M.SC. IN ZOOLOGY
SEMESTER – II
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NAME OF TOPIC: INTEGUMENTARY STSTEM (ZCT- 208)

Topic Guidelines

UNIT-1: CELL ASSOCIATION

UNIT 2: GLANDULAR SYSTEM

UNIT-1: CELL ASSOCIATION

- **The avascular epidermis is the interface between organism and environment, which is reflected in its variable structure from fishes to amniotes.**
- **The highly vascular dermis provides physiologic support for the interfacing epidermis.**

Skin Thickness

- **The thickness of each layer of the skin varies depending on body region and categorized based on the thickness of the epidermal and dermal layers.**
- **Hairless skin found in the palms of the hands and soles of the feet is thickest because the epidermis contains an extra layer, the stratum lucidum.**
- **The upper back is considered thickest based on the thickness of the dermis, but it is considered “thin skin” histologically because the epidermal thickness lacks the stratum lucidum layer and is thinner than hairless skin.**

Layers of Epidermis

The layers of the epidermis include

1. **the stratum basale (the deepest portion of the epidermis),**
2. **stratum spinosum,**
3. **stratum granulosum,**
4. **stratum lucidum, and**
5. **stratum corneum (the most superficial portion of the epidermis).**

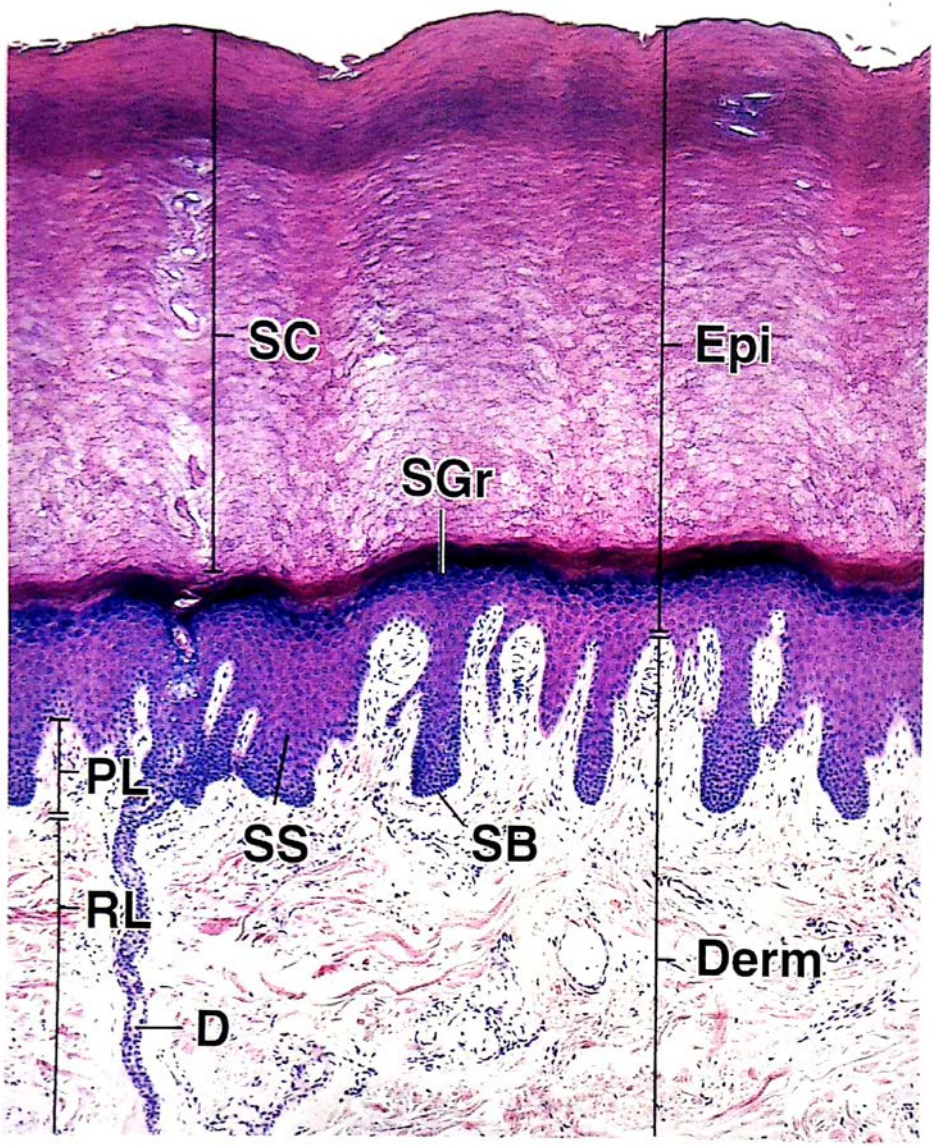

FIGURE 15.2. Photomicrograph showing the layers of thick skin. Specimen obtained from the skin of the sole of the foot (human) shows epidermis (*Epi*) containing the extremely thick stratum corneum (*SC*). Remaining layers of the epidermis (except for the stratum lucidum, which is not present on this slide), i.e., the stratum basale (*SB*), the stratum spinosum (*SS*), and the stratum granulosum (*SGr*), are clearly visible in this routine H&E preparation. The duct of a sweat gland (*D*) can be seen on the left as it traverses the dermis (*Derm*) and further spirals through the epidermis. At the sites where the ducts of the sweat gland enter the epidermis, note the epidermal downgrowths known as interpapillary pegs. The dermis contains papillae, protrusions of connective tissue that lie between the interpapillary pegs. Note also the greater cellularity of the papillary layer (*PL*) and that the collagen fibers of the reticular layer (*RL*) are thicker than those of the papillary layer. ×65.

