, it would need to be longer than the physical size of the feline skull in order for odor detection to be as efficient as it seems to be. Having multiple complex channels appears to be 100 times more efficient than having a single straight tube.

> *"It's a good design if you think about it," said Kai Zhao, associate professor of otolaryngology in Ohio State's College of Medicine and senior author of the study.*
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> *"For mammals, olfaction is very important in finding prey, identifying danger, finding food sources and tracking the environment. In fact, **a dog can take a sniff** and know what has passed through — was it a friend or not? That's an amazing olfactory system — and I think potentially there have been different ways to evolve to enhance that.*
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> *By observing these flow patterns and analyzing details of these flows, we think they could be two different flow zones that serve two different purposes."*[4]

Why Did Cat Noses Evolve To Be So Complex?

Unlike his earlier models of the rat and human nose, Zhao's high-resolution cat model and simulation experiments are much more complex, built from micro-CT scans of the feline head and microscopic-level identification of tissue types within the nasal cavity.

> *"We spent a lot of time developing the model and more sophisticated analysis to understand the functional benefit that this structure serves," Zhao explains. "The cat nose probably has a similar complexity level as the dog's, and it's more complex than a rodent's — and it begs the question — why was the nose evolved to be so complex?"*[5]

Computer simulations of breathing provided the answer: two distinct regions of inhaled air flow. The first, respiratory air, is filtered and spreads slowly above the roof of the mouth enroute to the lungs. The second stream contains the odor of the inhalation and moves quickly and directly through a central passage to the olfactory region in the rear of the nasal cavity. The analysis incorporated both the location of air flow and its speed through the bony structures (turbinates) inside the nose.

> *"We measured how much flow goes through specific ducts — one duct that delivers most odorant chemicals into the olfactory region, versus the rest, and analyzed the two patterns," Zhao said. "For respirant breathing, turbinates branch to divert flow into separate channels, sort of like a radiator grid in a car, which would be better for cleansing and humidifying.*
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> *But you want odor detection to be very fast, so there is one branch that delivers odor at high speed, potentially allowing for quick detection rather than waiting for air to filter through the respiratory zone — you could lose most of the odor if air has been cleansed and the process is slowed down."*

The simulation also revealed that the inhaled air that goes to the smell center is then recirculated in parallel channels when it arrives.

> *"We know so much about vision and hearing, but not so much about the nose. This work could lead to more understanding of the evolutionary pathways behind different nose structures, and the functional purpose they serve," Zhao said.*

'Smell Speed' of Cats Is > 100 Times Higher Than Amphibians

These study results deepen the general understanding of cats' enhanced sense of smell. Per the authors:

> *"The evolutionary occurrence of convoluted ethmoid turbinate structures in mammalian nose, remarkably resembles a different sensory organ, the snail-like coiled cochlea that is also unique to mammals. In birds and other non-mammalian vertebrates, the inner hearing organ, despite being called "cochlea", is instead a blind-ended tube. While the evolution of mammalian cochlea enhances our auditory frequency sensitivity and range, the functional benefit of the mammalian olfactory turbinates has only been speculated.*
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> *Using anatomically-accurate computational models, we revealed that convoluted turbinate structures in the domestic cat, as a model, may function as a parallel coiled chromatograph to significantly increase odor delivery speed and chromatography efficiency: > 100 times higher, compared to an "amphibian-like" straight nasal channel fitting the same skull space."*[6]

Sources and References

[1,6] Wu, Z. et al. PLOS Computational Biology, June 29, 2023

[2,3] Tech Explorist, June 29, 2023

[4,5] Phys.org, June 29, 2023