The Anatomy and Physiology of the Ears, Nose and Throat

CHAPTER 1

INTRODUCTION

The ear, nose and throat (ENT) form a highly interconnected region of the body that plays an essential role in sensory perception, communication, protection and overall health. A sound understanding of ENT anatomy and physiology underpins all clinical skills in this field. Without a clear grasp of structural relationships and functional processes, clinical examinations and procedures risk becoming mechanical tasks rather than informed assessments. For this reason, anatomy and physiology must be considered not in isolation, but as a living, dynamic system that directly informs clinical reasoning and patient care.

Conditions affecting the structures of the head and neck range widely, from minor ailments to some of the most complex and demanding disorders seen in clinical practice. The special senses associated with ENT play a vital role in everyday life, yet they are often taken for granted until difficulties occur. These senses underpin essential functions. Any disruption can have a significant impact on quality of life. Problems in these areas may interfere with communication, nutrition, sleep and overall well-being (Harkin 2024).

ENT structures are complex in their design and often small in scale, yet they have profound implications for quality of life. The ear not only enables hearing, a key mode of human interaction, but also governs balance and spatial orientation. The nose serves as the gateway to respiration, filtering and conditioning inspired air while also providing the sense of smell that underpins taste, appetite and safety behaviours. The throat and larynx coordinate swallowing, speech and airway protection, forming the crossroads of the respiratory and digestive systems. The neck houses vital structures, including lymph nodes, salivary glands, thyroid and major vessels, making it a key site for systemic as well as local disease.

From a clinical perspective, ENT presentations are among the most frequent reasons for healthcare consultation across both primary and secondary care. Yap (2025) notes that ENT diseases are not only prevalent, but also bring with them substantial economic, health and social implications. Earache, sore throat, nasal congestion, hearing loss, voice changes and neck lumps represent some of the most common symptoms encountered in practice. An appreciation of the underlying anatomy and physiology allows those who are offering care and support to people to link these symptoms with potential pathologies and to carry out focused, safe and effective examinations. Recognising the anatomical course of the Eustachian tube, for example, aids the understanding of recurrent otitis media, while knowledge of lymphatic drainage in the neck directs the examination of potential head and neck cancers.

The ENT system does not operate in silos; rather, it functions as an integrated network with shared innervation, blood supply and lymphatic drainage. Pathology in one region often has consequences for another. This interconnectedness highlights the necessity of a systems-based rather than compartmental approach to clinical skills. The anatomy and physiology of the ENT region should therefore be learned not only as discrete parts but also as an interrelated whole that influences the patient's presentation.

Anatomy and physiology of the ear, nose, throat and neck form the foundation of clinical skills in ENT. Every examination technique, procedural skill or diagnostic interpretation in ENT practice is anchored in this knowledge. Learning anatomy and physiology should not be seen as an abstract academic exercise but a practical necessity that ensures safe, competent and compassionate patient care.

This chapter introduces the anatomy and physiology of ENT. It will examine the complex structures and functions of these organs, highlighting how they interact to support essential senses and everyday activities. A sound understanding of this foundation enables those who offer people care and support to appreciate the importance of protecting ENT health and to recognise the wide-ranging effects that disorders in these areas can have on overall well-being and daily life.

THE EAR

The ear performs two essential functions: it enables hearing, allowing us to perceive and interpret the sounds in our environment, and it contributes to balance (equilibrium), helping the body maintain spatial orientation.

THE ANATOMY

Structurally, the ear is divided into three main regions, each with distinct roles:

1. Outer (external) ear
2. Middle ear
3. Inner ear

These regions work together to capture sound waves, transmit and amplify vibrations and convert mechanical energy into electrical signals that the brain can interpret, while also providing information about head position and movement for balance. Figure 1.1 depicts the regions of the ear.

The outer ear

The outer ear is also referred to as the external ear. This is the visible part of the external ear (see Figure 1.2). The outer ear plays a vital role in supporting the functions of the middle ear, although it is not considered an anatomical part of it. It consists of the auricle (pinna) and the external auditory canal (meatus), which together collect and channel sound waves towards the middle ear.

The auricle is the shell-shaped projection surrounding the opening of the external auditory canal. It is composed of elastic cartilage covered by skin and can be divided into distinct regions, including the helix, forming the outer rim and the earlobe, which lacks cartilage and is soft. The primary function of the auricle is to capture sound waves and direct them into the external auditory canal. Its asymmetrical shape introduces subtle timing differences in the arrival of sound to each ear, which assists in sound localisation.

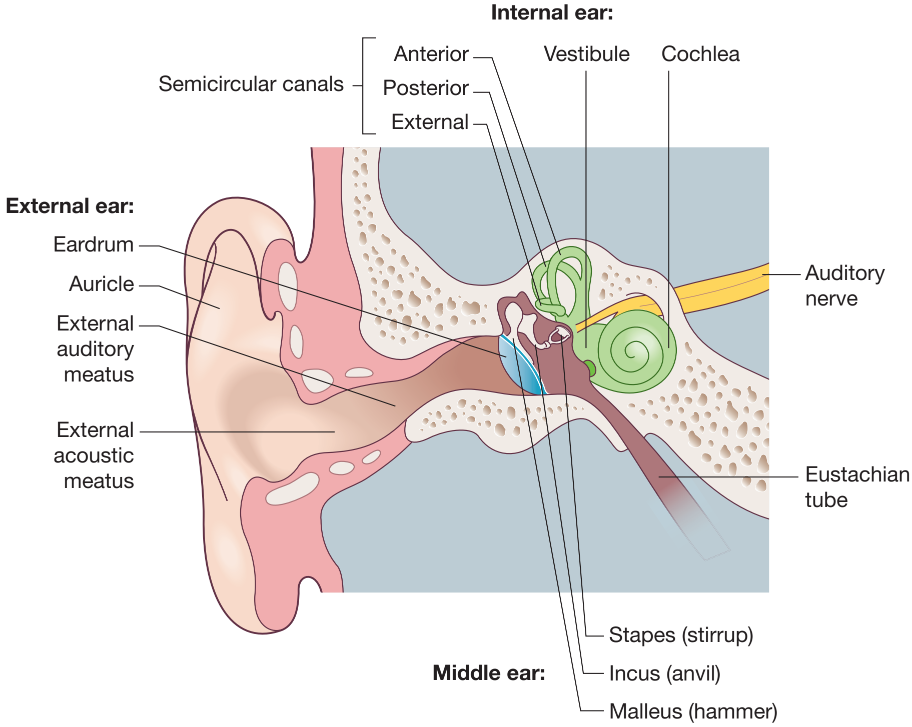

FIGURE 1.1 The ear. *Source*: Peate et al. (2014). With permission of John Wiley & Sons.

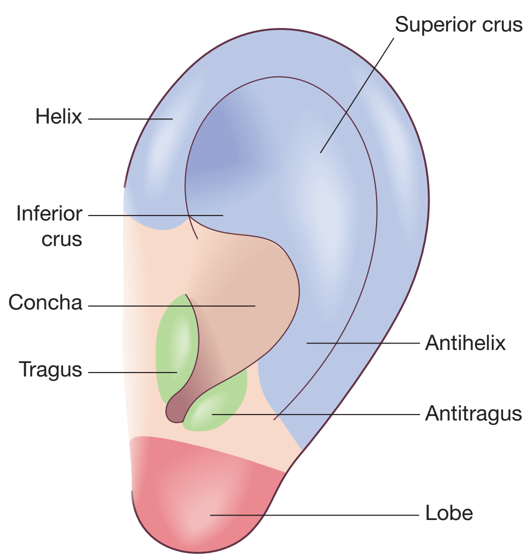

FIGURE 1.2 The outer ear. *Source*: Peate et al. (2014). With permission of John Wiley & Sons.

The external auditory canal is a short, S-shaped passage approximately 2.5 cm in length and 0.6 cm in diameter, extending from the auricle to the tympanic membrane (Meakin and Seewoodhary 2022). The outer portion near the auricle is made of elastic cartilage, while the inner portion passes through the temporal bone and therefore requires no supporting cartilage. The canal is lined with skin containing hairs, sebaceous (oil) glands and ceruminous glands, which are specialised sweat glands. The ceruminous glands produce a yellow-brown waxy substance called cerumen (earwax). Together with the hairs, these secretions lubricate the canal, trap debris and provide antimicrobial protection, helping to maintain a clean and healthy pathway for sound.