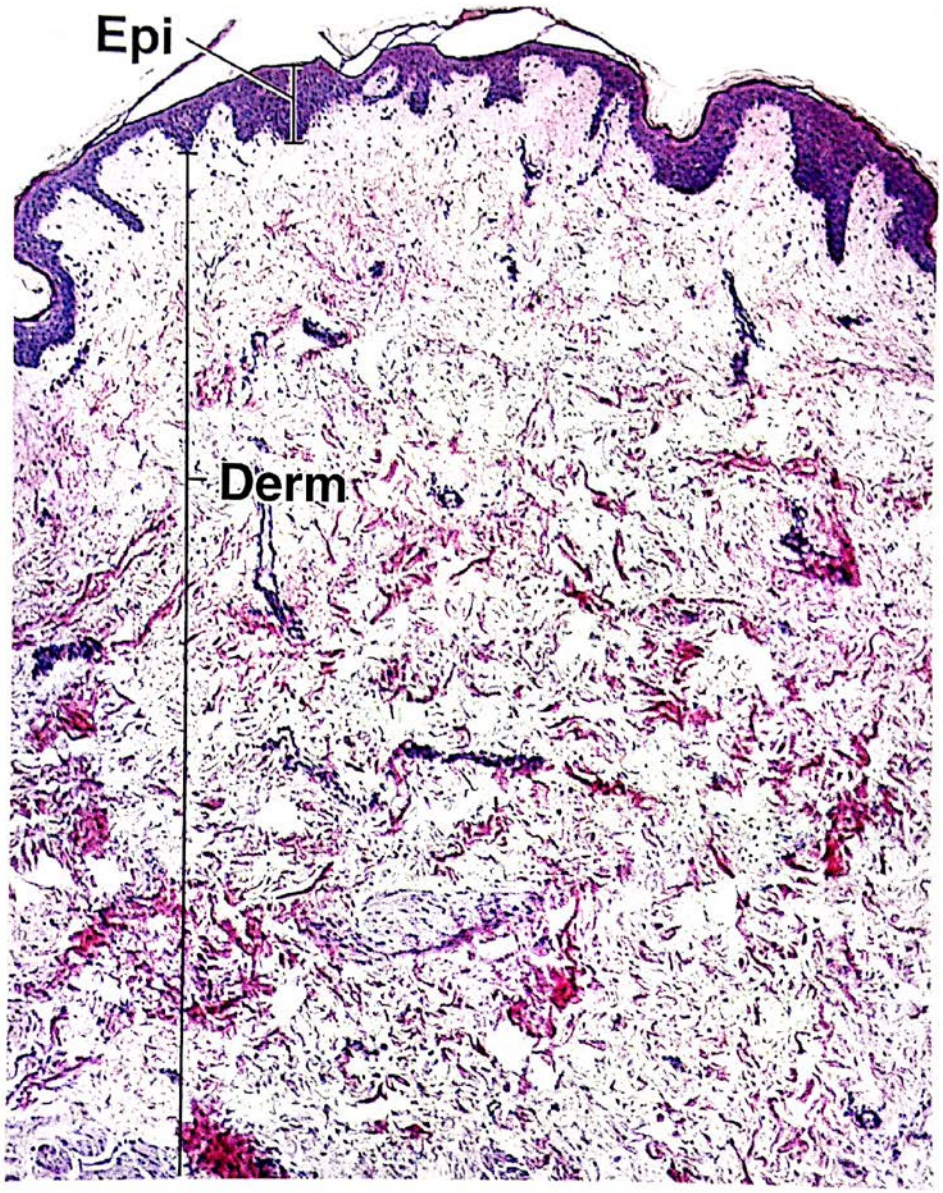

FIGURE 15.1. Photomicrograph showing the layers of thin skin. This hematoxylin and eosin (H&E)-stained specimen from human skin shows the two chief layers of the skin, the epidermis (*Epi*) and dermis (*Derm*). The epidermis forms the surface; it consists of stratified squamous epithelium that is keratinized. The dermis consists of two layers: the papillary layer, which is the most superficial layer and is adjacent to the epidermis, and the more deeply positioned reticular layer. The boundary between these two layers is not conspicuous; the papillary layer is, however, more cellular than the reticular layer. In addition, the collagen fibers of the reticular layer are thick (clearly visible in the lower part of the figure); those of the papillary layer are thin. ×45.

