

OLFACTORY TRACT

Authored by
mohammad looti

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1. Core Definition

The Olfactory Tract (often abbreviated as OT) is a critical structure within the central nervous system, serving as the direct anatomical pathway responsible for relaying processed olfactory information from the olfactory bulb to the primary olfactory cortex and related forebrain structures. This fibrous bundle represents the axons of the second-order sensory neurons--specifically the **mitral cells** and **tufted cells**--which project centrally from the posterior end of the olfactory bulb. Unlike most other sensory pathways, olfactory input bypasses the thalamus on its initial route to the cortex, highlighting the fundamental importance of the direct projection carried by the olfactory tract.

The tract is geometrically characterized as a flattened band of nerve fibers, positioned longitudinally along the ventral (bottom) surface of the brain's frontal lobe, residing within the olfactory sulcus lateral to the gyrus rectus. Its course begins immediately posterior to the olfactory bulb and culminates posteriorly in a slightly widened area known as the **olfactory trigone**. This terminal region is anatomically significant because it marks the point where the bundled fibers diverge into several distinct projections, known as the olfactory striae, enabling the distribution of odor information to specialized cortical and subcortical regions.

In essence, the olfactory tract is the bridge between the peripheral processing unit (the olfactory bulb) and the brain's olfactory centers. Damage or disruption to the continuity of the tract results in profound deficits in the sense of smell (anosmia), underscoring its indispensable role in chemical communication and perception. The integrity of this pathway is crucial not only for environmental sensing but also for essential functions such as appetite, memory, and emotional processing, given the tract's widespread connections to the limbic system.

2. Anatomy and Gross Morphology

Gross anatomical inspection reveals the olfactory tract as a relatively slender, whitish structure due to its heavy myelination. It emerges from the olfactory bulb, which rests on the cribriform plate of the ethmoid bone. The tract then runs posteriorly, adhering closely to the base of the frontal lobe. This positioning makes it vulnerable to injury from cranial trauma or tumors originating in the anterior cranial fossa.

The physical relationship between the olfactory tract and surrounding neuroanatomical features is vital for surgical and diagnostic purposes. It lies immediately superior to the dura mater and inferior to the orbital gyri of the frontal lobe. The tract itself contains both the axons traveling from the bulb

to the cortex (efferents) and fibers traveling back from the cortex to modulate the activity of the bulb (centrifugal or afferents). The overall morphology of the tract can vary slightly between individuals, but its location within the olfactory sulcus is consistent.

As the olfactory tract approaches its termination point, its physical structure transitions into the olfactory trigone, which is situated close to the anterior perforated substance and the optic chiasm. This transition region is critical, as the diverging fibers must navigate a dense area of vascularization and other cranial nerve structures. The tract's fibers do not terminate randomly; their organized divergence ensures that different aspects of the processed odor information are routed efficiently to dedicated areas for associative learning, discrimination, and emotional response.

3. Termination and Divisional Components: The Olfactory Striae

The olfactory trigone serves as the pivotal point where the olfactory tract fibers redistribute into the primary central connections. This divergence typically results in three specialized bundles of fibers, termed the olfactory striae, though the intermediate stria is often considered vestigial or functionally merged in humans.

Lateral Olfactory Stria (LOS): This is the most substantial and functionally significant projection. The fibers of the lateral stria course laterally and posteriorly toward the temporal lobe. Their primary target is the **primary olfactory cortex**, which includes the piriform cortex, the periamygdaloid area, and parts of the entorhinal cortex. This direct connection to the cortex is responsible for the conscious perception and initial discrimination of odors. The lateral stria ensures rapid, fundamental olfactory processing without immediate thalamic mediation.

Medial Olfactory Stria (MOS): The medial stria is generally smaller and projects medially toward the subcallosal area, the septal nuclei, and the contralateral olfactory bulb via the **anterior commissure**. The fibers traveling through the anterior commissure allow for inter-bulb communication, which is essential for comparing inputs from both nostrils and enhancing the acuity and spatial localization of the perceived odor source.

Intermediate Olfactory Stria (IOS): Historically recognized, this stria is often poorly developed or absent in primates, including humans, but when present, its fibers project toward the **olfactory tubercle** and the anterior perforated substance. In non-primate mammals, the intermediate stria plays a more prominent role, often contributing to projections toward the deep brain structures involved in behavioral responses to pheromones and social cues.

4. Cellular Composition and Synaptic Organization

The fibers constituting the olfactory tract are the axons of the principal output neurons of the olfactory bulb: the mitral cells and the tufted cells. These cells represent the second neural layer in

the olfactory pathway, processing input received from the olfactory receptor neurons (first-order neurons) located in the nasal epithelium.

