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What Makes Dogs Nose Special: Understanding the Anatomy of Canine Olfactory System

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Abstract

Dogs are extremely sniffing-oriented animals, which makes them perfect for different kinds of jobs such as guard dogs, therapy animals, and environmental monitoring. Dogs have over three hundred million olfactory receptors which assist them to identify even the most extended composed smell chemical odour. Many professional scent detection dogs can perform various tasks ranging from detecting drugs and explosives to diseases such as cancer and COVID-19. In this article, a specific focus is made on the structural and molecular features that underlie scent detection in dogs while underscoring their growing importance as companions across various human professions.

Keywords: Canine Olfaction, Olfactory System, Vomeronasal Organ, Olfactory Bulb and Dog

1. Introduction

Dogs (*Canis lupus familiaris*) have been tamed for variety of reasons such as hunting, guarding, security and many others. They have been related to people's lives. It goes without mentioning that dogs are remarkable in keepers of smell among other animals populating the globe. Perhaps the only component of the anatomy of a dog species that has been judged unequivocally remarkable is sight. Dogs obtain most of their information via their olfactory organs whereas humans make most of the sense through their eyes.

Recently, there has been increased focus on dogs aptitude for numerous activities such as hunting, herding and detection of various threats such as fire or an intruder. Researchers have proved that dogs can find the minute chemical odor related to drugs, diseases, and unusual creatures. Scent-detection dogs are now considered important not only in rescue services and

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police forces but also in environmental projects as their talents considerably boost wildlife monitoring and species identification.

2. Anatomy of the canine olfaction system

The sensory system in canines is ranked amongst one of the most complex sensory systems of nature especially capable of identifying scents in their pristine or in altered forms. Dogs have a large olfactory bulb in its brain that helps them to distinguish one smell easily from another completely. They have many olfactory receptor genes, and thus have a far wider range of smell sensitivity than humans. The various parts that make up the canine olfactory system are listed below:

Table 1: Key components with their respective functions of the canine olfactory system

Component	Function
Main Olfactory Epithelium (MOE)	Situated in the nasal cavity, concerned with the feeling of several odours.
Vomeronasal Organ (VNO)	Lies between the nasal and mouth ducts; responds to pheromones and volatile substances with low boiling point.
Nasal Airflow Mechanism	During sniffing, air splits into: - Upper Pathway: 12-13% reaches the olfactory area for prolonged detection. - Lower Pathway: Returns to lungs, improving odour exposure.
Sniffing Lateralization	Dogs prefers the right nostril for new/ unfamiliar /frightening odors but use the left one for familiar compounds, suggesting lateralized brain organization.
Olfactory Epithelium Structure	Consists of: - Olfactory Receptor Cells (ORCs): Carries neurones which have specialised in the detection of odour. - Sustentacular cells: These cells help to sustain the epithelium and support ORCs. - Olfactory Glands (Bowman's Glands): Release substances that cover up smells and shield the skin.

