The Anatomy and Physiology of the Skin

CHAPTER 1

INTRODUCTION

The skin, often described as the body's largest organ, is far more than a simple covering. It is a dynamic, multifunctional system that protects, regulates, senses and communicates. Encompassing approximately 1.5–2 m^2 in adults and accounting for about 15–20% of total body weight, the skin forms the most extensive interface between the individual and the external environment (Tortora and Derrickson 2023). Its complexity lies in its structure, which integrates epithelial, connective, vascular, lymphatic and neural elements into a cohesive barrier that is both resilient and adaptable.

From a clinical perspective, the skin serves as both a protective shield and a diagnostic canvas. Its colour, texture, hydration and integrity frequently reflect underlying systemic health. Subtle changes, such as pallor, jaundice, cyanosis or rashes, can provide important clues to endocrine, cardiovascular, haematological, infectious or autoimmune conditions. Equally, the skin's responses to injury, pressure and microbial challenge underpin many clinical skills central to healthcare practice, from wound assessment and pressure injury prevention to dermatological examination and recognition of systemic disease through cutaneous signs.

Understanding the anatomy and physiology of the skin is therefore essential for health and care professionals. Anatomically, the skin comprises three interrelated layers:

1. The epidermis: A stratified squamous epithelium with a dynamic cycle of keratinocyte proliferation and differentiation
2. The dermis: A connective tissue matrix providing tensile strength, elasticity and vascular support
3. The subcutaneous tissue (hypodermis): A layer of adipose and connective tissue that cushions, insulates and anchors the skin to underlying structures

These three layers work in concert with specialised appendages, which include hair follicles, sebaceous glands, sweat glands and nails, as well as sensory and immune cells, creating a system that is simultaneously structural, functional and communicative.

Physiologically, the skin's functions extend far beyond simple coverage. It provides a physical and immunological barrier against mechanical trauma, ultraviolet (UV) radiation, chemical agents and microbial invasion. It plays a critical role in thermoregulation, balancing heat conservation and dissipation through mechanisms such as vasomotor tone, sweating and piloerection. The skin contributes to fluid and electrolyte balance, preventing excessive water loss. Its rich network of sensory receptors enables the perception of touch, pressure, vibration, pain and temperature, essential for interaction with the environment and protection from harm. Furthermore, the skin participates in endocrine and metabolic processes, including the synthesis of vitamin D, the storage of lipids and the excretion of certain metabolic by-products.

Clinically, knowledge of skin anatomy and physiology provides the foundation for a wide range of skills. These include accurate skin inspection and palpation, the assessment of dermatological lesions, the recognition of normal versus pathological variation and the integration of skin findings into holistic patient care. Skills such as wound management, infection control and pressure injury prevention are grounded in an appreciation of the skin's regenerative capacity and its physiological limits. Moreover, effective communication with patients about their skin health, whether in relation to sun protection, chronic dermatological conditions or the psychosocial impact of visible skin disease, requires confidence in the underlying science as well as sensitivity to individual experience.

This chapter will therefore explore the anatomy and physiology of the skin in depth, highlighting both structural features and functional processes. Each section will integrate anatomical detail with clinical relevance, preparing those who offer care and support to people with skin conditions to apply foundational knowledge to real-world practice. In doing so, the chapter aims not only to enhance the understanding of the skin as an organ but also to support the development of practical, evidence-based clinical skills in dermatological and holistic care.

THE SKIN

The skin, the largest organ of the body, is one of the most clinically accessible. Unlike most organ systems, the skin can be directly observed and palpated without invasive tools, which makes it uniquely valuable in healthcare practice. Its structure is intricately linked to its wide-ranging physiological functions. For this reason, an understanding of the skin's anatomy and physiology is indispensable for effective clinical practice.

The relationship between skin structure and clinical practice is evident in the way its anatomy explains many of its clinical behaviours and presentations. The epidermis, with its keratinised layers, provides a robust barrier to the external environment, accounting for phenomena such as callus formation or the heightened vulnerability of damaged skin in burns (Madison 2003). Beneath it, the dermis is rich in collagen, elastin and vasculature, giving the skin its elasticity, its healing potential and its tendency to form scars or keloids. The hypodermis, composed primarily of adipose tissue, provides insulation and cushioning, while also serving as the target site for subcutaneous injections. In addition, the skin's appendages play crucial roles in thermoregulation, excretion and endocrine signalling, with dysfunction of these structures contributing to conditions such as hyperhidrosis or androgenetic alopecia. Together, these anatomical and physiological features form the foundation for many clinical assessments.

The diagnostic relevance of the skin lies in its ability to reflect disturbances in internal physiology, making it a visible marker of systemic health. Endocrine disorders often have cutaneous manifestations, such as the thin, fragile skin and striae seen in Cushing's syndrome or the characteristic hyperpigmentation of Addison's disease (Dover et al. 2023). Haematological abnormalities may present with petechiae, ecchymoses or generalised pallor, while cardiopulmonary compromise can be revealed by cyanosis or digital clubbing (Dover et al. 2023) (see Figure 1.1). Likewise, hepatobiliary dysfunction may be detected through the presence of jaundice and associated pruritus (Pannifex and Mellinghoff 2024). Because the skin is directly accessible to examination, these features can often be identified early, prompting further investigation and facilitating timely intervention.