The arterial supply of the external ear arises from the posterior auricular artery, the anterior auricular branch of the superficial temporal artery and the occipital artery, with veins generally following the course of the arteries. Innervation is provided primarily by the auriculotemporal nerve (branch of cranial nerve V), with contributions from cranial nerves VII, IX and X, as well as the great auricular nerve. These multiple nerves work together to allow the ear to feel touch, pressure and pain, which is important for protecting the ear and responding to injury or infection.

Sound waves entering the external auditory canal reach the tympanic membrane (eardrum), a thin, translucent membrane covered externally by skin and internally by mucosa. Shaped like a slightly flattened cone that projects into the middle ear, the tympanic membrane vibrates in response to sound waves. These vibrations are then transmitted to the ossicles of the middle ear, allowing the auditory signal to continue along the auditory pathway for processing.

The middle ear

The middle ear, also known as the tympanic cavity, is a small, air-filled space within the petrous portion of the temporal bone. Its primary function is to transmit sound efficiently from the air of the external ear to the fluid of the inner ear. Sound waves collected by the auricle and transmitted via the tympanic membrane (eardrum) (see Figure 1.3) are conducted through the ossicular chain, allowing the mechanical vibrations to reach the inner ear.

The middle ear extends from the tympanic membrane laterally to the oval window medially. Its walls are anatomically complex, with significant relationships to surrounding structures. It is connected to the nasopharynx via the auditory (Eustachian) tube, which helps maintain an air-filled environment and equalises pressure on both sides of the tympanic membrane. The Eustachian tube is normally closed at the nasopharyngeal end but opens during swallowing or yawning, allowing air to pass through. Failure of pressure equalisation can restrict tympanic membrane movement, reducing hearing.

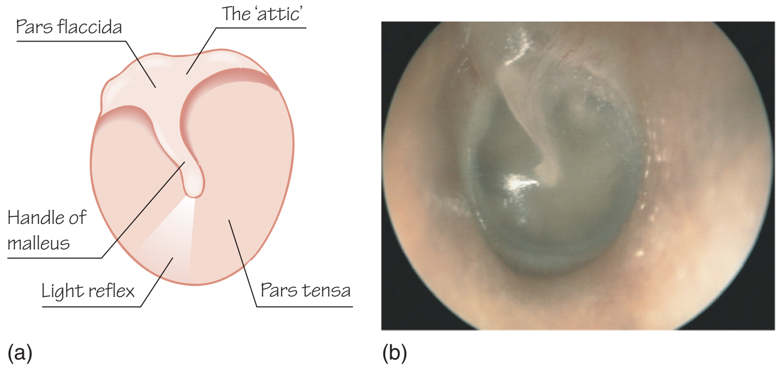

FIGURE 1.3 The tympanic membrane (the ear drum): (a) diagrammatic representation; (b) seen with an otoscope. *Source*: Munir and Clarke (2012). With permission of John Wiley & Sons.

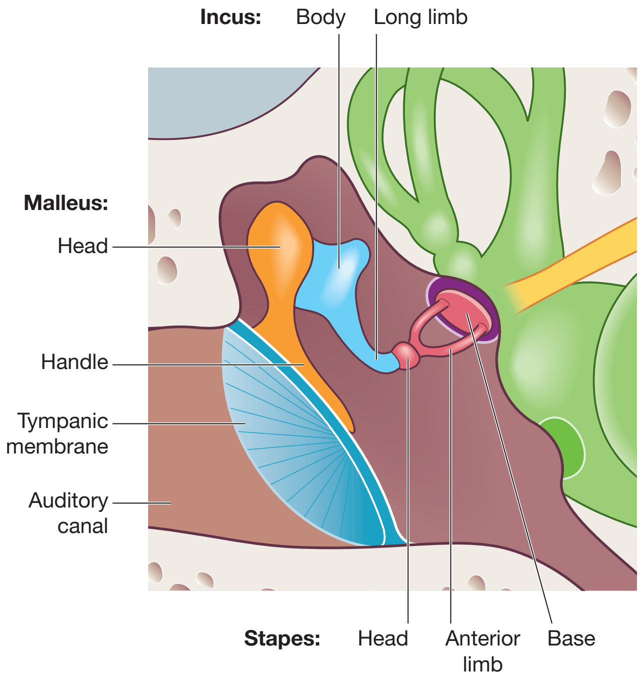

FIGURE 1.4 The ossicles. *Source*: Peate et al. (2014). With permission of John Wiley & Sons.

Within the middle ear lie the three ossicles, the malleus, incus and stapes. These are the smallest bones in the body (see Figure 1.4). These bones transmit and amplify vibrations from the tympanic membrane to the oval window of the inner ear. The malleus attaches to the inner surface of the tympanic membrane, the incus connects the malleus to the stapes and the stapes interfaces with the oval window. The ossicles are joined by the smallest synovial joints in the body, each supported by tiny ligaments and capsules.

To protect the tympanic membrane and ossicles from damage due to loud sounds, two small muscles modulate their movement: the tensor tympani, attached to the malleus, stiffens the tympanic membrane when contracted and the stapedius, attached to the stapes, dampens movement against the oval window. Together, these structures enable humans to detect a wide range of sounds while minimising the risk of injury from excessive vibration.

Table 1.1 provides a discussion of the key structures of the middle ear.

The inner ear

The inner ear, also called the labyrinth, contains the sensory receptors that are responsible for hearing and equilibrium, which together form the basis of the auditory and vestibular systems. It is a complex structure composed of a membranous labyrinth encased within a bony (osseous) labyrinth, both of which are housed within the temporal bone. The bony labyrinth forms the rigid outer framework, while the membranous labyrinth, a delicate network of fluid-filled tubes, contains the sensory receptors. The space between these two labyrinths is filled with perilymph, a fluid resembling cerebrospinal fluid, whereas the membranous labyrinth itself contains endolymph, a potassium-rich fluid critical for sensory transduction. Functionally, the inner ear can be divided into three primary regions (see Figure 1.5):

Table 1.1 Key structures of the middle ear

Structure	Description and function	Notes
Tympanic membrane	Thin, oval, semi-transparent membrane separating the external ear from middle ear. Transfers air vibrations collected by the auricle to the ossicles.	Multiple structures occupy the tympanic cavity around it, including muscles, nerves and the auditory tube. Essential for effective sound transmission; restricted movement reduces hearing.
Ossicles	Chain of three movable bones: Malleus (hammer), incus (anvil) and stapes (stirrup). Transmit and amplify sound from the tympanic membrane to the perilymph of the inner ear.	Smallest bones in the body; joints are tiny synovial joints with ligaments. Amplification enables hearing of quiet sounds but can make the ear vulnerable to loud noises.
Auditory tube (Eustachian tube)	Connects the middle ear to the nasopharynx. Equalises pressure across the tympanic membrane.	Normally closed at the nasopharyngeal end; opens during swallowing or yawning. Dysfunction can cause middle ear pressure problems and hearing impairment.
Blood supply and innervation	Supplied by arteries mainly from the external and internal carotid. Innervated by the auriculotemporal nerve (cranial V), tympanic nerve (cranial IX) and the auricular branch of cranial nerve X (vagus).	Knowledge of vascular and nerve supply is essential for surgical approaches and understanding referred pain patterns.

1. Vestibule

   The vestibule contains two membranous sacs, the saccule and utricle, which house specialised hair cell receptors. These receptors detect linear acceleration and gravity, providing the central nervous system with essential information about head position and static balance.

2. Semicircular canals

   Three semicircular canals: anterior, posterior and lateral enclose semicircular ducts filled with endolymph. Receptors in the ampullae of these ducts respond to rotational movements of the head, enabling the detection of angular acceleration. The vestibule and semicircular canals together constitute the vestibular complex, which is fundamental for maintaining dynamic balance and coordinating eye movements during head motion.

3. Cochlea

   The cochlea is a spiral-shaped, bony chamber that houses the cochlear duct, a component of the membranous labyrinth. Within this duct lies the organ of Corti, the primary receptor organ for hearing. Inner hair cells serve as sensory receptors, transmitting auditory information via the afferent fibres of the VIII cranial nerve (vestibulocochlear nerve) to the brainstem. Outer hair cells receive efferent input, modulating the mechanical properties of the cochlear duct to enhance sensitivity and frequency selectivity. The cochlea is flanked by two perilymph-filled chambers, the scala vestibuli and scala tympani, which help propagate sound vibrations from the oval window to the round window, ensuring efficient transfer of acoustic energy.