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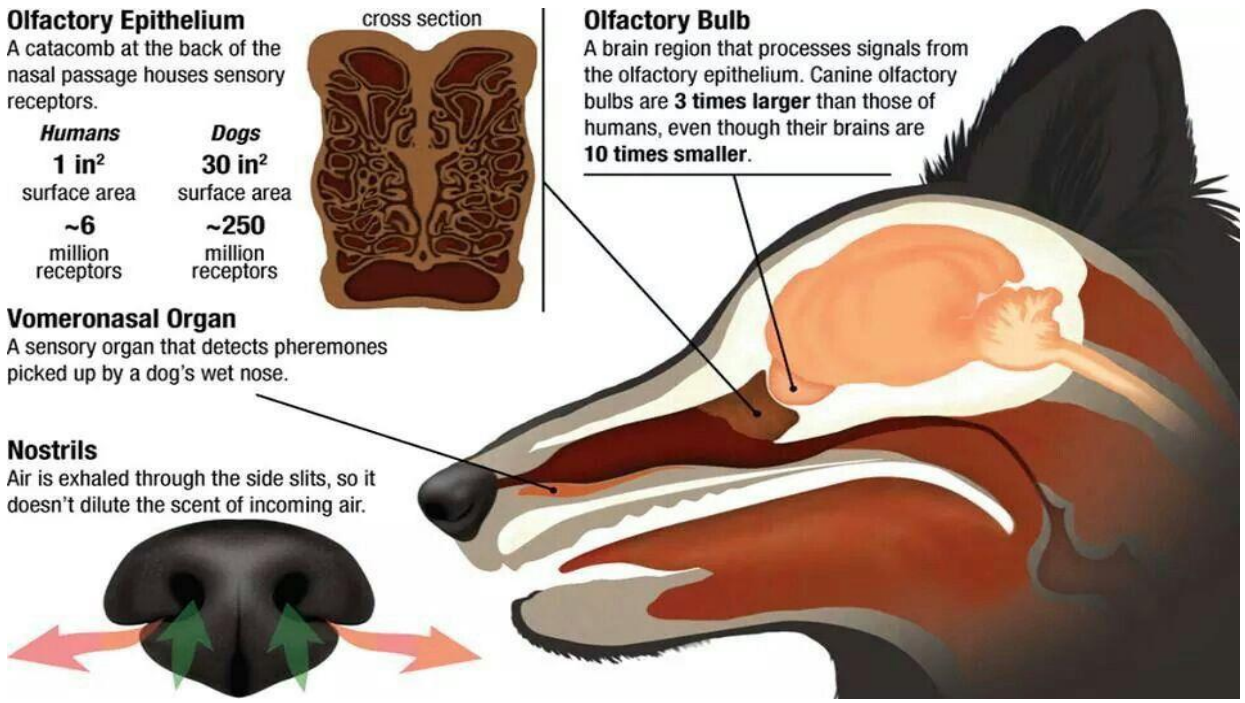

Figure 1: The image demonstrates the anatomical and functional differences between the olfactory systems of humans and dogs, emphasizing dogs' superior sense of smell (Image adapted from: https://www.aocompounding.com/blog/dogs-sense-of-smell).