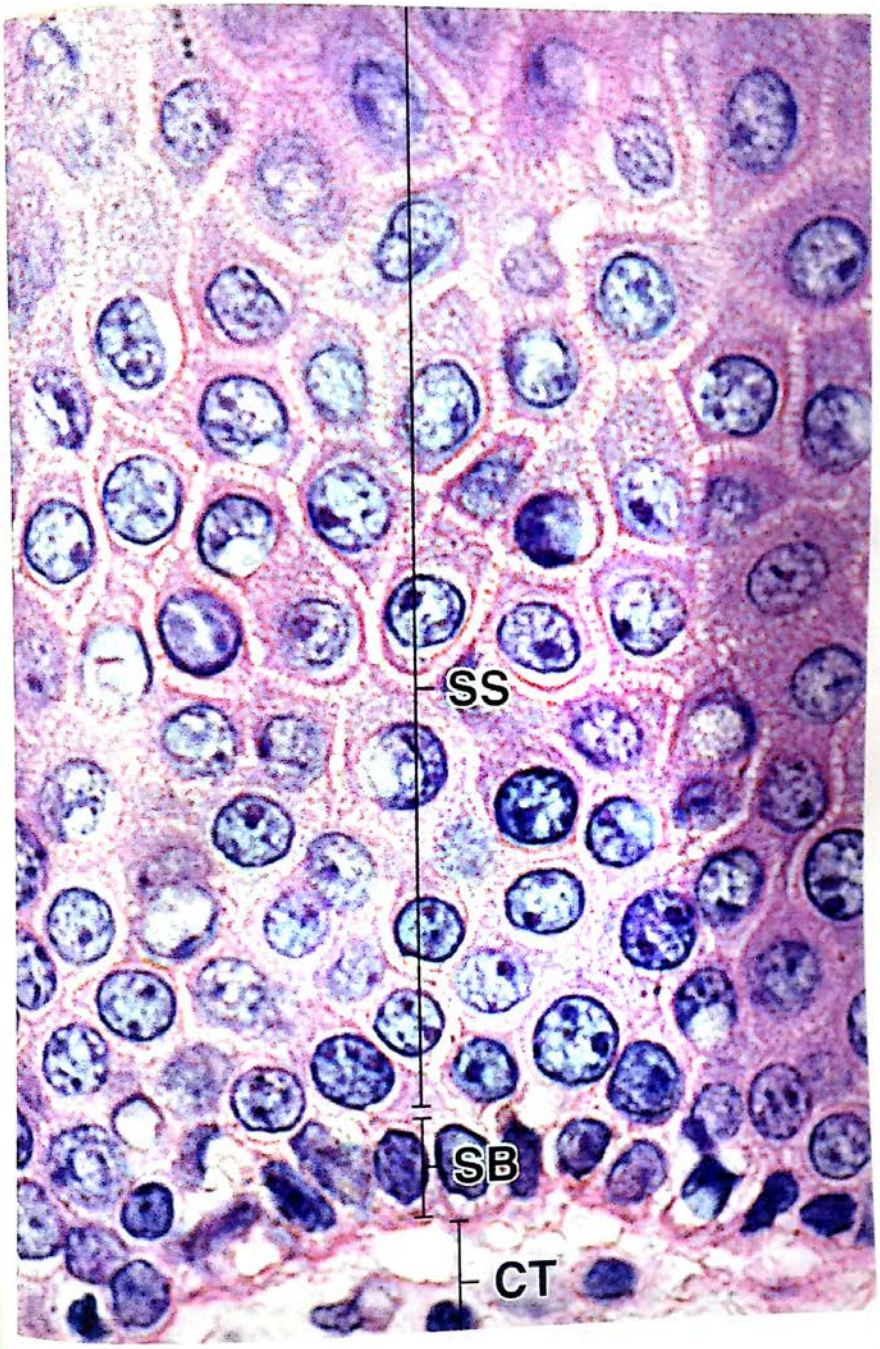

FIGURE 15.3. Photomicrograph of the stratum spinosum and stratum basale. The epidermis of thin skin is shown here at higher magnification. The one-cell-deep layer at the base of the epidermis just above the connective tissue (*CT*) of the dermis is the stratum basale (*SB*). The cells of this layer rest on the basement membrane. A layer referred to as the stratum spinosum (*SS*) is located just above the stratum basale. It consists of cells with spinous processes on their surfaces. These processes are attached to spinous processes of neighboring cells by desmosomes and together appear as intercellular bridges. ×640.

Stratum basale / stratum germinativum

1. **Stratum basale, also known as stratum germinativum, is the deepest layer, separated from the dermis by the basement membrane (basal lamina) and attached to the basement membrane by hemidesmosomes.**
2. **The cells found in this layer are cuboidal to columnar mitotically active stem cells that are constantly producing keratinocytes.**
3. **This layer also contains melanocytes.**

Stratum spinosum

1. **Stratum spinosum, 8-10 cell layers, also known as the prickle cell layer contains irregular, polyhedral cells with cytoplasmic processes, sometimes called “spines”, that extend outward and contact neighboring cells by desmosomes.**
2. **Dendritic cells can be found in this layer.**

Stratum granulosum