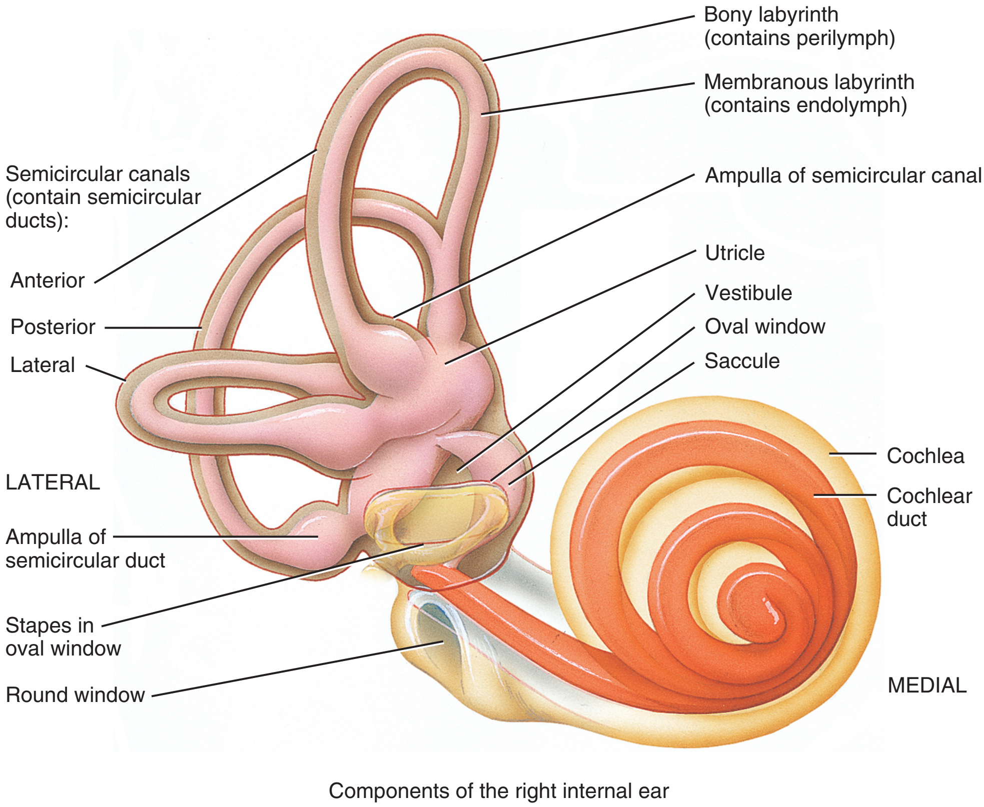

FIGURE 1.5 The inner ear. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

The cochlea communicates with the middle ear through two specialised openings known as the windows of the cochlea. The oval window, located at the base of the stapes, serves to transmit mechanical vibrations from the middle ear into the perilymph of the cochlea. In contrast, the round window functions as a pressure release, separating the perilymph from the air-filled middle ear and allowing the fluid within the cochlea to move freely. Together, these windows ensure that sound energy is efficiently transferred into the cochlear fluids, enabling precise stimulation of the auditory receptors.

The inner ear is supplied primarily by the internal auditory artery, which passes through the internal auditory meatus and divides into three branches, including the cochlear artery that supplies the cochlea via the spiral arteries. Sensory input is conveyed by the vestibulocochlear nerve (cranial nerve VIII), with separate divisions for the auditory and vestibular components.

The precise arrangement of the inner ear's fluids, membranous structures and sensory receptors allows it to convert mechanical vibrations and head movements into neural signals. This enables perception of sound across a wide frequency range, maintains balance and posture and coordinates eye movements with head motion. Dysfunction in any part of the inner ear can result in hearing loss, vertigo or balance disorders, highlighting the clinical significance of its intricate anatomy.

BALANCE

Maintaining balance (equilibrium) is a complex physiological process. The sense of equilibrium, a critical component of balance, is mediated by specialised receptors located in the semicircular ducts, utricle and saccule of the inner ear. Receptors within the semicircular ducts are primarily active during movement, responding to rotational movements of the head, but remain largely inactive when the body is stationary. There are three semicircular ducts: lateral, posterior and anterior, each of which is continuous with the utricle.

Each duct contains an ampulla, an enlarged region that houses the majority of its sensory receptors. Within the ampulla, the receptors are clustered on a structure called the crista, which is bound to a gelatinous mass known as the cupula that spans the width of the ampulla (see Figure 1.6). The sensory receptors themselves are hair cells, which are surrounded by supporting cells and monitored by the dendrites of sensory neurones.

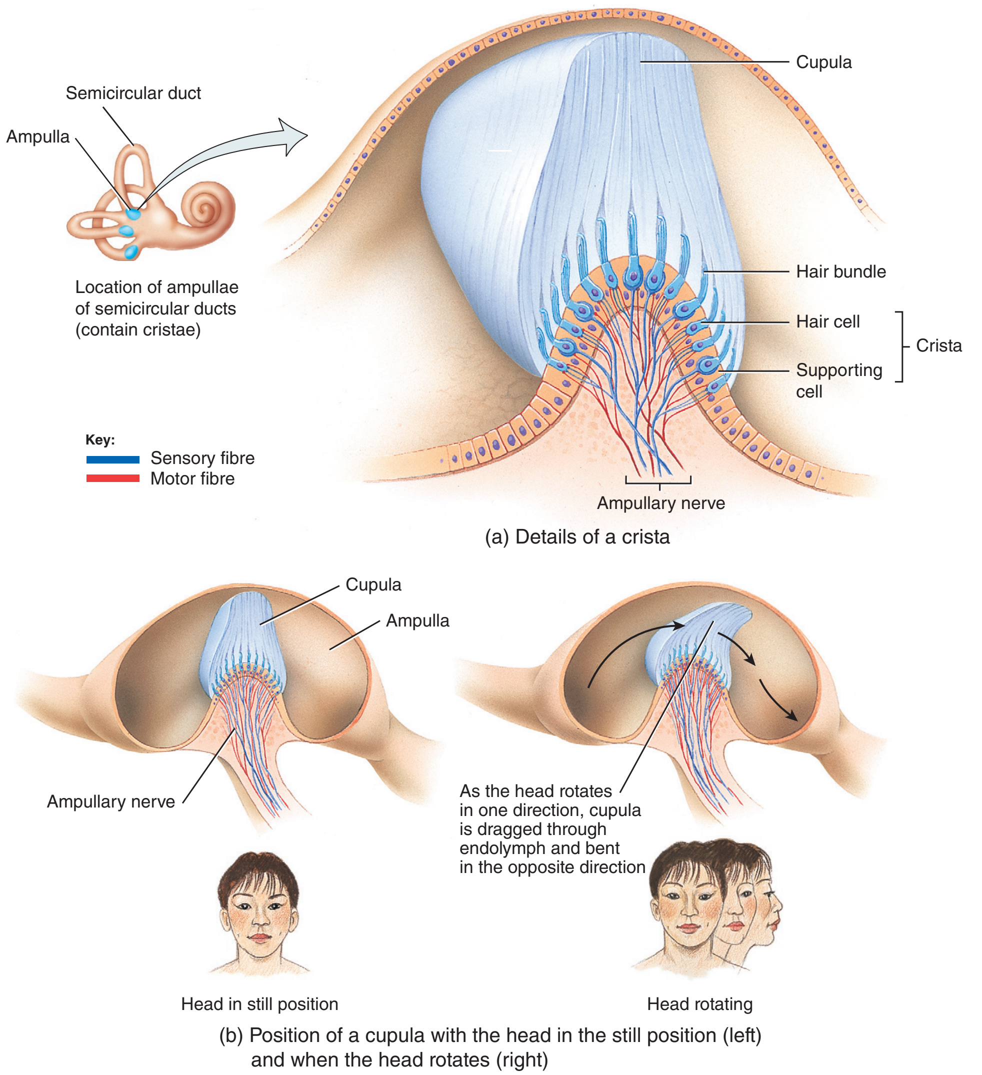

FIGURE 1.6 Maintaining balance (equilibrium). *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

The free surfaces of the hair cells are covered with stereocilia, long, hair-like projections and a single larger projection called the kinocilium. When the cupula is deflected by movement of the endolymph, the stereocilia and kinocilium bend, causing a change in the release of neurotransmitters from the hair cells (see Figure 1.7). For example, if the head turns to the left, fluid movement within the lateral semicircular canal bends the stereocilia, distorting the hair cell membranes and altering neurotransmitter release, which the brain interprets as rotational movement. The combination of input from all three semicircular ducts allows the brain to detect movement in any plane.