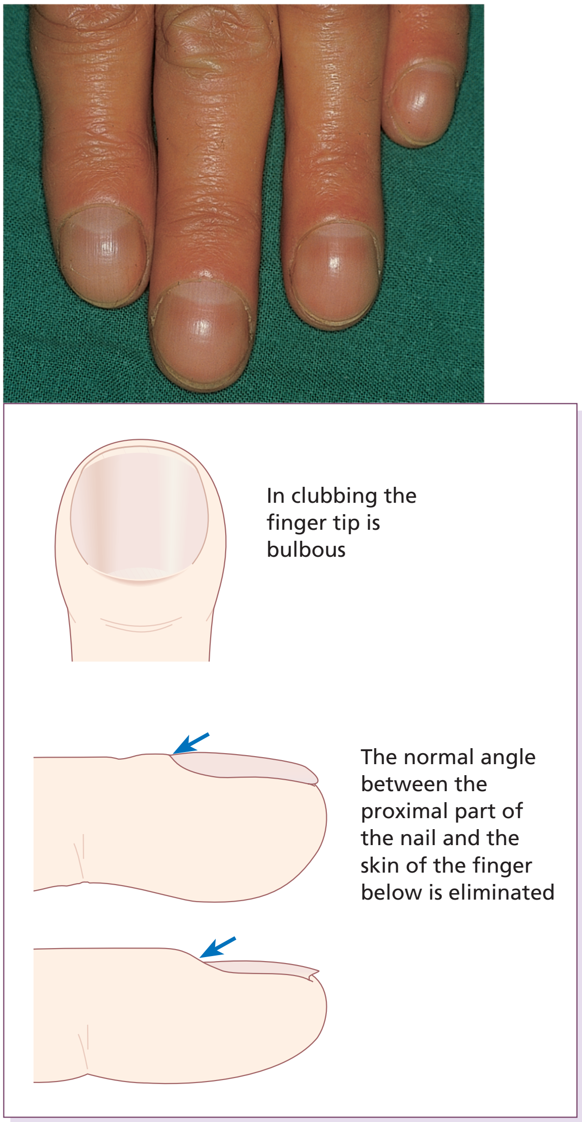

FIGURE 1.1 Clubbing

Beyond diagnosis, the skin is also central to a wide range of therapeutic practices. Its permeability allows for drug delivery through transdermal patches, while its accessibility enables intradermal allergy testing and subcutaneous administration of medications such as insulin. An understanding of skin structure also informs wound care, including decisions about debridement, dressing selection and the prevention of pressure injuries. Dermatological therapies, particularly those delivered topically, rely on a sound knowledge of barrier function and absorption. Even surgical practice benefits from this knowledge: for instance, aligning incisions with Langer's lines (these are tension lines of the skin) can reduce scarring and promote optimal healing (Blyth and Oakley 2019). In all these contexts, a firm grasp of skin anatomy and physiology enhances both the safety and efficacy of therapeutic interventions.

SKIN STRUCTURES

The skin consists of two primary layers: the epidermis and the dermis. Beneath the dermis lies the subcutaneous fascia, also known as the hypodermis, which is composed of loose connective tissue and adipose tissue (Colbert et al. 2020). While this layer anchors the skin to underlying structures and provides cushioning and insulation, it is not considered a true component of the skin itself. Figure 1.2 shows the skin and its associated structures.

THE EPIDERMIS

The epidermis is the superficial and thinnest layer of the skin and represents the portion most readily visible. Although the skin covers the entire body, it exhibits significant regional variations that reflect differences in flexibility, hair distribution and type, density and type of glands, pigmentation, vascularity, innervation and overall thickness (Tortora and Derrickson 2023). These variations are particularly notable at the extremes of the body: the eyelids have the thinnest skin, measuring approximately 0.5 mm, whereas the heel possesses the thickest skin, up to 4.0 mm in thickness.

The epidermis is composed of keratinised stratified squamous epithelium and contains four principal types of cells (Figure 1.3):

1. Keratinocytes
2. Melanocytes
3. Langerhans cells
4. Merkel cells

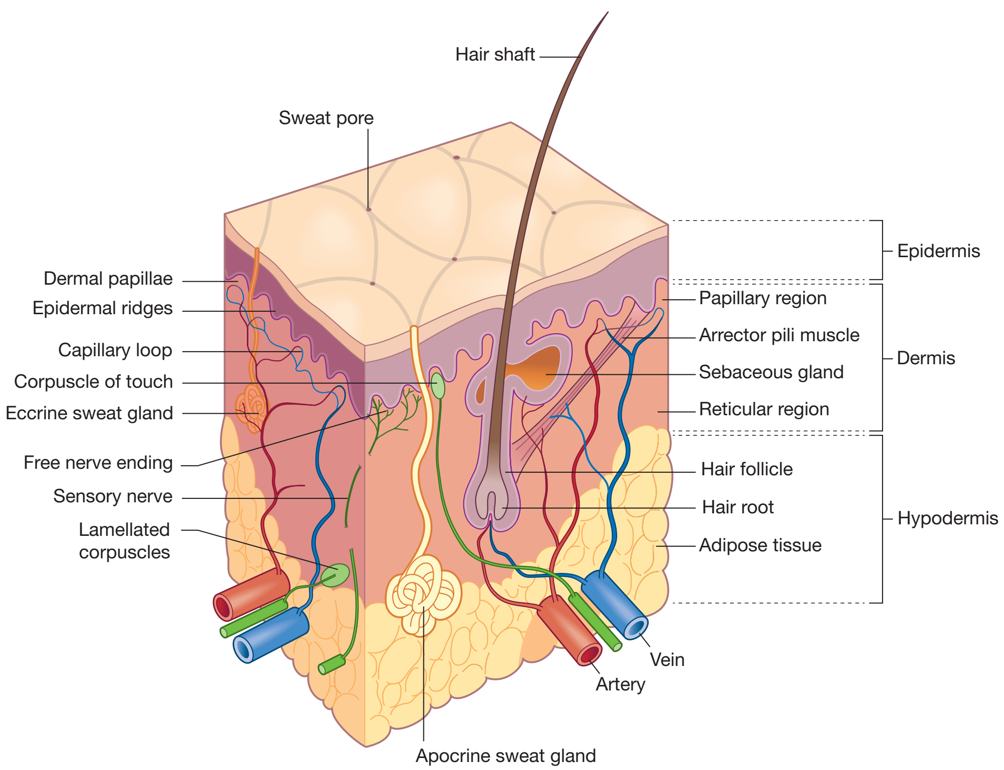

FIGURE 1.2 The skin and associated structures. *Source*: Peate (2014). With permission of John Wiley & Sons.

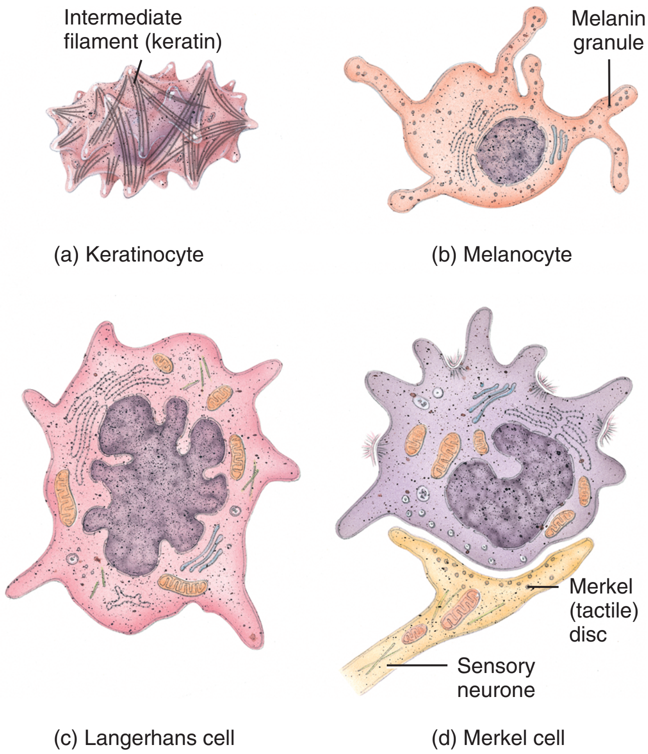

FIGURE 1.3 Four different cell types found in the epidermis. *Source*: Tortora and Derrickson (2009). With permission of John Wiley & Sons.