1. **Stratum granulosum, 3-5 cell layers, contains diamond shaped cells with keratohyalin granules and lamellar granules.**
2. **Keratohyalin granules contain keratin precursors that eventually aggregate, crosslink, and form bundles.**
3. **The lamellar granules contain the glycolipids that get secreted to the surface of the cells and function as a glue, keeping the cells stuck together.**

Stratum lucidum

1. **Stratum lucidum, 2-3 cell layers, present in thicker skin found in the palms and soles, is a thin clear layer consisting of eleidin which is a transformation product of keratohyalin.**

Stratum corneum

1. **Stratum corneum, 20-30 cell layers, is the uppermost layer, made up of keratin and horny scales made up of dead keratinocytes, known as anucleate squamous cells.**
2. **This is the layer which varies most in thickness, especially in callused skin.**
3. **Within this layer, the dead keratinocytes secrete defensins which are part of our first immune defense.**

Cells of the Epidermis

1. **Keratinocytes**
2. **Melanocytes**
3. **Langerhans' cells**
4. **Merkel's cell**

Keratinocytes

1. **Keratinocytes are the predominant cell type of epidermis and originate in the basal layer, produce keratin, and are responsible for the formation of the epidermal water barrier by making and secreting lipids.**
2. **Keratinocytes also regulate calcium absorption by the activation of cholesterol precursors by UVB light to form vitamin D.**