In contrast, the utricle and saccule provide information about equilibrium, whether the body is stationary or in motion. These two chambers are connected by a narrow passageway that also communicates with the endolymphatic duct. Hair cells in the utricle and saccule are clustered within maculae, oval sensory regions. The cilia of these hair cells are embedded in a gelatinous layer topped with densely packed calcium carbonate crystals called statoconia. This combination of gelatinous layer and crystals is referred to as an otolith.

When the head is in a neutral position, the otoconia (statoconia) rest on the macula, exerting a baseline gravitational load on the otolithic membrane; changes in head position or linear acceleration result in deflection of the hair cell stereocilia. A similar process occurs during linear acceleration, such as when a car accelerates: the otoliths lag slightly due to inertia and the resulting deflection of the hair cells informs the brain about the change in motion. The brain integrates these signals with visual information to differentiate between the effects of gravity and linear acceleration (see Figure 1.8).

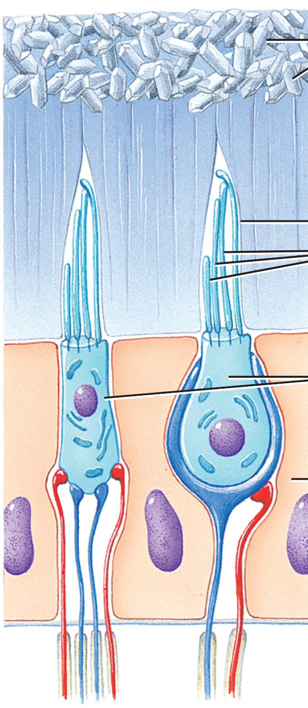

FIGURE 1.7 Hair cells and otoliths. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

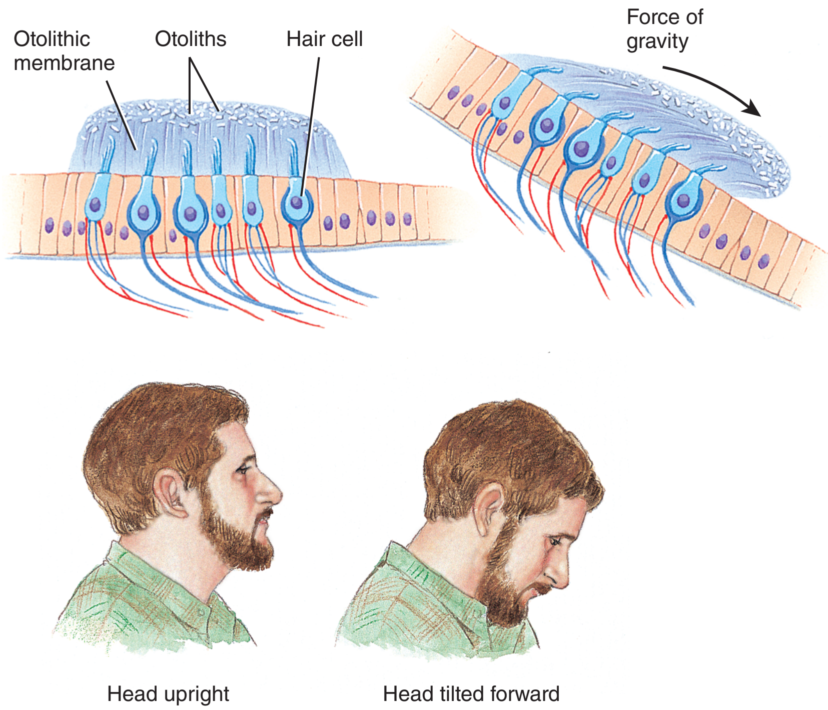

FIGURE 1.8 Position of the macula with head upright (left) and tilted forward (right). *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

PATHWAYS FOR EQUILIBRIUM SENSATIONS

Hair cells in the semicircular canals, utricle and saccule send signals to neurones in the vestibular ganglia. These neurones form the vestibular nerve (part of cranial nerve VIII) and carry information to the vestibular nuclei in the brainstem. The vestibular nuclei:

1. Integrate balance information from both sides of the head.
2. Transmit signals to the cerebellum to assist in the control of posture and coordinated movement.
3. Relay information to higher brain centres, contributing to conscious awareness of body position and movement.
4. Mediate reflexes involving the eyes, head and neck, helping to stabilise vision during movement (e.g. the vestibulo-ocular reflex).

This system helps us stay balanced, sense motion and move smoothly.

HEARING AND SOUND

Hearing is a vital sense that allows us to interact with and interpret the world around us. It is essential for communication, enabling speech, conversation and social interaction (Oxenham 2019). Beyond language, hearing allows us to appreciate music, recognise environmental sounds such as traffic or alarms and respond appropriately to signals in our surroundings. The ability to detect, differentiate and interpret sounds influences safety, learning and social engagement, making it a critical component of daily life.

Sound itself consists of vibrations transmitted through air or other media, which the ear detects and converts into electrical signals that the brain can understand. The process of hearing depends on the intricate structure of the outer, middle and inner ear, each of which plays a unique role in capturing, transmitting and processing sound. By understanding the mechanisms of hearing, healthcare professionals can better appreciate the impact of auditory disorders and the importance of preserving auditory function for overall quality of life.

Hearing is mediated by hair cell receptors located within the cochlear duct of the inner ear. These hair cells are similar to those found in the semicircular canals and vestibule, but their placement within the cochlear duct, along with the surrounding structures, protects them from stimuli other than sound.

The ossicular chain of the middle ear transmits and amplifies sound pressure waves from the air into pressure waves in the perilymph of the cochlea. These waves stimulate hair cells along the length of the cochlear spiral:

- Frequency (pitch) is determined by the specific region of the cochlear duct that is activated.
- Intensity (volume) is determined by the number of hair cells stimulated at that location.

The cochlea contains three fluid-filled ducts (see Figure 1.9):

1. Vestibular duct (scala vestibuli) connects to the oval window.
2. Tympanic duct (scala tympani) connects to the round window.
3. Cochlear duct (scala media) lies between the vestibular and tympanic ducts, separated from the tympanic duct by the basilar membrane. The vestibular and tympanic ducts are continuous at the apex of the cochlear spiral, forming a single perilymphatic chamber (see Figure 1.10).

Within the cochlear duct lies the organ of Corti, which rests on the basilar membrane. Hair cells in the organ of Corti are arranged in longitudinal rows. They do not possess kinocilia;

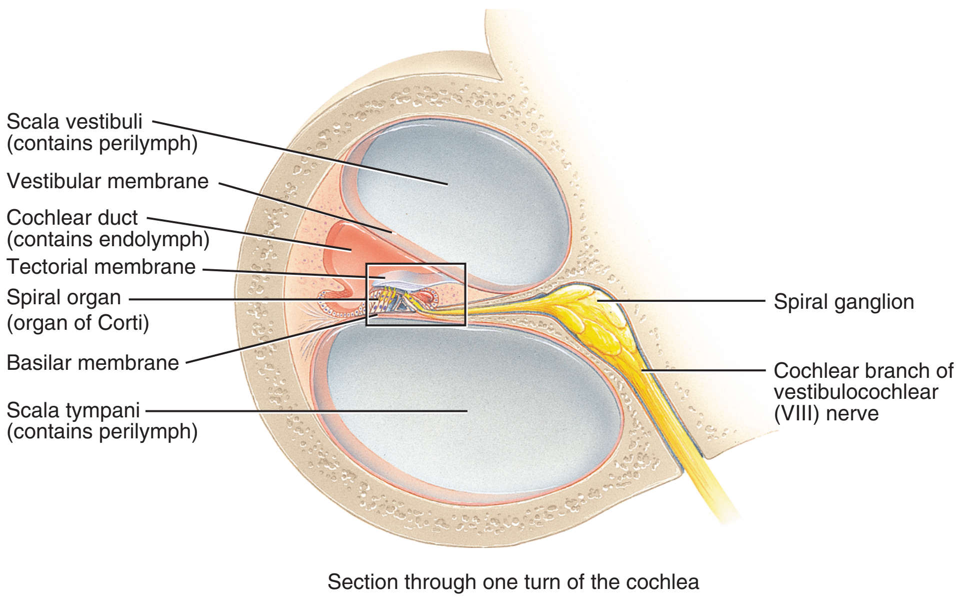

FIGURE 1.9 The cochlea: A cross-section. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

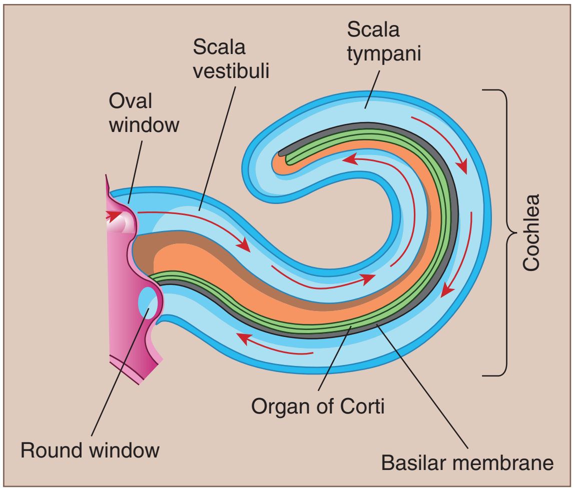

FIGURE 1.10 Cochlea showing the continuous nature of the vestibular and tympanic ducts. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

instead, their stereocilia contact the tectorial membrane, which is attached to the inner wall of the cochlear duct. When pressure waves in the perilymph cause the basilar membrane to move, the stereocilia are deflected against the tectorial membrane, initiating sensory transduction.