KERATINOCYTES

Keratinocytes are the predominant cell type of the epidermis and are organised into four structurally distinct layers. Their primary function is the synthesis of keratin, a resilient fibrous protein that provides mechanical strength and protects the skin, as well as the underlying tissues, from thermal injury, microbial invasion and chemical insult. Beyond keratin production, keratinocytes are integral to the development of the epidermal barrier. They contribute to the water-resistant properties of the skin by forming a seal that minimises transepidermal water loss and prevents excessive absorption of external moisture. This barrier function also serves to restrict the penetration of potentially harmful foreign substances.

MELANOCYTES

Melanocytes are specialised pigment-producing cells. Their principal function is the synthesis of melanin, the pigment responsible for skin, hair and eye colour, as well as for photoprotection. Within the epidermis, melanocytes are most abundant in regions such as the face, limbs, nipples, areolae and penis. These cells are characterised by long dendritic processes that extend between adjacent keratinocytes, enabling the transfer of melanin granules (melanosomes) to surrounding cells. Through this process, melanin is distributed across the epidermis, contributing to an individual's natural skin colour and providing defence against UV radiation.

In response to increased sun exposure, melanocytes upregulate melanin production to absorb additional UV radiation. The resulting pigmentation manifests as tanning, which indicates cellular injury and represents an adaptive defence mechanism to limit further damage. Importantly, the number of melanocytes is relatively consistent across all individuals, irrespective of their skin colour. Variations in pigmentation arise instead from differences in the amount and type of melanin synthesised, as well as in its distribution and degradation. Individuals with darker skin produce greater quantities of melanin and therefore possess enhanced natural protection against the harmful effects of UV radiation.

Melanocytes may also aggregate to form clusters that are known as naevi (commonly referred to as moles). These benign collections of melanocytes are particularly common in individuals with lighter skin tones, who typically develop between 10 and 50 naevi over their lifetime.

LANGERHANS CELLS

Langerhans cells are specialised immune cells of the epidermis that originate in the red bone marrow. After migrating to the skin, these cells constitute a small proportion of the total epidermal cell population. Langerhans cells function as antigen-presenting cells. They capture and process foreign substances in the skin and then display them to lymphocytes, thereby initiating and coordinating the immune response within the epidermis. By capturing and processing microbial antigens, Langerhans cells activate lymphocytes and coordinate with other immune cells to mount an effective defence against invading microorganisms (Tortora and Derrickson 2023).

These cells are particularly vulnerable to UV radiation, which can impair their structural integrity and functional capacity. Damage caused by excessive sun exposure reduces their ability to detect pathogens and regulate immune reactions within the skin, thereby compromising cutaneous immunity.

MERKEL CELLS

Merkel cells are specialised epidermal cells; they are involved in the sensation of touch. Each Merkel cell forms a synaptic connection with the flattened terminal of a sensory neurone, together creating a structure that is known as a tactile disc (also referred to as a Merkel disc). Although they represent the least numerous cell type within the epidermis, these cells play a crucial role in mechanoreception, enabling the detection of fine touch and pressure stimuli (Waugh and Grant 2023).

EPIDERMAL LAYERS

Just as the skin is composed of two primary layers, the epidermis and dermis, the epidermis itself is organised into several distinct layers of keratinocytes. These layers, known as strata, develop progressively as keratinocytes mature and migrate towards the skin surface. Each stratum has characteristic structural and functional features that contribute to the protective properties of the epidermis, all of which are visible under the microscope (see Figure 1.4).

THE EPIDERMAL STRATA

The distinct strata of keratinocytes reflect the different stages of cellular development and maturation:

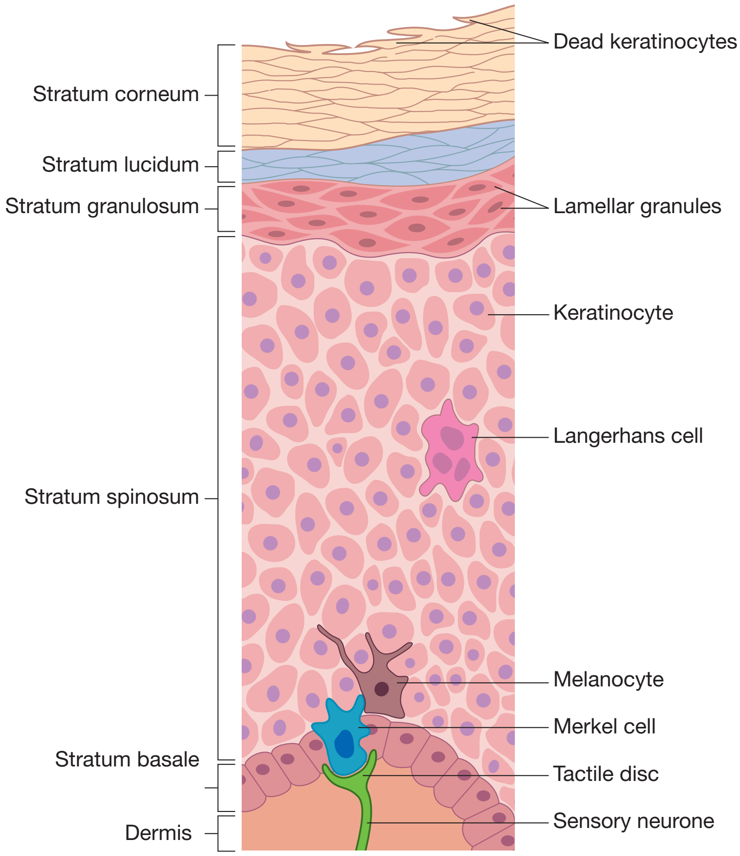

FIGURE 1.4 Layers of the epidermis

- Stratum basale (basal layer): The deepest layer, consisting of a single row of basal keratinocytes that continuously divide to produce new cells. This layer also contains melanocytes and Merkel cells.
- Stratum spinosum (prickle cell layer): Located above the basal layer, this stratum contains several layers of keratinocytes connected by desmosomes, giving the cells a spiny appearance under the microscope. It provides strength and flexibility to the skin.
- Stratum granulosum (granular layer): Positioned just beneath the stratum lucidum, the stratum granulosum consists of three to five layers of flattened keratinocytes. These cells are characterised by the presence of cytoplasmic granules, hence the name 'granulosum', which include lamellar granules that secrete lipids. These lipids contribute to the formation of a water-resistant barrier, preventing excessive fluid loss while also protecting against microbial invasion.

