GENERAL PHYSIOLOGY

BS Hons

1ST SEMESTER

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The skin

- The skin completely covers the body and is continuous with the membranes lining the body orifices.
- It

1. protects the underlying structures from injury and from invasion by microbes
2. contains sensory nerve endings that enable discrimination of pain, temperature and touch
3. is involved in the regulation of body temperature

Structure of the skin

- The skin is the largest organ in the body and has a surface area of about 1.5–2 m2 in adults.
- In certain areas, it contains accessory structures: glands, hair and nails.
- **There are two main layers; the epidermis, which covers the dermis**. Between the skin and underlying structures is a subcutaneous layer composed of areolar tissue and adipose (fat) tissue.

Epidermis

1. This is the most superficial layer and is composed of stratified keratinised squamous epithelium
2. It varies in thickness, being thickest on the palms of the hands and soles of the feet.
3. There are no blood vessels or nerve endings in the epidermis, but its deeper layers are bathed in interstitial fluid from the dermis, which provides oxygen and nutrients, and drains away as lymph

Epidermis

- There are several layers (strata) of cells in the epidermis which extend from the deepest germinative layer to the most superficial stratum corneum (a thick horny layer)
- Epidermal cells originate in the germinative layer and undergo gradual change as they progress towards the skin surface.
- The cells on the surface are flat, thin, non-nucleated, dead cells, or squames, in which the cytoplasm has been replaced by the fibrous protein keratin. The surface cells are constantly rubbed off and replaced by those beneath. Complete replacement of the epidermis takes about a month.

Epidermis

- Healthy epidermis depends upon three processes being synchronised:

1. desquamation (shedding) of the keratinised cells from the surface
2. Effective keratinisation of cells approaching the surface
3. Continual cell division in the deeper layers with newly formed cells being pushed upwards to the surface. Hairs, secretions from sebaceous glands and ducts of sweat glands pass through the epidermis to reach the surface.

Epidermis

- Upward projections of the dermal layer, the dermal papillae anchor this securely to the more superficial epidermis and allow passage and exchange of nutrients and wastes to the lower part of the epidermis.
- This arrangement stabilises the two layers preventing damage due to shearing forces. Blisters develop when trauma causes separation of the dermis and epidermis, and serous fluid collects between the two layers.
- In areas where the skin is subject to greater wear and tear, e.g. the palms and fingers of the hands and soles of the feet, the epidermis is thicker and hairs are absent.
- In these areas the dermal papillae are arranged in parallel lines giving the skin surface a ridged appearance. The pattern of ridges on the fingertips is unique to every individual and the impression made by them is the 'fingerprint'

Skin colour is affected by various factors.

- Melanin, a dark pigment derived from the amino acid tyrosine and secreted by melanocytes in the deep germinative layer, is absorbed by surrounding epithelial cells.
- Normal saturation of haemoglobin and the amount of blood circulating in the dermis give white skin its pink colour
- Excessive levels of bile pigments in blood and carotenes in subcutaneous fat give the skin a yellowish colour

Dermis

- The dermis is tough and elastic.
- It is formed from connective tissue and the matrix contains collagen fibres interlaced with elastic fibres. Rupture of elastic fibres occurs when the skin is overstretched, resulting in permanent striae, or stretch marks, that may be found in pregnancy and obesity.
- Collagen fibres bind water and give the skin its tensile strength, but as this ability declines with age, wrinkles develop. Fibroblasts macrophages and mast cells are the main cells found in the dermis.

The structures in the dermis are

- blood and lymph vessels
- sensory nerve endings
- sweat glands and their ducts
- hairs, arrector pili muscles and sebaceous glands.

Blood and lymph vessels.

- Arterioles form a fine network with capillary branches supplying sweat glands, sebaceous glands, hair follicles and the dermis. Lymph vessels form a network throughout the dermis.

Sensory nerve endings

- Sensory receptors (specialised nerve endings) sensitive to touch, temperature, pressure and pain are widely distributed in the dermis. Incoming stimuli activate different types of sensory receptors for example, the Pacinian corpuscle is sensitive to deep pressure
- The skin is an important sensory organ through which individuals receive information about their environment. Nerve impulses, generated in the sensory receptors in the dermis, are transmitted to the spinal cord by sensory nerves . From there impulses are conducted to the sensory area of the cerebrum where the sensations are perceived

Sweat glands

- These are widely distributed throughout the skin and are most numerous in the palms of the hands, soles of the feet, axillae and groins.
- They are formed from epithelial cells. The bodies of the glands lie coiled in the subcutaneous tissue.
- There are two types of sweat gland.
- **Eccrine sweat glands are the more common type and open onto the skin surface through tiny pores, and the sweat produced here is a clear, watery fluid important in regulating body temperature.**
- **Apocrine glands open into hair follicles and become active at puberty. They may play a role in sexual arousal. These glands are found, for example, in the axilla. Bacterial decomposition of their secretions causes an unpleasant odour.**