See Box 1.1 for an overview of sound and hearing.

BOX 1.1 SOUND

Sound is produced when a source vibrates, setting the surrounding air molecules into motion. These vibrations create pressure waves that travel outwards from the source. When something vibrates and creates sound, it pushes air molecules together in some regions (compression) and pulls them apart in others (rarefaction). When these waves reach the ear, they are detected and interpreted by the auditory system.

Two key properties of sound waves determine how we perceive them. The frequency of the wave, which is measured in hertz (Hz) or cycles per second, corresponds to what is experienced as pitch. Low-frequency waves produce low-pitched sounds, such as a deep drumbeat, while high-frequency waves generate high-pitched sounds, for example, a whistle. Frequencies are usually perceived between 20 and 20,000 Hz, although this range narrows with age and exposure to noise.

The amplitude of the wave relates to its energy and is perceived as loudness or intensity. Greater amplitude produces louder sounds, while smaller amplitude results in quieter sounds. Amplitude is often measured in decibels (dB), which reflects the large range of sound intensities the human ear can detect, from the faint rustle of leaves (around 20 dB) to the roar of a jet engine (above 120 dB). Prolonged exposure to high-amplitude sound can damage the delicate hair cells of the inner ear, leading to noise-induced hearing loss.

The features frequency and amplitude are summarised in Table 1.2. The table provides everyday examples to illustrate how they influence hearing.

It is also important to recognise that real-world sounds are rarely composed of a single pure frequency. Most sounds are complex, consisting of multiple frequencies and amplitudes combined

Table 1.2 Sound waves and their perception

Frequency and amplitude	Definition	Perceived as	Examples
Frequency	Number of sound waves per second, measured in hertz (Hz)	Pitch (how high or low a sound is)	Low frequency: Deep sounds such as a bass drum or thunder or a deep voice. High frequency: High sounds such as a whistle, birdsong or a child's voice. Human hearing range: 20–20,000 Hz (reduces with age or noise exposure).
Amplitude	Size or strength of the sound wave	Loudness/ intensity(how loud or soft a sound is)	Low amplitude: Soft sounds such as a whisper, rustling leaves or a ticking clock. High amplitude: Loud sounds such as a rock concert, a siren or a jet engine. Loudness is measured in decibels (dB); very loud sounds can damage hearing.

Source: Adapted from Meakin and Seewoodhary (2022).

together. The auditory system is able to separate and interpret these components, allowing the distinction between different voices, recognition of musical instruments or the detection of subtle changes in tone during speech.

Understanding these fundamental properties of sound provides the foundation for interpreting audiometric testing and recognising patterns of hearing impairment. For example, high-frequency hearing loss is common in age-related presbycusis, while low-frequency loss may occur in Ménière's disease. Thus, the physics of sound is directly relevant to the skills required in ENT examination and diagnosis.

THE HEARING PROCESS

Hearing involves a sequence of six stages, detailing how sound waves travel from the external environment through the structures of the ear and are converted into electrical signals that the brain perceives as sound (Clare 2026a):

1. Entry of sound waves: Sound waves travel through the external auditory canal and strike the tympanic membrane, causing it to vibrate.
2. Ossicle movement: These vibrations are transmitted to the ossicles, which amplify the sound.

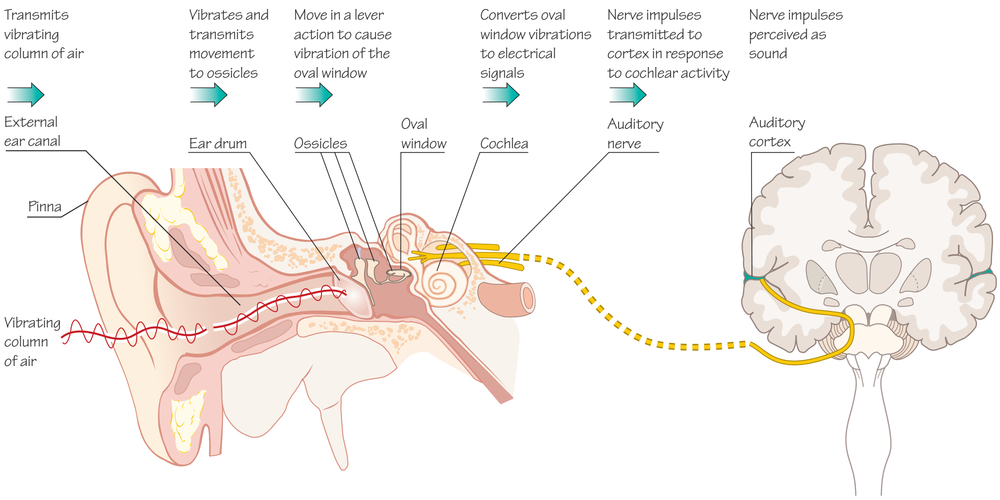

FIGURE 1.11 The conversion of external sound into auditory perception in the cerebral cortex. *Source*: Munir and Clarke (2012). With permission of John Wiley & Sons.

3. Stapes action: Movement of the stapes at the oval window generates pressure waves in the perilymph of the vestibular duct.
4. Basilar membrane response: The pressure waves cause the basilar membrane to vibrate. The location of maximum vibration depends on the frequency of the sound – high-frequency sounds stimulate areas near the oval window, while low-frequency sounds affect regions further along the cochlear spiral. The amplitude of vibration conveys information about the loudness of the sound.
5. Hair cell activation: Vibrations of the basilar membrane bend the stereocilia of hair cells against the tectorial membrane, leading to the release of neurotransmitters. Soft sounds activate only a few hair cells, while louder sounds stimulate more cells across multiple rows.
6. Signal transmission: Information about the location and intensity of stimulation is carried to the brain via the cochlear branch of the vestibulocochlear nerve (cranial nerve VIII). The cell bodies of these neurones are located in the spiral ganglia of the cochlea. Signals are then relayed to the cochlear nuclei in the medulla oblongata and onwards to higher auditory centres in the brain for perception and processing.

See Figure 1.11 for the process by which sound from the environment is transformed into signals that the brain interprets as hearing.

THE NOSE

The primary function of the nose is to provide a passageway for air entering and leaving the respiratory tract. In performing this role, the nose acts as a natural 'air conditioner', ensuring that inspired air is warmed, humidified and filtered before reaching the lower respiratory tract. Tiny hairs and mucous membranes trap dust, microbes and other particulate matter, protecting the lungs from potential harm.

Beyond its role in respiration, the nose is also essential for olfaction (the sense of smell), which contributes to taste, environmental awareness and detection of hazards such as smoke or spoiled food. The structural features of the nose, including the nasal cavity, turbinates and meatuses, create turbulent airflow, which enhances the contact of air with the mucosal surfaces for more effective filtration and humidification.

The nose also plays a role in the resonance of the voice, influencing speech quality. Its anatomical and physiological functions are therefore vital not only for respiratory health but also for sensory perception and communication, highlighting the clinical importance of understanding its structure and function in healthcare practice.

The nose is the initial part of the respiratory tract and also houses the receptors responsible for the sense of smell. Its functions can be summarised into three main roles:

1. Conditioning inhaled air: Warming, humidifying and filtering it
2. Olfaction: Detecting odours from the environment
3. Resonance: Acting as a chamber that modifies and enriches the quality of speech

Anatomically, the nose can be divided into external and internal sections.