  The keratinocytes in this layer undergo progressive flattening due to pressure from the underlying layers. They also undergo apoptosis, losing their nuclei and other organelles, which renders them compact and brittle. This process of programmed cell death and keratin accumulation is referred to as keratinisation, a critical step in the formation of the skin's tough, protective outer layers. As cells move upwards from the stratum granulosum towards the surface, the epidermis becomes increasingly resilient, preparing to perform its barrier and protective functions.

- Stratum lucidum (clear layer): Found only in thick, hairless skin (such as the palms and soles), this thin, translucent layer consists of dead keratinocytes. The cells have no nucleus and are tightly packed, providing a barrier to fluid loss.
- Stratum corneum (horny layer): The outermost layer, made up of multiple layers of dead, flattened keratinocytes that are fully keratinised, consisting of approximately 25 layers of flattened, overlapping, dead keratinocytes. These cells are densely packed with keratin and have lost most of their intracellular fluid. Whereas the deeper epidermal layers contain around 70% water, the stratum corneum retains only about 20%. The cells in this layer are extremely tough and resistant, forming a 'horny' surface that is further reinforced by a lipid coating, which enhances the barrier properties of the skin. Continuous mechanical friction leads to the regular shedding (sloughing) of cells from this layer, a process balanced by the constant renewal of keratinocytes from below. In addition to structural strength, the stratum corneum performs vital protective functions. It serves as a physical barrier against light, heat, microorganisms, chemicals and mechanical injury. Prolonged exposure to sunlight stimulates the thickening of this layer, increasing its capacity to absorb UV radiation. If UV rays penetrate beyond the epidermis into the dermis, they can damage the protein content of the skin and contribute to the development of skin cancers.

Together, these strata provide mechanical strength, water resistance and protection against environmental insults.

THE DERMIS

The dermis is the deeper layer of the skin; it is located immediately beneath the epidermis. It is primarily composed of dense connective tissue rich in collagen and elastic fibres, which provide structural support, tensile strength and elasticity. The dermis houses a variety of essential structures, including:

- Blood vessels
- Nerves
- Lymphatic vessels
- Smooth muscle fibres
- Sweat glands
- Hair follicles
- Sebaceous glands

The elastic fibre network within the dermis not only supports these structures but also allows the skin to stretch during movement and to return to its original shape at rest. Structurally, the dermis can be divided into two layers:

- Papillary layer: The superficial portion of the dermis is characterised by finger-like projections (dermal papillae) that interdigitate (fit together) with the epidermis, increasing the surface area for nutrient exchange and strengthening the dermal–epidermal connection. The unique arrangement of these papillae also gives rise to fingerprints.

- Reticular layer: The deeper portion of the dermis, which is attached to the underlying subcutaneous tissue and provides the skin with most of its mechanical strength and elasticity.

Figure 1.5 illustrates the relative positions of the epidermis, dermis and subcutaneous layers.

STRUCTURAL LAYERS OF THE DERMIS

The dermis can be subdivided into two distinct layers: the papillary layer and the reticular layer. Together, these layers constitute the full thickness of the dermis, with the papillary layer forming approximately one-fifth of the total dermal depth (Tortora and Derrickson 2023).

Papillary layer

The superficial portion of the dermis features finger-like projections that are called dermal papillae; these interlock with the epidermis. The ridges formed by these papillae, known as friction ridges, enhance grip on the hands and feet by increasing surface friction. This layer contains a rich capillary network that supplies nutrients to the epidermis. It also houses Meissner's corpuscles, specialised tactile receptors that detect fine touch, as well as nerve endings that are sensitive to temperature, pain and itching sensations.

Reticular layer

The deeper portion of the dermis is composed of irregular, dense connective tissue containing fibroblasts, collagen bundles and coarse elastic fibres. This layer provides mechanical strength, elasticity and structural support. It contains additional sensory receptors, such as Pacinian corpuscles, which detect deep pressure and vibration. The reticular layer also accommodates accessory structures, including sweat glands, lymphatic vessels, smooth muscle fibres and hair follicles, which will be discussed in the following section.

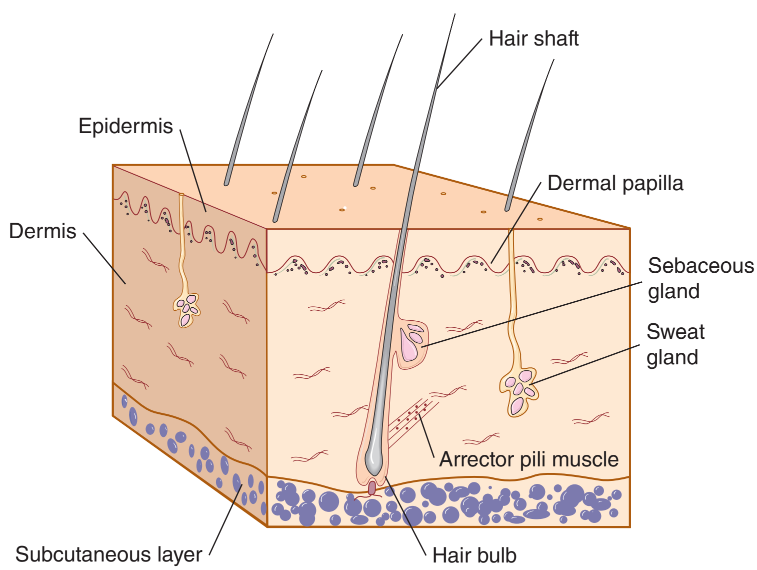

FIGURE 1.5 The three layers of skin: the epidermis, the dermis and the subcutaneous layer. *Source*: Reproduced with permission of Nair and Peate (2009). With permission of John Wiley & Sons.