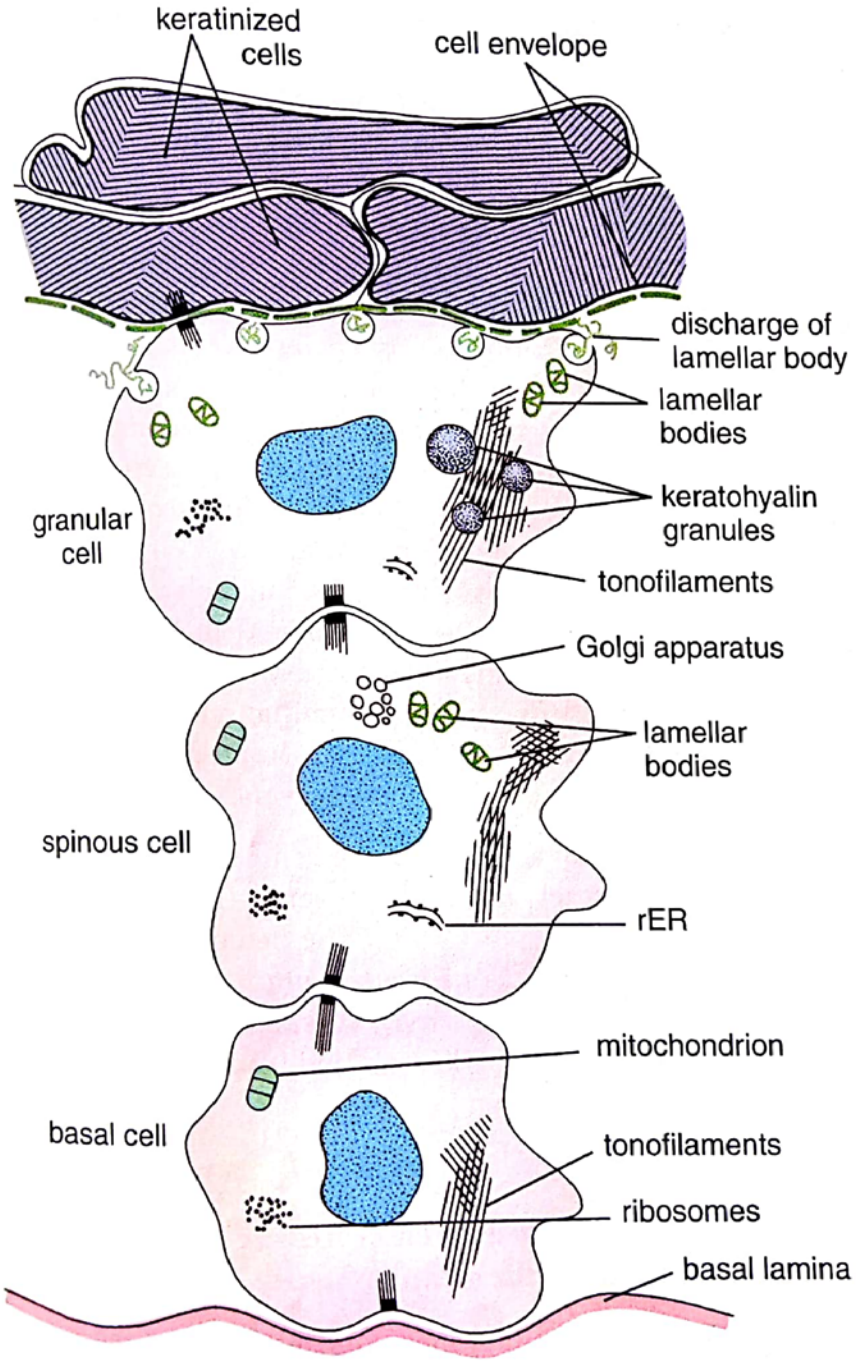

FIGURE 15.4. Schematic diagram of keratinocytes in the epidermis. The keratinocytes in this figure reflect different stages in the life cycle of the cell as it passes from the basal layer through the spinous and granular layers to the surface keratinized layer. The basal cell begins to synthesize tonofilaments (intermediate [keratin] filaments); these are grouped into bundles and seen in the light microscope as tonofibrils. The cell enters the spinous layer, where the synthesis of tonofilaments continues. In the upper part of the spinous layer, the cells begin to produce keratohyalin granules containing intermediate filament–associated proteins and glycolipid-containing lamellar bodies. Within the granular layer, the cell discharges lamellar bodies; the remainder of the cell cytoplasm contains numerous keratohyalin granules in close association with tonofilaments. The surface cells are keratinized; they contain a thickened plasma membrane and bundles of tonofilaments in a specialized matrix. *rER,* rough endoplasmic reticulum. (Reprinted with permission from Matoltsy AG, Parrakal PF. In: Zelickson AS, eds. Ultrastructure of Normal and Abnormal Skin. Philadelphia: Lea & Febiger, 1967.)