EXTERNAL NOSE

This consists of a framework of bone and cartilage, covered by muscle and skin and lined internally with a mucous membrane. The framework is attached to the frontal and maxillary bones of the skull. The external nose is divided by the nasal septum into two airways or nares (nostrils), which are roughly equal in size and form part of the structural framework.

INTERNAL NOSE

The nasal cavity is a large chamber lined with ciliated mucous membrane; its vestibule contains coarse nasal hairs (vibrissae) that trap large particles from inhaled air. Smaller particles that enter the nose become trapped in the sticky mucus produced by the membrane and are transported to the nasopharynx via the ciliary system. The internal nose is divided into two sides by a continuation of the septum. The nasal septum is composed of cartilage at the front and bone at the back. The nasal entrance is lined with vibrissae, while the internal passages are lined with ciliated columnar mucous membrane. These passages are richly supplied with blood vessels. The lower posterior region of the cavity receives blood from a branch of the maxillary artery and the mucosa is further supplied by the anterior and posterior ethmoidal arteries. These vessels converge at a highly vascular area on each side of the septum known as Little's area (Harkin and Jamieson 2024).

Each side contains three bony shelves called turbinates, which increase the surface area over which air passes, enhancing humidification and warming (see Figure 1.12). The internal nose also has an extensive vascular supply, which, together with the turbinates, maximises air conditioning. Additionally, it contains openings (ostia) from the paranasal sinuses, which connect the sinuses to the nasal cavity. The paranasal sinuses support respiratory efficiency, protection and voice resonance. They also reduce skull weight and provide some protection against facial trauma (Clare 2026b).

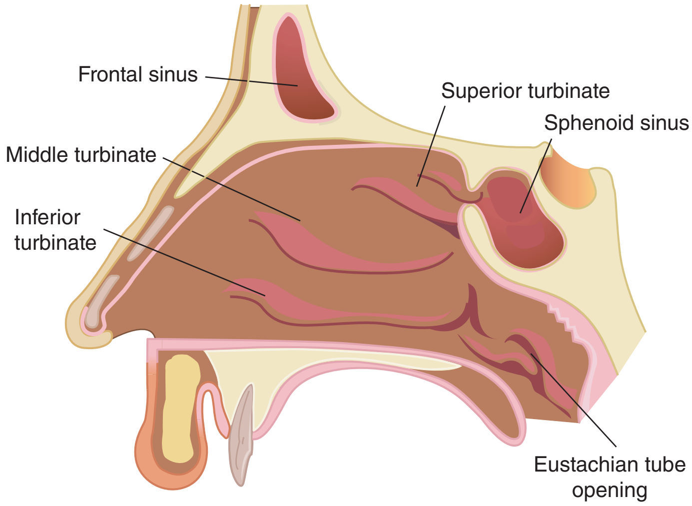

FIGURE 1.12 Structures of the nose. *Source*: Peate (2021). With permission of John Wiley & Sons.

OLFACTION

Olfaction refers to the sense of smell. From an evolutionary perspective, the sense of smell is one of the oldest human senses (Brandt and Huppert 2025). Olfaction plays a crucial role in survival: it allows the detection of food that is safe to consume versus food that is spoiled, helps identify environmental dangers such as hazardous chemicals and contributes to pleasure through scents such as flowers and perfumes. The sense of smell relies on specialised receptors that respond to airborne chemical particles. Within the nasal cavity, on either side of the nasal septum, there are paired olfactory organs, each composed of two main layers (see Figure 1.13):

1. Olfactory epithelium: This epithelial layer contains:
   - Olfactory receptor cells, which detect odorants
   - Supporting cells, which provide structural and metabolic support
   - Basal cells, a population of regenerative stem cells that differentiate into new receptor cells to replace those that die, ensuring the continual renewal of the epithelium
2. Lamina propria: This underlying layer of areolar connective tissue contains:
   - Numerous blood vessels and nerves, which support tissue function.
   - Olfactory glands (Bowman's glands) secrete a lipid-rich fluid that absorbs water to form a viscous mucus. This mucus covers the olfactory epithelium, trapping odorant molecules and facilitating their interaction with receptor cells.

OLFACTORY RECEPTORS AND PATHWAYS

The olfactory receptors are highly specialised neurones located within the olfactory epithelium. Each receptor cell extends a slender dendritic process beyond the epithelial surface (see Figure 1.13). From the tip of this projection arise up to 20 fine cilia that extend laterally

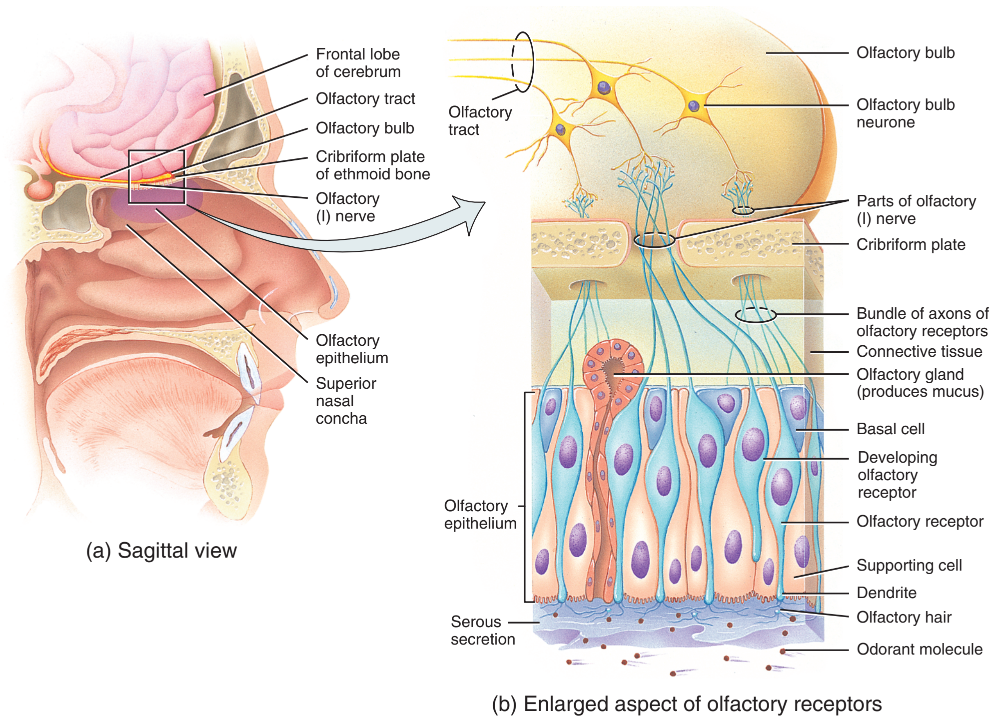

FIGURE 1.13 The anatomy of olfaction: gross and microscopic. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

into the overlying mucus layer. These cilia increase the surface area available for interaction with dissolved odorant molecules.

Odorant chemicals first dissolve in the mucus, where they bind to specific odorant-binding proteins on the surface of the cilia. This interaction leads to the opening of sodium channels in the receptor cell membrane, causing a local depolarisation. If the depolarisation is sufficient, an action potential is initiated within the receptor cell and the signal is transmitted onwards.

The olfactory system is remarkably sensitive; in some cases, as few as four molecules may activate a receptor. However, activation of individual receptor cells does not guarantee conscious awareness of a smell. Along the olfactory pathway, there is extensive convergence of signals and inhibitory processing at synapses. This means that some inputs are suppressed before they reach the olfactory cortex. Despite this modulation, the threshold for olfactory detection remains extremely low. A practical example is the addition of trace amounts of odorant chemicals to otherwise odourless natural gas, allowing even minute leaks to be detected.

From each side of the nasal cavity, axons of receptor cells gather into 20 or more small bundles that pass through the cribriform plate of the ethmoid bone (see Figure 1.14). These bundles together form the right and left olfactory nerves. Upon reaching the olfactory bulbs, the axons converge and synapse with postsynaptic mitral cells within large spherical structures called glomeruli. The olfactory bulbs also receive efferent fibres from higher brain regions, allowing modulation of incoming signals, for example, through central adaptation, where sensitivity to persistent odours diminishes over time.