SKIN APPENDAGES AND THEIR FUNCTIONS

The skin contains several accessory structures, also referred to as appendages, which arise from the epidermis and extend into the dermis. These structures play important roles in protection, sensation and maintaining homeostasis. The primary accessory structures include:

- Hair
- Skin glands
- Nails

HAIR

Hair is present on most areas of the body, with the exception of the palms, soles and lips. Its distribution, density, colour and texture vary according to location, age, sex and ethnicity. Hair develops in distinct stages, beginning with lanugo, a fine, downy, non-pigmented hair that appears around the fifth month of fetal development. Shortly before birth, lanugo on the eyelashes, eyebrows and scalp is shed and replaced by coarser, pigmented hair.

Hair contributes to an individual's distinctive appearance. Its colour is determined by melanocytes that are located within the hair bulb, and a progressive reduction in melanin production results in grey hair. Hair growth is influenced by both genetic and hormonal factors.

While hair loss can be a natural part of ageing or a response to various factors, understanding its causes and available treatments is essential (Box 1.1). For cancer patients undergoing chemotherapy, for instance, scalp cooling may present a promising option to mitigate hair loss. However, its effectiveness varies, and patients should consult with their healthcare providers to determine the best approach for their individual circumstances.

BOX 1.1 UNDERSTANDING HAIR LOSS (ALOPECIA)

Hair loss, medically termed alopecia, can manifest in various forms, ranging from temporary shedding to permanent baldness. While occasional hair thinning is common and often not a cause for concern, persistent or sudden hair loss may indicate underlying health issues.

Common causes of hair loss

Genetics: Androgenetic alopecia, commonly known as male or female pattern baldness, is hereditary and typically results in gradual hair thinning over time.

Medical conditions: Autoimmune disorders such as alopecia areata cause the immune system to attack hair follicles, leading to patchy hair loss (see Figure 1.6). Other conditions include thyroid imbalances, systemic lupus erythematosus (lupus) and anaemia.

Nutritional deficiencies: Deficiencies in essential nutrients such as iron, zinc, vitamin D and biotin can impair hair growth and lead to shedding.

Stress: Chronic physical or emotional stress can disrupt the hair growth cycle, leading to conditions such as telogen effluvium, where hair prematurely enters the shedding phase.

Medications and treatments: Certain drugs, including chemotherapy agents, can cause hair loss as a side effect. Chemotherapy targets rapidly dividing cells, which unfortunately includes hair follicle cells.

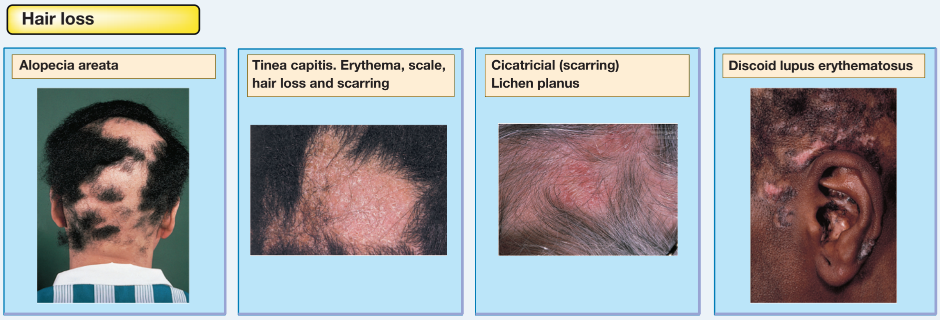

FIGURE 1.6 Alopecia areata

Hormonal changes: Pregnancy, menopause and hormonal therapies can lead to temporary hair loss due to fluctuations in hormone levels.

Physical trauma: Scalp injuries or tight hairstyles that pull on the hair can damage hair follicles, leading to hair loss.

Scalp cooling

Chemotherapy-induced alopecia is a distressing side effect for many cancer patients. Scalp cooling has emerged as a preventive measure to reduce the incidence and severity of hair loss during chemotherapy.

How scalp cooling works

Scalp cooling involves the use of a cooling cap or device worn during chemotherapy sessions. The cold temperature constricts blood vessels in the scalp, reducing the amount of chemotherapy drugs reaching the hair follicles. This mechanism helps protect the follicles from the toxic effects of the treatment.

Effectiveness of scalp cooling

The success of scalp cooling varies based on several factors:

Chemotherapy regimen: Scalp cooling is more effective with certain chemotherapy drugs, particularly taxane-based treatments.

Cooling duration and temperature: The duration of cooling and maintaining an optimal temperature are crucial for effectiveness. Studies suggest that cooling for 30 minutes before, during and after chemotherapy at temperatures around 18 °C can enhance results.

Individual response: Not all patients respond equally to scalp cooling. Factors such as scalp temperature tolerance and hair type can influence outcomes.

Limitations and considerations

Not universally effective: Scalp cooling may be less effective with certain chemotherapy agents, such as anthracyclines.

Side effects: Some patients may experience scalp discomfort, headaches or cold-induced skin reactions during treatment.

Accessibility: Availability of scalp cooling devices may be limited, and not all healthcare facilities offer this option.

Source: Adapted from Cruickshank (2024) and Bakkour (2024).

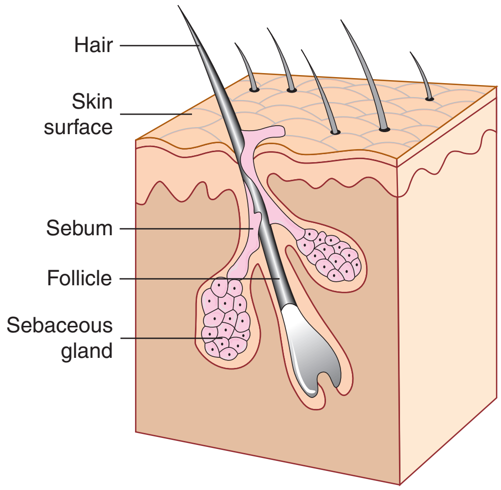

FIGURE 1.7 Pilosebaceous unit. *Source*: Reproduced with permission of Nair and Peate (2009). With permission of John Wiley & Sons.

Structurally, hair is composed of keratin, a protein produced by cells at the base of a hair follicle. Each hair grows from a single follicle and serves multiple functions, including:

- Thermoregulation
- Protection from environmental factors
- Sexual and social signalling

The primary protective role of hair is to reduce heat loss. Hair follicles are present across nearly the entire skin surface, with each pore serving as the opening to a follicle located in the dermis above the subcutaneous layer. Hair traps air, providing insulation against heat loss. Attached to each follicle is a small smooth muscle, the arrector pili, which contracts in response to cold, fear or emotion, causing hair to stand erect and producing the appearance of 'goose bumps'.