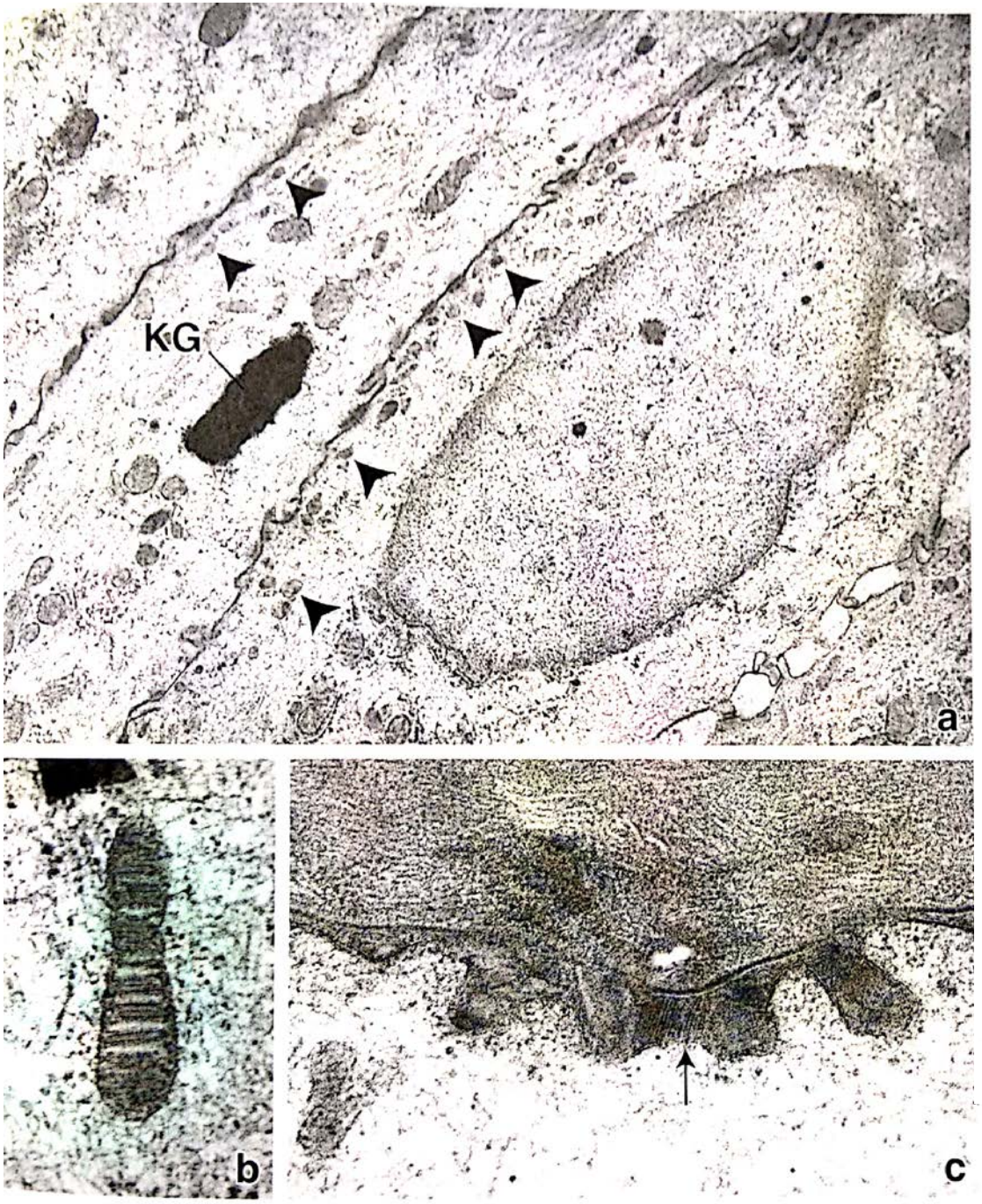

FIGURE 15.6. Electron micrographs of keratinocytes. a. Much of the keratinocyte cytoplasm is filled with tonofilaments. One keratinocyte exhibits a keratohyalin granule (*KG*). Near the plasma membrane closest to the surface (upper left), two keratinocytes display lamellar bodies (*arrowheads*). ×8,500. **b.** A lamellar body at higher magnification. ×135,000. **c.** Part of a keratinized cell and the underlying keratinocyte. Located between the cells are the contents of the lamellar bodies, which have been discharged into the intercellular space (*arrow*) to form the lipid envelope. ×90,000. (Courtesy of Dr. Albert I. Farbman.)