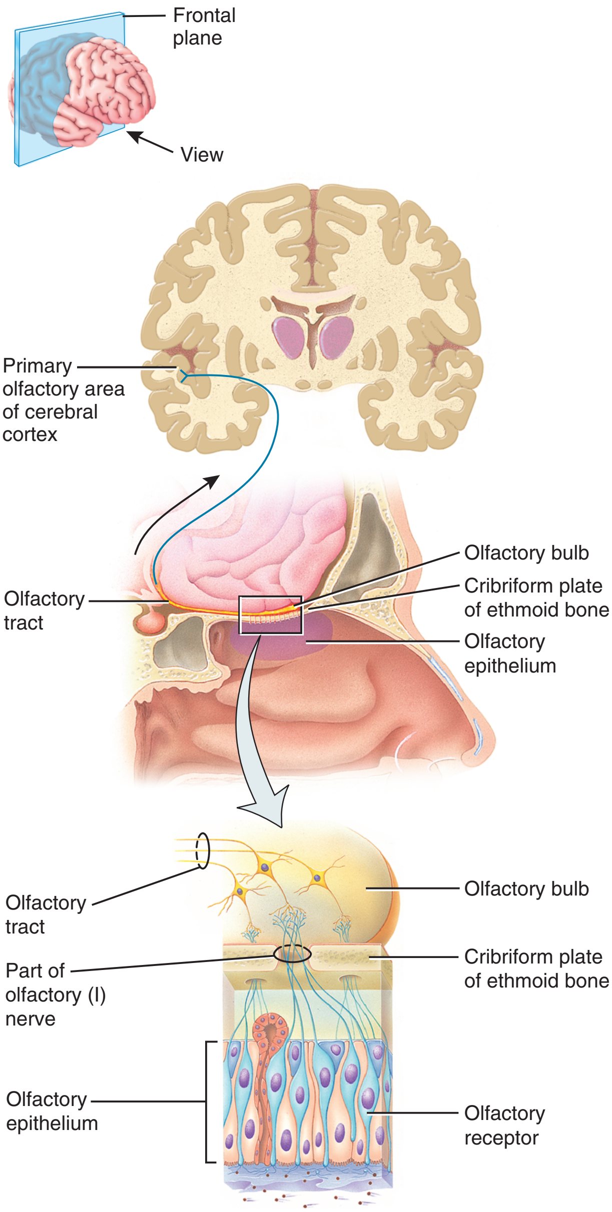

FIGURE 1.14 Olfactory pathway. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

THROAT

The throat is usually considered to consist of the pharynx and the larynx. The pharynx can be divided into three parts. The nasopharynx extends from the nasal septum to the Eustachian tubes and rests behind and above the soft palate. The oropharynx (middle part of the pharynx) extends from the soft palate to the hyoid bone; it contains the base of the tongue, the uvula and the tonsils and is surrounded by lymphoid tissue. The laryngopharynx is also known clinically as the hypopharynx; it is the most inferior portion of the pharynx. The oropharynx and

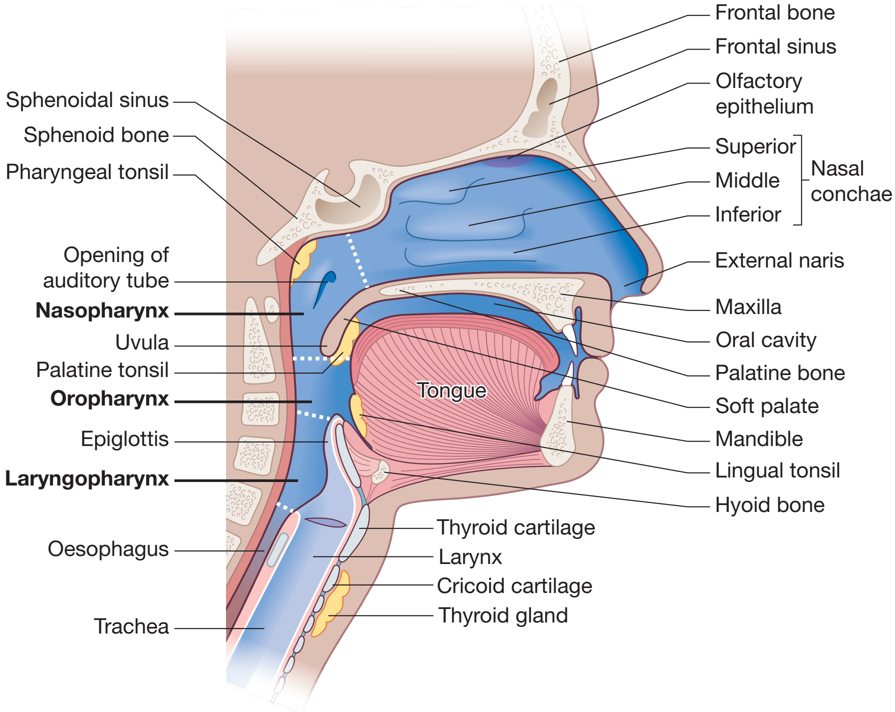

FIGURE 1.15 The respiratory tract. *Source*: Peate et al. (2014). With permission of John Wiley & Sons.

the laryngopharynx are passages for food and respiratory gases. Because of its location, the laryngopharynx is a frequent site for impaction of foreign bodies and is also a region where certain cancers (hypopharyngeal carcinomas) may develop.

A detailed structure of the respiratory tract is found in Figure 1.15. This identifies the oropharynx, nasopharynx and laryngopharynx.

THE PHARYNX

The pharynx is a fibromuscular tube measuring approximately 12–14 cm in length. It forms an important component of both the respiratory and digestive systems, providing a shared passageway for air, food and liquids. Figure 1.16 shows the pharynx during the state of swallowing.

Anatomical extent:

- Superiorly: The pharynx begins at the base of the skull.
- Inferiorly: It ends at the level of the sixth cervical vertebra (C6), where it narrows and continues as the oesophagus.

General structure:

The pharyngeal wall is composed of four layers:

1. Mucous membrane: Lines the inside surface, varies according to the region (respiratory epithelium in the nasopharynx; non-keratinised stratified squamous epithelium in the oropharynx and laryngopharynx)

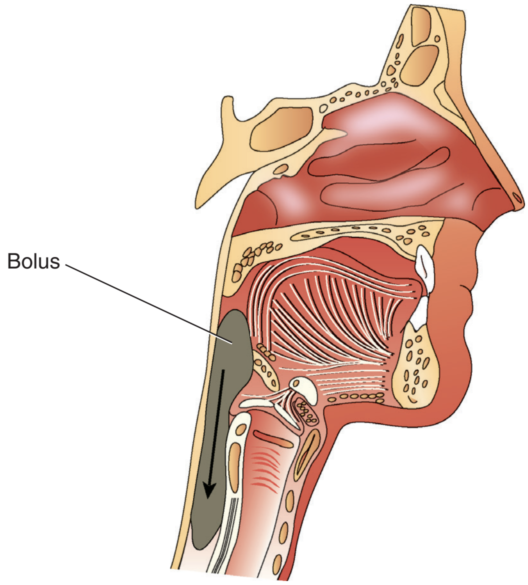

FIGURE 1.16 The pharynx during the state of swallowing. *Source*: Peate (2021). With permission of John Wiley & Sons.

2. Submucosa (pharyngobasilar fascia): Providing structural support
3. Muscular layer: Made up of circular (constrictor muscles) and longitudinal muscles that coordinate swallowing
4. Buccopharyngeal fascia: The outer covering, a connective tissue layer that separates the pharynx from prevertebral structures

Functions:

- Acts as a respiratory pathway: Conducting air from the nasal cavity to the larynx
- Serves as a digestive pathway: Conducting food and liquid from the oral cavity to the oesophagus
- Plays a role in resonance and speech: As the shape and patency of the pharyngeal cavity influence vocal quality
- Contains lymphoid tissue (e.g. tonsils) that contribute to immune defence

NASOPHARYNX

- Location: Uppermost part of the pharynx, behind the nasal cavity and above the soft palate
- Function: Purely respiratory; allows passage of air from the nasal cavity

- Features:
  - Opening of the Eustachian (auditory) tube, which equalises middle ear pressure
  - Contains the pharyngeal tonsil (adenoids) in its roof

OROPHARYNX

- Location: Middle part of the pharynx, behind the oral cavity; extends from the soft palate down to the epiglottis
- Function: Serves both respiratory and digestive roles, passageway for air, food and liquid
- Features:
  - Palatine tonsils in the lateral walls
  - The base of the tongue forms part of its anterior boundary

LARYNGOPHARYNX (HYPOPHARYNX)

- Location: Lowest part of the pharynx; behind the larynx. Extends from the epiglottis/hyoid bone to the lower border of the cricoid cartilage (C6)
- Function: Directs food and liquid towards the oesophagus while keeping it out of the airway
- Features:
  - Surrounds the laryngeal inlet
  - Contains piriform fossae (common site for food impaction)

Table 1.3 summarises the boundaries, primary functions, key anatomical features and common clinical considerations for each region of the pharynx.