Hair also serves specific protective functions: scalp hair shields the head from UV radiation, eyelashes and eyebrows protect the eyes from foreign particles and nasal hair prevents the inhalation of dust, insects and other debris.

Each hair follicle is associated with sebaceous glands, which secrete sebum, an oily substance that lubricates the skin and hair, enhances water resistance and removes cellular waste. Sebum is slightly acidic and possesses antibacterial and antifungal properties (Cook and Shepherd 2025). The distribution of sebaceous glands is greatest on the scalp, face, upper torso and anogenital regions, and gland activity peaks during puberty under the influence of sex hormones. The onion-shaped bulb at the base, the follicle, contains blood vessels, providing nourishment for the developing hair. Figure 1.7 illustrates the pilosebaceous unit, comprising the hair follicle, hair shaft and sebaceous gland.

GLANDS OF THE SKIN

The skin contains several types of glands, which can be considered miniature organs due to their specialised structures and functions. Sweat glands are coiled tubular structures composed of epithelial tissue and open onto the skin surface through pores (see Figure 1.8). Each

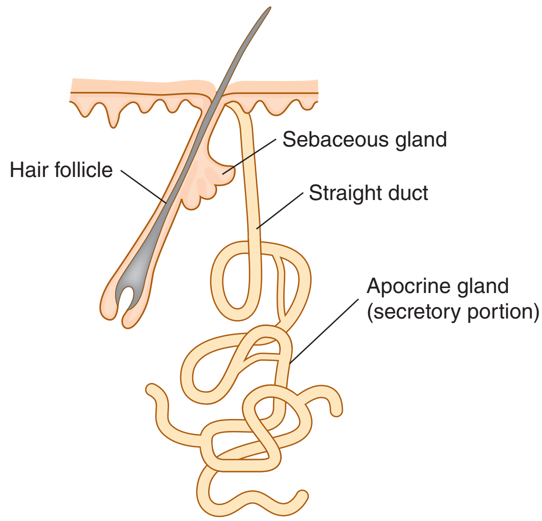

FIGURE 1.8 Sweat gland. *Source*: Reproduced with permission of Nair and Peate (2009). With permission of John Wiley & Sons.

gland has its own blood and nerve supply and secretes a slightly acidic fluid that is primarily composed of water and electrolytes.

Sweat glands are classified into two main types: eccrine and apocrine glands, each with distinct locations and functional roles.

ECCRINE GLANDS

Eccrine glands are widely distributed across the body, with higher concentrations on the forehead, axillae, palms and soles. The activity of the eccrine glands is regulated by the sympathetic nervous system, responding to heat, fear, stress, exercise and pyrexia. The primary function of eccrine glands is associated with thermoregulation, achieved through the cooling effect of sweat evaporation on the skin surface. During periods of elevated body temperature or emotional stress, the eccrine glands will increase sweat production to maintain thermal homeostasis.

APOCRINE GLANDS

Apocrine glands are larger, deeper and less numerous than eccrine glands; they are found in more restricted areas of the body, including the axillae, pubic region, nipples and perineum. Their exact physiological function remains not fully understood. Apocrine glands become fully active at puberty and produce thicker, milky secretions. They respond to stress and heightened emotional states by increasing secretion. Several specialised forms of apocrine glands exist, including the following:

- Moll glands of the eyelids
- Ceruminous glands in the external auditory canal (producing earwax)
- Mammary glands in the breasts (producing milk)

Apocrine secretions can also release pheromones; these are chemical signals that influence social and sexual behaviours through olfactory cues. The secreted material is initially odourless but can develop a characteristic body odour when metabolised by surface bacteria.

NAILS

Nails serve as a protective covering for the distal ends of the fingers and toes. They are composed of tightly packed, dead, hard keratinised epidermal cells, forming a firm and smooth surface that shields the underlying tissues and enhances fine manipulation of objects (see Figure 1.9).

NAIL STRUCTURE AND FUNCTION

The firm, horn-like nature of nails is due to the high concentration of keratin present within their cells. Nails themselves lack nerve endings; however, they act as a counterforce to the sensitive fingertips, which are richly supplied with nerve endings, allowing precise tactile perception and the manipulation of objects.

The nail body appears pink because of the presence of the underlying blood capillaries. At the proximal end, the white, crescent-shaped area is known as the lunula, which consists of air mixed with keratin from the nail matrix. The size of the lunula will vary among individuals. The cuticle or eponychium is an extension of the stratum corneum that overlaps the proximal nail fold, providing protection to the nail matrix.

NAIL GROWTH

Fingernails grow faster than toenails, though growth slows with age. On average, nails grow at approximately 0.01 cm per day (1 cm per 100 days). Complete regrowth of fingernails typically

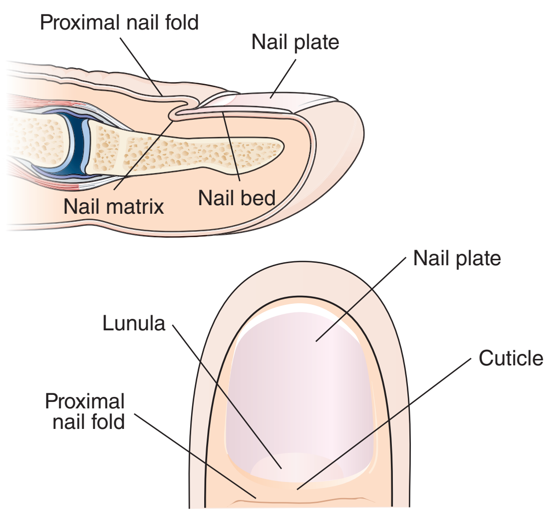

FIGURE 1.9 Nail. *Source*: Reproduced with permission of Nair and Peate (2009). With permission of John Wiley & Sons.

takes 4–6 months, whereas toenails require 12–18 months. Growth is influenced by several factors, including age, season, physical activity and genetics. Trauma, inflammation or infection can delay nail growth and compromise nail integrity.

Changes in the appearance or texture of nails can also serve as indicators of systemic health conditions. For example, chronic cardiopulmonary disease, nutritional deficiencies or fungal infections may manifest through distinct alterations in the nails (Fickertt-Wilson et al. 2025).

Table 1.1 provides an overview of the accessory skin structures.