Hairs

- These grow from hair follicles, downgrowths of epidermal cells into the dermis or subcutaneous tissue.
- At the base of the follicle is a cluster of cells called the hair papilla or bulb.
- The hair is formed by multiplication of cells of the bulb and as they are pushed upwards, away from their source of nutrition, the cells die and become keratinised. The part of the hair above the skin is the shaft and the remainder, the root.
- Hair colour is genetically determined and depends on the amount and type of melanin present. White hair is the result of the replacement of melanin by tiny air bubbles

Arrector pili

- These are little bundles of smooth muscle fibres attached to the hair follicles.
- Contraction makes the hair stand erect and raises the skin around the hair, causing ‘goose flesh’.
- The muscles are stimulated by sympathetic nerve fibres in response to fear and cold.
- Erect hairs trap air, which acts as an insulating layer.
- This is an efficient warming mechanism, especially when accompanied by shivering, i.e. involuntary contraction of skeletal muscles.

Sebaceous glands

- These consist of secretory epithelial cells derived from the same tissue as the hair follicles.
- They secrete an oily antimicrobial substance, sebum, into the hair follicles and are present in the skin of all parts of the body except the palms of the hands and the soles of the feet.
- They are most numerous in the scalp, face, axillae and groins. In regions of transition from one type of superficial epithelium to another, such as lips, eyelids, nipple, labia minora and glans penis, there are sebaceous glands that are independent of hair follicles, secreting sebum directly onto the surface.

Sebaceous glands

- Sebum keeps the hair soft and pliable and gives it a shiny appearance.
- On the skin it provides some waterproofing and acts as a bactericidal and fungicidal agent, preventing infection.
- It also prevents drying and cracking of skin, especially on exposure to heat and sunlight. The activity of these glands increases at puberty and is less at the extremes of age, rendering the skin of infants and older adults prone to the effects of excessive moisture (maceration).

Nails

- Human nails are equivalent to the claws, horns and hooves of animals. Derived from the same cells as epidermis and hair these are hard, horny keratin plates that protect the tips of the fingers and toes.
- The root of the nail is embedded in the skin and covered by the cuticle, which forms the hemispherical pale area called the **lunula.** The nail plate is the exposed part that has grown out from the nail bed, the germinative zone of the epidermis. Finger nails grow more quickly than toe nails and growth is faster when the environmental temperature is high

Functions of the skin

Protection

- The skin forms a relatively waterproof layer, provided mainly by its keratinised epithelium, which protects the deeper, more delicate structures. As an important nonspecific defence mechanism it acts as a barrier against: • invasion by micro-organisms • chemicals • physical agents, e.g. mild trauma, ultraviolet light • dehydration

Regulation of body temperature

- Body temperature remains fairly constant around 36.8°C across a wide range of environmental temperatures ensuring that the optimal range for enzyme activity required for metabolism is maintained.
- In health, variations are usually limited to between 0.5 and 0.75°C, although it rises slightly in the evening, during exercise and in women just after ovulation.
- To maintain this constant temperature, a negative feedback system regulates the balance between heat produced in the body and heat lost to the environment.

Heat production

The principal organs involved are:

skeletal muscles – contraction of skeletal muscles produces a large amount of heat and the more strenuous the muscular exercise, the greater the heat produced. Shivering also involves skeletal muscle contraction, which increases heat production when there is the risk of body temperature falling below normal.

The liver is very metabolically active, which produces heat as a by-product. Metabolic rate and heat production are increased after eating. • **the digestive organs** that generate heat during peristalsis and the chemical reactions involved in digestion.

Heat loss

- Most heat loss from the body occurs through the skin. Small amounts are lost in expired air, urine and faeces.
- Only heat loss through the skin can be regulated; heat lost by the other routes cannot be controlled. Heat loss through the skin is affected by the difference between body and environmental temperatures, the amount of the body surface exposed and the type of clothes worn.
- Air insulates against heat loss when trapped in layers of clothing and between the skin and clothing. For this reason several layers of lightweight clothes provide more effective insulation against low environmental temperatures than one heavy garment.

Mechanisms of heat loss

- In radiation, the main mechanism, exposed parts of the body radiate heat away from the body.
- In evaporation, the body is cooled as body heat converts the water in sweat to water vapour.
- In conduction, clothes and other objects in direct contact with the skin take up heat. In convection, air passing over the exposed parts of the body is heated and rises, cool air replaces it and convection currents are set up.
- Convection also cools the body when clothes are worn, except when they are windproof.

Control of body temperature

- The temperature regulating centre in the hypothalamus is sensitive to the temperature of circulating blood. This centre responds to decreasing temperature by sending nerve impulses to:
- arterioles in the dermis, which constrict decreasing blood flow to the skin
- skeletal muscles stimulating shivering.
- As heat is conserved, body temperature rises and when it returns to the normal range again the negative feedback mechanism is switched off

Mechanisms of heat loss

- Conversely when body temperature rises, heat loss is increased by dilation of arterioles in the dermis, increasing blood flow to the skin, and stimulation of the sweat glands causing sweating, until it falls into the normal range again when the negative feedback mechanism is switched off.