Table 1.3 The pharynx: boundaries, primary functions, key features and common clinical considerations

Region	Boundaries	Function	Features	Clinical importance
Nasopharynx	Base of skull to soft palate	Air passage only	Behind nasal cavity; opening of Eustachian tube; pharyngeal tonsil (adenoids) in roof	Adenoid hypertrophy; otitis media; nasopharyngeal carcinoma; nasal foreign bodies
Oropharynx	Soft palate to epiglottis	Air and food passage	Behind oral cavity; palatine tonsils; base of tongue forms part of anterior boundary	Tonsillitis; peritonsillar abscess; oropharyngeal cancer; airway obstruction
Laryngopharynx (hypopharynx)	Epiglottis/hyoid bone to lower border of cricoid cartilage (C6)	Directs food and air; leads to oesophagus	Behind larynx; surrounds laryngeal inlet; contains piriform fossae	Foreign body impaction; hypopharyngeal cancer; aspiration risk; ENT/anaesthetic procedures

CONCLUSION

A thorough understanding of the anatomy and physiology of the ENT is essential for safe and effective clinical practice. Knowledge of the structural organisation, from the external and middle ear to the inner ear, the divisions of the pharynx and the nasal and laryngeal structures provides the foundation for accurate assessment, diagnosis and procedural skills.

Physiological principles, including hearing, balance, olfaction, respiration and swallowing, underpin normal function and guide the clinician in recognising abnormal signs. Awareness of clinically relevant features, such as tonsillar anatomy, the piriform fossae or the Eustachian tube, allows healthcare professionals to anticipate common problems, identify pathologies and perform interventions with confidence.

An understanding of ENT anatomy and physiology provides the foundation for competent, evidence-based clinical practice. When combined with functional knowledge, this can help to improve the ability to perform ENT examinations, carry out procedural skills and conduct patient assessments effectively, while ensuring patient safety and dignity.

GLOSSARY OF TERMS

Auricle (pinna): The external, cartilaginous part of the ear that collects sound waves.

Balance (equilibrium): The sense of spatial orientation maintained by the vestibular system, vision and proprioception.

Cerumen: Earwax; a protective secretion that traps debris and has antimicrobial properties.

Cochlea: A spiral-shaped organ of the inner ear containing receptors for hearing.

Cranial nerves: Twelve pairs of nerves arising from the brain; several are involved in ENT functions.

Cricoid cartilage: A ring-shaped cartilage located inferior to the thyroid cartilage in the larynx.

Epiglottis: A leaf-shaped cartilage that closes over the laryngeal inlet during swallowing to prevent aspiration.

Eustachian tube (auditory tube): A canal connecting the middle ear to the nasopharynx, helping equalise pressure.

External auditory canal: The passage leading from the auricle to the tympanic membrane.

Laryngopharynx (hypopharynx): The lower part of the pharynx that directs food towards the oesophagus.

Larynx: The 'voice box', involved in sound production, airway protection and breathing.

Mucosa: A moist membrane lining internal cavities such as the nasal passages and pharynx.

Nasal cavity: The internal chamber of the nose, divided by the septum and lined with mucosa.

Nasal conchae (turbinates): Curved bony shelves that increase the nasal cavity's surface area.

Nasal septum: The partition separating the nasal cavity into left and right sides.

Nasopharynx: The upper section of the pharynx, located behind the nasal cavity.

Olfactory nerve (cranial nerve I): The nerve transmitting smell signals to the brain.

Organ of Corti: The sensory organ within the cochlea that converts sound vibrations into nerve impulses.

Oropharynx: The middle region of the pharynx located behind the oral cavity.

Ossicles: The three tiny bones of the middle ear (malleus, incus and stapes) that transmit sound.

Paranasal sinuses: Air-filled cavities within the skull bones that lighten the head and aid vocal resonance.

Pharynx: A muscular tube divided into the nasopharynx, oropharynx and laryngopharynx.

Semicircular canals: Three looped structures in the inner ear involved in detecting rotational movement.

Tonsils: Lymphoid structures situated in the pharyngeal region that play a role in immune defence.

Trachea: The windpipe; a tube carrying air from the larynx to the bronchi.

Tympanic membrane (eardrum): A thin membrane that vibrates in response to sound waves.

Vestibular system: The structures of the inner ear responsible for balance.

Vestibulocochlear nerve (cranial nerve VIII): The nerve responsible for hearing and balance.

Vocal folds (vocal cords): Mucosal folds within the larynx that vibrate to produce sound.

MULTIPLE CHOICE QUESTIONS

1. Which structure collects and funnels sound waves into the external auditory canal?
   a) Cochlea
   b) Auricle (pinna)
   c) Tympanic membrane
   d) Stapes

2. The ossicles are located in which part of the ear?
   a) Inner ear
   b) Outer ear
   c) Middle ear
   d) Cochlear duct

3. Which structure equalises pressure between the middle ear and the nasopharynx?
   a) Cochlear duct
   b) Eustachian tube
   c) Vestibule
   d) Semicircular canal

4. The organ of Corti is responsible for
   a) Balance
   b) Sound amplification
   c) Pressure equalisation
   d) Converting sound vibrations into nerve impulses

5. The semicircular canals primarily detect:
   a) Smell
   b) Linear acceleration
   c) Rotational movement
   d) Sound vibrations

6. Which structure separates the outer and middle ear?
   a) Tympanic membrane
   b) Cochlea
   c) Vestibule
   d) Round window

7. Which part of the nasal cavity warms, humidifies and filters inspired air?
   a) Nasal septum
   b) Turbinates (conchae)
   c) Olfactory bulb
   d) Maxillary sinus

8. The paranasal sinuses function to:
   a) Produce cerumen
   b) Assist the thyroid gland
   c) Support mastication
   d) Lighten the skull and add resonance to the voice

9. Which structure prevents food entering the airway during swallowing?
   a) Uvula
   b) Tonsils
   c) Epiglottis
   d) False vocal cords

10. Which part of the upper respiratory tract directly leads into the larynx?
   a) Nasopharynx
   b) Oropharynx
   c) Trachea
   d) Laryngopharynx

REFERENCES

Brandt, T. and Huppert, D. (2025). The mysterious sense of smell: Evolution, historical perspectives, and neurological disorders. *Frontiers in Human Neuroscience* 19: 1588935. https://doi.org/10.3389/fnhum.2025.1588935.

Clare, C. (2026a). The senses (Chapter 16). In: *Fundamentals of Anatomy and Physiology*, 4e (ed. I. Peate and S. Evans). Oxford: Wiley.

Clare, C. (2026b). The ear, nose and throat, and eyes, and associated disorders (Chapter 22). In: *Fundamentals of Anatomy and Physiology*, 5e (ed. I. Peate, C. Clare, and A. Wheeldon). Oxford: Wiley.

Harkin, H. and Jamieson, L.V. (2024). Nursing patients with disorders of the ear, nose and throat (Chapter 16). In: *Alexander's Nursing Practice*, 6e (ed. I. Peate). London: Elsevier.

Meakin, S. and Seewoodhary, M. (2022). The person with an ear of eye disorder (Chapter 33). In: *Nursing Practice*, 3e (ed. I. Peate and A. Mitchell). Oxford: Wiley.

Munir, N. and Clarke, R. (2012). *Ear, Nose and Throat at a Glance*. Germany: John Wiley & Sons, Incorporated.

Oxenham, A.J. (2019). How we hear: The perception and neural coding of sound. *Annual Review of Psychology* 69: 27–50. https://doi.org/10.1146/annurev-psych-122216-011635.

Peate, I. (ed.) (2021). *Fundamentals of Applied Pathophysiology: An Essential Guide for Nursing and Healthcare Students*, 4e. Wiley-Blackwell. ISBN 978-1-119-69949.

Peate, I., Wild, K., and Nair, M. (eds). (2014). *Nursing Practice: Knowledge and Care*. Wiley-Blackwell.

Tortora, G.J. and Derrickson, B.H. (2009). *Principles of Anatomy and Physiology*, 12e. Hoboken, NJ: John Wiley & Sons, Inc.

Yap, K. (2025). *Diseases of the Ear, Nose and Throat*. Burlington: Allied Health Press.