Table 1.1 The accessory skin structures

Accessory structure	Description	Location/distribution	Structure/key features	Function
Hair	Thread-like growths of dead keratin	Most of the body, except palms, soles, lips; density varies by age, gender, ethnicity	Grows from follicles in the dermis; melanocytes in the hair bulb determine colour; associated with arrector pili and sebaceous glands	Thermoregulation, protection (scalp, eyelashes, nostrils), social/sexual signalling, sensory enhancement
Eccrine sweat glands	Coiled tubular glands secreting watery, slightly acidic sweat	Widely distributed; abundant on forehead, axillae, palms, soles	Simple coiled tubular structure; separate blood and nerve supply	Thermoregulation via sweat evaporation, excretion of salts and waste, maintaining skin pH
Apocrine sweat glands	Coiled glands producing thicker secretions; activated at puberty	Localised: axillae, pubic region, nipples, perineum	Larger, deeper than eccrine; associated with hair follicles; specialised types include ceruminous glands (earwax), mammary glands (milk), Moll glands (eyelids)	Stress/emotion-induced secretion, pheromone release, body odour formation; exact function not fully understood
Sebaceous glands	Oil-secreting glands producing sebum	Associated with hair follicles; most abundant on scalp, face, upper torso, anogenital region	Holocrine gland; slightly acidic, antibacterial, antifungal secretion	Lubrication of hair and skin, waterproofing, removal of cellular debris
Nails	Hard, keratinised protective plates covering finger and toe tips	Distal ends of fingers and toes	Nail plate, nail bed, lunula, cuticle (eponychium); composed of dead keratin; no nerve endings	Protection of digits, counterforce for fingertips (enhances tactile perception), indicator of health; fingernails grow faster than toenails

PHYSIOLOGICAL ROLES OF THE SKIN

An understanding of the skin's structure provides a foundation for appreciating its diverse and essential functions, enabling those who offer care and support to people to deliver care in a skilled, evidence-based and informed manner. The skin performs multiple physiological and protective roles, including:

- Sensation: Detection of touch, pressure, pain, temperature and vibration through specialised sensory receptors.
- Thermoregulation: Maintenance of body temperature via sweat production, blood vessel dilation and constriction and insulation provided by hair and subcutaneous tissue.
- Protection: Serving as a physical and chemical barrier against mechanical injury, pathogens, harmful chemicals and UV radiation.
- Excretion and absorption: Elimination of waste products (e.g. urea, salts) through sweat and selective absorption of certain substances.
- Synthesis of vitamin D: Conversion of 7-dehydrocholesterol in the skin to vitamin D3 in response to UVB radiation, which is vital for calcium metabolism and bone health.

SENSATION

The skin contains a variety of specialised receptor sites capable of detecting changes in the external environment, including variations in temperature, pressure and mechanical stimuli. These receptors consist of diverse nerve endings distributed throughout the skin, which transmit sensory information to the brain for processing.

Sensory input from the skin is referred to as cutaneous sensation, encompassing touch, pressure, vibration, tickling and irritation. Certain areas of the body, such as the lips, fingertips and genitalia, have a higher density of sensory receptors, making them particularly sensitive to external stimuli. The perception of pain serves as a critical protective mechanism, signalling actual or potential tissue damage and prompting appropriate behavioural or physiological responses.

THERMOREGULATION

The skin plays a vital role in homeostasis by regulating body temperature, maintaining it within narrow limits despite fluctuations in external conditions or physical activity. Effective thermoregulation is essential for survival, as even small temperature changes can alter enzyme activity and affect cellular chemistry. The skin achieves this regulation through a range of integrated physiological mechanisms.

One key mechanism involves changes in blood vessel diameter. When body temperature rises, vasodilatation occurs: the blood vessels near the skin surface widen, which brings warm blood from deeper tissues closer to the surface. This facilitates heat loss through radiation. Simultaneously, sweat glands secrete sweat onto the skin surface, and evaporation of this fluid produces a cooling effect.

Conversely, in a cold environment, vasoconstriction occurs: the blood vessels narrow, keeping warm blood closer to the core and reducing heat loss from the skin surface.

Hair also contributes to thermoregulation. Contraction of the arrector pili muscles causes hairs to stand erect, trapping pockets of air that act as insulation, reducing heat loss and helping to maintain body temperature.

PROTECTION

The skin serves as the body's primary protective barrier, employing multiple mechanisms to defend against environmental hazards, pathogens and fluid loss. One key protective function is melanin production, which shields underlying tissues from harmful UV radiation. The skin also maintains its structural integrity through continuous cell renewal, shedding dead cells and facilitating the migration of new cells to replace damaged tissue. Wound healing is a critical example of the skin's ability to restore protection after injury.

Chemical and cellular defences further enhance protection. Sebum, an oily secretion from sebaceous glands, contains antibacterial compounds that help destroy surface bacteria. Sweat contributes to this defence by maintaining an acidic pH that inhibits bacterial growth. Within the dermis, phagocytic macrophages can ingest and destroy viruses and bacteria that penetrate the epidermal barrier.

The skin also protects the body by regulating fluid and waste balance. Through over two million pores, sweat and other secretions help eliminate metabolic waste, preventing accumulation of potentially harmful substances. By acting as a waterproof barrier, the skin prevents dehydration and blocks the entry of harmful environmental fluids, contributing to overall homeostasis and maintaining the body's internal environment.

EXCRETION AND ABSORPTION

The skin plays an important role in both excretion and absorption, complementing its protective functions. Through the process of sweating, the skin excretes water, sodium, carbon dioxide, ammonia and urea. The volume of sweat excreted varies with activity level, with more active individuals losing greater amounts of fluid.

In addition to excretion, the skin is capable of absorbing substances from the external environment. Some absorbed materials may be harmful, such as heavy metals, for example, lead and mercury. Conversely, therapeutic agents, including certain topical medications, can be delivered through the skin for systemic or local effects. The skin can also absorb fat-soluble vitamins (A, D, E and K), as well as gases such as oxygen and carbon dioxide, contributing to physiological processes and homeostasis.

CONCLUSION

A thorough understanding of the anatomy and physiology of the skin is fundamental for healthcare professionals, not only to appreciate its complex structure and multiple functions but also to underpin effective clinical practice. The skin is more than a physical barrier; it is a dynamic organ that is involved in protection, sensation, thermoregulation, excretion, absorption and vitamin D synthesis, supported by a range of specialised cells, layers and accessory structures.

From a clinical perspective, knowledge of skin anatomy and physiology directly informs patient assessment, diagnosis and intervention. Recognising normal skin structure and function allows those who offer care and support to people to identify early signs of pathology, monitor the impact of systemic diseases and evaluate the effectiveness of treatments. Skills such as inspection, palpation and measurement of skin integrity, as well as the assessment of hair, nails and glands, are all grounded in a clear understanding of the underlying biology.