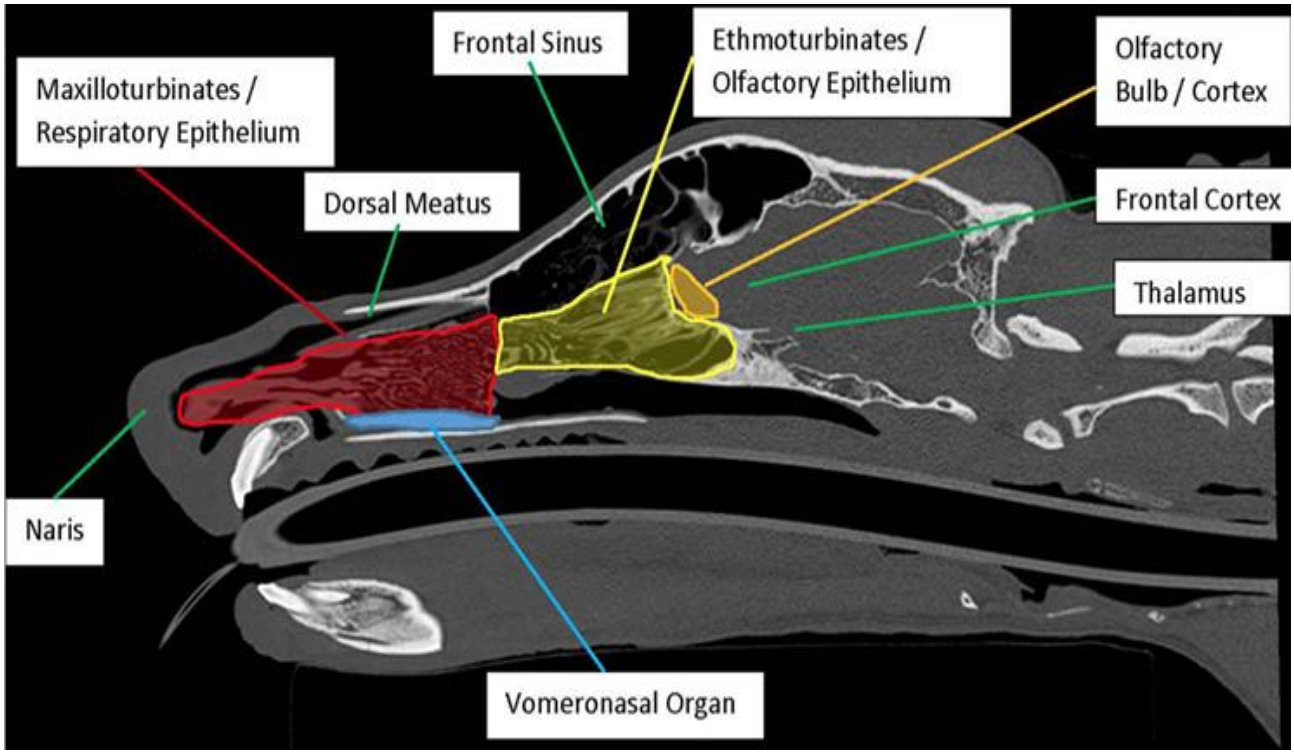

Figure 2: Left sagittal plane highlighting the anatomy associated with olfaction (Image adapted from: Jenkins et al., 2018).

2.1. The neurophysiological basis of the canine olfaction

Canines are blessed with a significantly better smell system compared to human beings, a trait evolved from the wolves. They were required to cross vast distances in order to find their

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target; their nostrils are deliberately designed to add to the structure of the nasal cavity, improving the smell perception. The external nose of a dog includes multiple ridge lines that form numerous wrinkles, increasing the surface area for olfactory reception; the olfactory bulb in this location is 40 times larger than that of a human.

Interestingly, Jacobson's organ, or the vomeronasal organ which is specific to the nasal passage allows dogs to pick pheromones and get information about other animals. Dogs have an extra of 300 million olfactory receptors while in humans has about 6 million, this allows dogs to smell even at very low concentrations. These awesome olfactory abilities are both innate and genetically predetermined, and graduall developed, making dogs extraordinary super-sensitive, with virtually unlimited ability to distinguish smells.

2.2 Training for scent detection

Scent detection in dogs is both a genetic trait and a learnt behaviour that involves the manifestation of genetically predisposed actions. These include Bloodhounds, German Shepherds and Labradors, for the former has a unique organ for smelling while the latter are famous for their obeying nature. Training in general starts with scent differentiation where the dog learns that a particular scent is followed by a favorable reward for example food or toys. Narcotics detection involve exposure of the dogs to specific scent of narcotics (Moser et al., 2019) while medical detection involves the recognition of different odour associated with diseases such as cancer or diabetes using the scent of specific chemical compounds known as volatile organic compounds (Bauër et al., 2022). This thorough training helps the dogs to accurately perform in real-world scenarios and this has numerous utilities in domains; police work and medical fields.

3. Selective breeding for improved olfaction and to performance specific task

Dogs are divided into working, sporting and toy groups consequently differentiating in genes towards hunting, tracking and companionship thus variances in their olfactory capacity. Dogs such as Bloodhounds, Beagles and Basset Hounds are examples of dogs that have large olfactory lobes and a huge number of neurones in their nose. Whereas breeds such as the Greyhound and Whippet are bred for sight, they possess far less developed smell organs. A wide range of scent-discriminating characteristics exists in dog breeds as a product of selective breeding.