Melanocytes

1. **Melanocytes are derived from neural crest cells and primarily produce melanin, which is responsible for the pigment of the skin. They are found between cells of stratum basale and produce melanin.**
2. **UVB light stimulates melanin secretion which is protective against UV radiation, acting as a built-in sunscreen.**
3. **Melanin is produced during the conversion of tyrosine to DOPA by the enzyme tyrosinase. Melanin then travels from cell to cell by a process that relies on the long processes extending from the melanocytes to the neighboring epidermal cells.**
4. **Melanin granules from melanocytes are transferred via the long processes to the cytoplasm of basal keratinocyte.**
5. **Melanin transferred to neighboring keratinocytes by “pigment donation”; involves phagocytosis of tips of melanocyte processes by keratinocytes.**

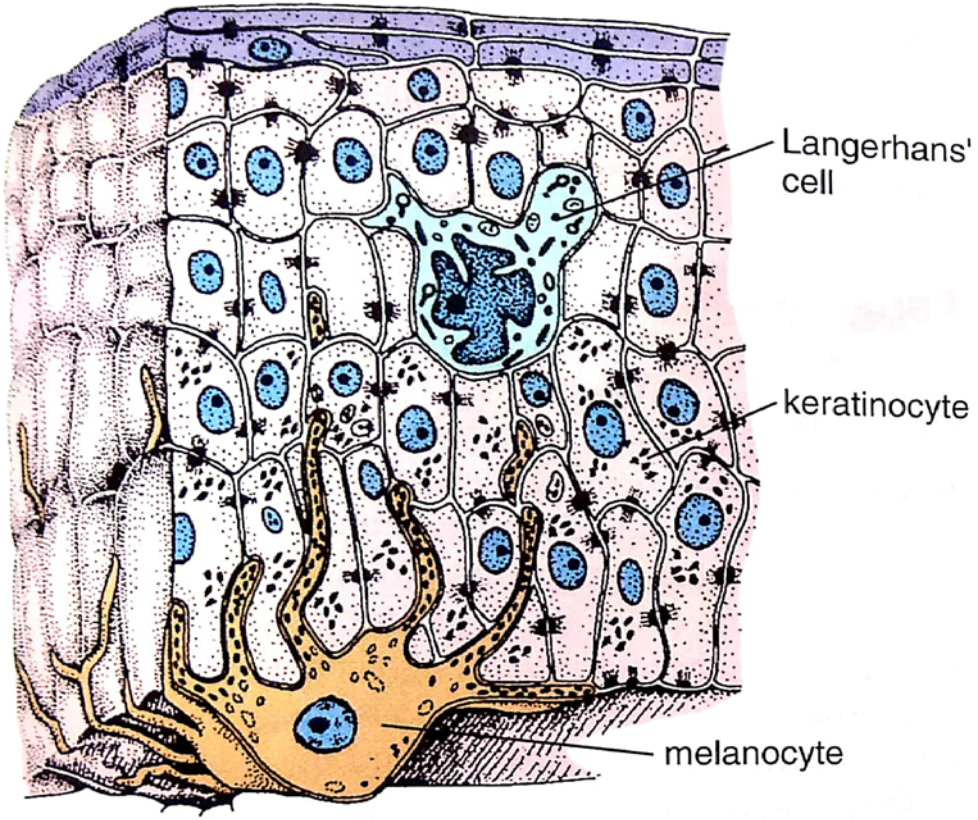

FIGURE 15.7. Diagram of the epidermis. This diagram shows a melanocyte interacting with several cells of the stratum basale and the stratum spinosum. The melanocyte has long dendritic processes that contain accumulated melanosomes and extend between the cells of the epidermis. The Langerhans' cell is a dendritic cell often confused with a melanocyte. It is actually part of the mononuclear phagocytotic system and functions as an antigen-presenting cell of the immune system in the initiation of cutaneous hypersensitivity reactions (contact allergic dermatitis). (Modified from Weiss L, ed. Cell and Tissue Biology: A Textbook of Histology, 6th ed. Baltimore: Urban & Schwarzenberg, 1988.)