Activity of the sweat glands

- When body temperature is increased by 0.25 to 0.5°C the sweat glands secrete sweat onto the skin surface. Evaporation of sweat cools the body, but is slower in humid conditions.
- Loss of heat from the body by evaporation of water through the skin and expired air still occurs even when the environmental temperature is low.
- This is called **insensible water loss** (around 500 mL per day) and is accompanied by insensible heat loss.

Regulation of blood flow through the skin

- The amount of heat lost from the skin depends largely on blood flow through dermal capillaries.
- As body temperature rises, the arterioles dilate and more blood enters the capillary network in the skin.
- The skin is warm and pink in colour. In addition to increasing the amount of sweat produced, the temperature of the skin rises and more heat is lost by radiation, conduction and convection.
- If the environmental temperature is low or if heat production is decreased, the arterioles in the dermis are constricted. This reduces blood flow to the body surface, conserving heat. The skin appears paler and feels cool.

Fever

- This is often the result of infection and is caused by release of chemicals (pyrogens) from inflammatory cells and invading bacteria.
- Pyrogens, e.g. interleukin 1, act on the hypothalamus, which releases prostaglandins that reset the hypothalamic thermostat to a higher temperature.
- The body responds by activating heat-promoting mechanisms, e.g. shivering and vasoconstriction, until the new higher temperature is reached.
- When the thermostat is reset to the normal level, heat-loss mechanisms are activated. There is profuse sweating and vasodilation accompanied by warm, pink (flushed) skin until body temperature falls to the normal range again.

Hypothermia

- This means a core (e.g. rectal) temperature below 35°C. At a core temperature below 32°C, compensatory mechanisms that restore body temperature normally fail, e.g. shivering is replaced by muscle rigidity and cramps, vasoconstriction fails and blood pressure, pulse and respiration rates fall. Confusion and disorientation occur. Death usually occurs when the temperature falls below 25°C. Individuals at the extremes of age are prone to hypothermia as temperature regulation is less effective in the young and older adults

Formation of vitamin D

- 7-Dehydrocholesterol is a lipid-based substance in the skin and is converted to vitamin D by sunlight.
- This vitamin is used with calcium and phosphate in the formation and maintenance of bone.

Cutaneous sensation

- Sensory receptors are nerve endings in the dermis that are sensitive to touch, pressure, temperature or pain. Stimulation generates nerve impulses in sensory nerves that are transmitted to the cerebral cortex . Some areas have more sensory receptors than others causing them to be especially sensitive, e.g. the lips and fingertips.

Absorption

- This property is limited but substances that can be absorbed include: • some drugs, in transdermal patches, e.g. hormone replacement therapy during the menopause, nicotine as an aid to smoking cessation • some toxic chemicals, e.g. mercury.

Excretion

- The skin is a minor excretory organ for some substances including: • sodium chloride in sweat; excess sweating may lead to low blood sodium levels (hyponatraemia) • urea, especially when kidney function is impaired • aromatic substances, e.g. garlic and other spices.

Wound healing

- **Systemic factors.** These include good nutritional status and general health. Infection, impaired immunity, poor blood supply and systemic conditions, e.g. diabetes mellitus and cancer, reduce the rate of wound healing.
- **Local factors.** Local factors that facilitate wound healing include a good blood supply to provide oxygen and nutrients and remove waste products, and freedom from contamination by, e.g., microbes, foreign bodies or toxic chemicals.

Wound Healing Overview

Feature	Primary	Secondary
Tissue loss	Minimal	Large
Granulation tissue	Minimal	Abundant
Epithelialization	Rapid	Slow
Wound contraction	Slight	Marked (myofibroblasts)
Scar	Thin line	Large, irregular

Phases of Wound Healing

- **1. Inflammatory Phase (0–3 days)**
- Vasoconstriction → clot formation (platelets, fibrin)
- Vasodilation → WBC migration
- **Cells:** Neutrophils → Macrophages (release PDGF, TGF-β, VEGF)
- **2. Proliferative Phase (3–10 days)**
- **Fibroblasts:** Collagen type III formation
- **Angiogenesis:** VEGF-mediated new capillaries
- **Granulation tissue** forms → epithelial migration begins

Phases

- **3. Remodeling Phase (2 wks–months)**
- Type III → Type I collagen
- Vascular regression → pale scar
- Tensile strength ↑ (≈80% of normal skin)

Examples

- **Primary healing:** Surgical wound, paper cut
- **Secondary healing:** Burn, ulcer, trauma
- **Tertiary (delayed primary):** Initially open → later closed


ANY
QUESTIONS?


THANK YOU