Mitral cells are the dominant projection neurons, possessing large cell bodies and dendritic trees that synapse with the axons of receptor cells within structures called glomeruli in the olfactory bulb. The vast majority of the olfactory tract is composed of the long, myelinated axons originating from these mitral cells. These axons carry highly processed information--patterns of neural activity representing specific odorants--and project these signals broadly across the primary olfactory targets.

Tufted cells are smaller, secondary projection neurons whose axons also contribute to the olfactory tract, often terminating in more restricted areas, such as the olfactory tubercle and specific parts of the piriform cortex. While both cell types contribute to odor transmission, their distinct projection patterns and physiological properties suggest they may encode different features of the odor stimulus, such as speed of recognition versus detailed quality assessment.

Furthermore, the olfactory tract is not strictly efferent. It contains numerous centrifugal fibers originating from cortical and subcortical areas--such as the anterior olfactory nucleus (AON) and the piriform cortex--that project back into the olfactory bulb. These centrifugal pathways utilize neurotransmitters like GABA and acetylcholine and are crucial for feedback regulation, allowing the brain to modulate the sensitivity and filtering capabilities of the olfactory bulb based on attention, context, and previous experience.

5. Functional Role and Central Olfactory Circuitry

The primary function of the olfactory tract is to ensure the rapid and robust transmission of coded odor information to the central nervous system (CNS). The unique organization of the olfactory pathway--where the tract delivers signals directly to the cortex--is a hallmark of the evolutionary antiquity of this sensory system. This direct cortical access facilitates the tight integration of smell with emotion and memory, structures mediated largely by the limbic system.

Upon reaching the primary olfactory cortex via the lateral olfactory stria, the sensory data is rapidly disseminated. This primary cortex acts as a critical hub for feature extraction and pattern recognition, allowing the brain to identify and categorize the incoming odorant. From here, the olfactory system projects to tertiary centers, including the **medial dorsal nucleus of the thalamus** (which then projects to the orbitofrontal cortex for conscious odor identification), the hypothalamus (linking smell to appetite and feeding behaviors), and the amygdala (integrating smell with fear, pleasure, and memory).

The speed of transmission through the olfactory tract is essential for survival behaviors. Olfactory stimuli often trigger immediate, reflexive actions, such as avoiding spoiled food, identifying

predators, or engaging in mating rituals, particularly in non-human mammals. The integrity of the tract ensures that these critical signals reach the deep limbic structures swiftly, promoting adaptive behavioral responses before a fully conscious, cognitive assessment of the odor is completed.

6. Clinical Significance and Related Pathologies

Pathological disruption of the olfactory tract can have significant clinical consequences, primarily leading to varying degrees of olfactory dysfunction. The most common presentation following severe tract damage is **unilateral or bilateral anosmia** (complete loss of smell) or hyposmia (reduced smell sensitivity).

The tract is vulnerable to several types of injury or disease. Since it rests upon the floor of the frontal cranial fossa, traumatic brain injury (TBI), especially those involving fracture of the cribriform plate, can shear the fibers connecting the bulb to the tract, or damage the tract itself. Furthermore, masses or tumors, such as meningiomas or gliomas arising near the ventral surface of the frontal lobe, can compress the olfactory tract, leading to slowly progressive anosmia that may go unnoticed until advanced stages. Conditions like Foster Kennedy syndrome, though complex, often involve symptoms related to olfactory tract dysfunction due to frontal lobe masses.

In the context of neurodegenerative disorders, the olfactory tract is often implicated early. Reduced olfactory function is recognized as one of the earliest non-motor symptoms of both **Parkinson's disease** and **Alzheimer's disease**. Pathological hallmarks of these diseases (e.g., Lewy bodies or amyloid plaques) often first appear in the olfactory bulb and tract before spreading to the rest of the brain, suggesting that the tract may serve as a critical gateway for the spread of pathology or simply reflecting the high metabolic vulnerability of these neurons.

7. Comparative Neuroanatomy

The structure and size of the olfactory tract vary markedly across species, reflecting the relative importance of olfaction in their survival. Species classified as **macrosmatic** (having a highly developed sense of smell, e.g., dogs, rodents) possess very large, prominent olfactory bulbs and correspondingly robust olfactory tracts that occupy a significant proportion of the ventral forebrain area. This increased size correlates with a greater number of projection neurons and a more extensive cortical target field.

Conversely, in **microsmatic** species, such as humans and some primates, the olfactory system is proportionally smaller relative to the size of the rest of the brain, a feature often attributed to the dominance of visual processing. Although the human olfactory tract is smaller, its fundamental organization remains conserved, maintaining the direct projection to the piriform cortex. Comparative studies of the olfactory tract provide insights into evolutionary pressures and the development of sensory hierarchies, often utilizing tract tracing techniques to map the precise

connections established by the olfactory striae in various animal models.

Further Reading

[Olfactory Tract \(Wikipedia\)](#)

[Neuroscience of Olfaction \(NCBI Bookshelf\)](#)

[Olfactory Cortex](#)

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