Furthermore, integrating this knowledge with practical skills can help to deliver care in a skilled, informed and evidence-based manner, ensuring patient safety, comfort and dignity.

Whether this is performing wound care, assessing for dermatological conditions or offering patients information on preventive strategies, the caregiver's competence is strengthened by an intimate knowledge of skin structure, function and adaptive responses.

Developing the theoretical and practical aspects of skin biology can help to equip healthcare professionals with the confidence and precision that is required to provide people with high-quality, patient-centred care across a wide range of clinical settings.

GLOSSARY OF TERMS

Accessory structures: Appendages of the skin, including hair, nails, sweat glands and sebaceous glands, which contribute to protection, sensation and thermoregulation.

Adipose tissue: Fat cells in the subcutaneous layer that provide insulation, energy storage and cushioning.

Apocrine glands: Sweat glands found in specific areas (axillae, pubic region, nipples) that produce thicker secretions and may be involved in pheromone release; typically activated at puberty.

Arrector pili: Small smooth muscles attached to hair follicles that cause hairs to stand erect, contributing to thermoregulation.

Barrier function: The ability of the skin to prevent excessive water loss and block the entry of pathogens, chemicals and environmental toxins.

Basal cells: Cells in the stratum basale responsible for generating new keratinocytes.

Cuticle (eponychium): The extension of stratum corneum over the proximal nail fold, protecting the nail matrix from infection.

Dermal macrophages: Immune cells within the dermis that phagocytose pathogens, contributing to skin defence.

Dermal papillae: Finger-like projections of the dermis that increase surface area for nutrient exchange and contribute to fingerprints.

Dermis: The thick layer of connective tissue beneath the epidermis containing blood vessels, nerves, sweat glands, hair follicles and sebaceous glands.

Eccrine glands: Sweat glands distributed over most of the body, responsible for thermoregulation via watery sweat secretion.

Epidermis: The outer layer of skin composed of stratified squamous epithelium, primarily keratinocytes.

Excretion: The removal of waste substances from the body via sweat or other skin secretions.

Hair follicle: A tubular invagination of the epidermis from which hair grows, often associated with sebaceous glands and arrector pili muscles.

Hair shaft: The visible, keratinised part of the hair that extends above the skin surface.

Keratin: A tough, fibrous protein produced by keratinocytes that provides structural strength to the skin, hair and nails.

Keratinocytes: The main cells of the epidermis responsible for producing keratin and forming the protective barrier.

Langerhans cells: Immune cells in the epidermis that act as antigen-presenting cells to detect and respond to pathogens.

Lunula: The whitish, crescent-shaped area at the base of the nail plate, representing part of the nail matrix.

Meissner's corpuscles: Tactile receptors located in the papillary dermis, sensitive to light touch and texture.

Melanocytes: Pigment-producing cells in the stratum basale that synthesise melanin, providing protection against UV radiation.

Nails: Hard, keratinised structures covering the distal ends of fingers and toes, providing protection and enhancing fine motor function.

Pacinian corpuscles: Sensory receptors located in the reticular dermis that detect deep pressure and vibration.

Papillary layer: The superficial layer of the dermis containing dermal papillae, capillaries and Meissner's corpuscles for tactile sensation.

Reticular layer: The deeper layer of the dermis composed of dense irregular connective tissue, providing strength and housing accessory structures.

Sebaceous glands: Oil-producing glands associated with hair follicles that secrete sebum to lubricate and waterproof the skin.

Stratum basale: The deepest layer of the epidermis containing basal cells and melanocytes; responsible for continuous cell regeneration.

Stratum corneum: The outermost layer of the epidermis, composed of dead, keratinised cells forming a protective barrier.

Stratum granulosum: A layer of flattened keratinocytes containing keratohyalin granules and lamellar bodies, contributing to water resistance.

Stratum lucidum: A clear layer of the epidermis found only in thick skin, such as the palms and soles.

Stratum spinosum: The 'prickle cell' layer of the epidermis providing strength and flexibility through desmosomal connections.

Subcutaneous layer (hypodermis): The deepest layer of skin, composed mainly of adipose tissue, providing insulation, cushioning and energy storage.

Sweat glands: Glands in the skin that secrete sweat for thermoregulation, excretion and maintenance of skin pH.

Tactile disc (Merkel disc): Sensory structure formed by the contact between a Merkel cell and a nerve ending, responsible for detecting fine touch.

Thermoregulation: The skin's role in maintaining body temperature through blood flow modulation, sweating and hair adjustments.

Vitamin D synthesis: Conversion of 7-dehydrocholesterol to vitamin D3 in the skin under UVB radiation, important for calcium metabolism.

MULTIPLE CHOICE QUESTIONS

1. Why is knowledge of skin anatomy important for clinical practice?
   a) It allows accurate assessment of skin integrity and early detection of pathology
   b) It helps patients grow hair
   c) It prevents UV damage automatically
   d) It replaces the need for diagnostic tests

2. Which of the following is the outermost layer of the epidermis?
   a) Stratum basale
   b) Stratum spinosum
   c) Stratum granulosum
   d) Stratum corneum

3. Which cells are primarily responsible for producing keratin in the epidermis?
   a) Melanocytes
   b) Keratinocytes
   c) Langerhans cells
   d) Merkel cells

4. What is the primary function of melanocytes?
   a) Detect touch
   b) Produce melanin for UV protection
   c) Secrete sebum
   d) Promote keratinisation

5. Langerhans cells are important because they:
   a) Produce sweat
   b) Detect fine touch
   c) Act as antigen-presenting cells in the skin
   d) Secrete melanin

6. Pacinian corpuscles are sensitive to:
   a) Light touch
   b) Deep pressure and vibration
   c) Temperature changes
   d) Pain

7. The arrector pili muscles are responsible for:
   a) Raising hairs to trap air for insulation
   b) Hair production
   c) Sebum secretion
   d) Nail growth

8. Which sweat glands are primarily involved in thermoregulation?
   a) Apocrine glands
   b) Ceruminous glands
   c) Sebaceous glands
   d) Eccrine glands

9. Sebum is secreted by:
   a) Sweat glands
   b) Sebaceous glands
   c) Apocrine glands
   d) Merkel cells

10. Which type of hair loss is often temporary and caused by stress or illness?
   a) Androgenetic alopecia
   b) Male pattern baldness
   c) Alopecia areata
   d) Telogen effluvium

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