Both hunting as well as herding breeds are employed in police work, but, breeds like the German Shepherd or a Labrador Retriever have a concentration on smell and an elevated level of drive and trainability. Scenthounds include Bloodhound and Beagle are renowned to perform extraordinarily well and trail activities over several days old. Labradors and Belgian

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Malinois are used for drug and bomb detection duties because of the sense of smell. Dog breeds such as Pointer and Springer Spaniels that are used to find out the scent of from a distance make the list indicate that these skills of dogs are not restricted to searches of narcotics, explosives, and diseases.

3.1 Variation in the olfactory anatomy and number of receptors

Sensitisation ability varies between species and breeds because the physical structure of their olfactory organ is not the same. Smeller breeds are Bloodhound, German Shepherd, Collie, etc; contain expanded nasal fossa and greater olfactory region which boost scent catching ability. Instead, Pugs and Bulldogs have a short snout, and little places on their face that can come into contact with drippy noses, rendering them less capable of perceiving aromas. Moreover, there is also diversity in the quantity of olfactory receptors present in any given breed. Bloodhounds have roughly 300 million receptors and make the best of track leaders; Beagles and Basset Hounds have approximately 225 million receptors. However, companion breeds such as Pudgy and Chihuahua have considerably fewer receptors and, consequently, have a weak sense of smell. These variances can explain why some breeds are superior to others when it comes to scent work and why some are weaker to no better than random dogs off the street when it comes to this skill.

3.2. Morphological flexibility and genetic heterogeneity in the olfactory assessment of Canidae

Some canines by their breeding underwent certain modifications of genotypes depending on the environment and intensity impacting their olfactory abilities. For instance, breeds like Newfoundland and Portuguese Water Dog operate well in both water as well as in the air. Some Arctic breeds are marked by good smell detection, even if scent particles behave differently in the frigid air, such as Siberian Huskie. On the other hand, Jack Russell Terriers are uniquely specialised to hunting as they have unusual shaped snouts and smell organs. Just as some human beings have a broader taste bud than others, various dog breeds have distinct skills of a smell because of different genes that influence the formation of their smelling organs. Breed differences are a component of each of these characteristics that why some breeds have hereditary advantages in odor analysis, while others may wholly lack them. Larger breeds do contain larger outwardly nasal airways spaces where more olfactory receptors can fit but the sniffing behavior is the same. Thus, sighthounds demonstrate more often and actively the smelling that increases the effectiveness of personnel for scent detection.

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4. Applications of canine scent detection

4.1 Law enforcement and security applications

Detection dogs serve a big use in the police job, including detecting contraband, explosives, and lost individuals. Through an excellent sense of smell, they can scent narcotics like cocaine and heroin even in concealed regions of cars or other locations (DeGreeff & Maughan, 2022). Due to the escalating security risks, explosive detection canines play a significant role in detecting other dangerous materials such as TNT and RDX in airports and other essential social events (Marshall & Oxley, 2011). Furthermore, search and rescue (SAR) dogs are important assets for identifying people during catastrophes since they use the scent of persons in the debris which will tremendously assist in rescuing and retrieving the afflicted individuals (Cvetković, & Miljković, 2024).

4.2 Healthcare and medicine

Detection dogs are the recent addition to the medical team as they are capable of identifying ailments such as cancer, diabetes, and COVID-19. To be used during the pandemic in crowded environments, it was trained to diagnose COVID-19 with an accuracy of over 90% using samples of sweat (Devillier et al., 2022). Cancers viz. Lung, breast and prostate among others can be diagnosed via breath, urine or sweat with a level of accuracy of 88-97% (McCulloch et al., 2006). Dogs trained for type 1 diabetes can independently recognize a change in breath or sweat to alert for hypoglycemia with 83% accuracy (Rooney et al., 2019).

5. Conclusion

Dogs have evolved their olfactory, or smell, skills over centuries. By now it must be evident that dogs' olfactory skills are not just a wonder of the natural world but also have universal applications. It is expected that in the future, more complex applications will be explored as training methodologies improve and technologies are developed. As more humans turn to dogs for scent detection, the role of the dog is only going to progress in the ability to provide safety within health standards, security, and defences which makes the dog a good friend of humanity.

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