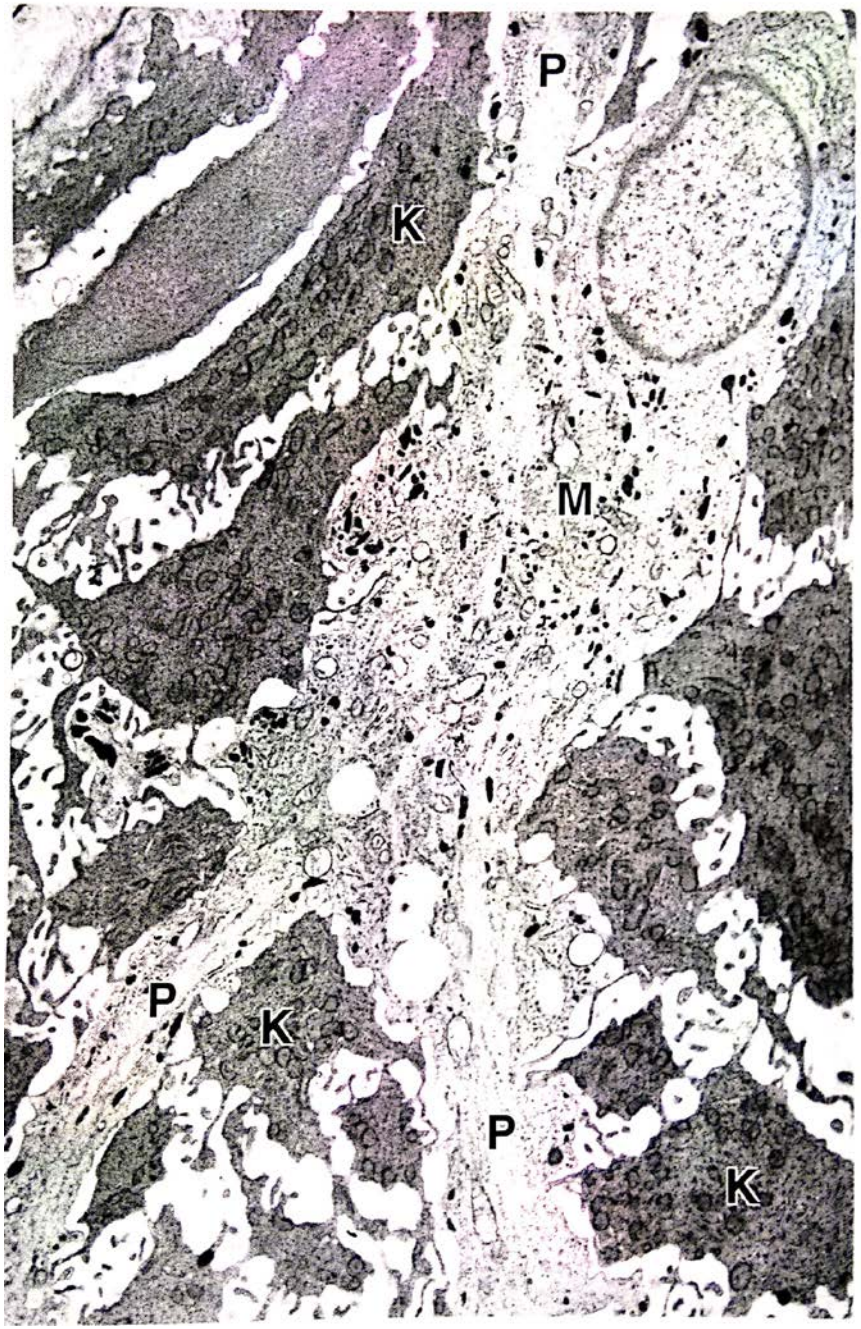

FIGURE 15.8. Electron micrograph of a melanocyte. The melanocyte (*M*) reveals several processes (*P*) extending between neighboring keratinocytes (*K*). The small dark bodies are melanosomes. ×8,500. (Courtesy of Dr. Bryce L. Munger.)

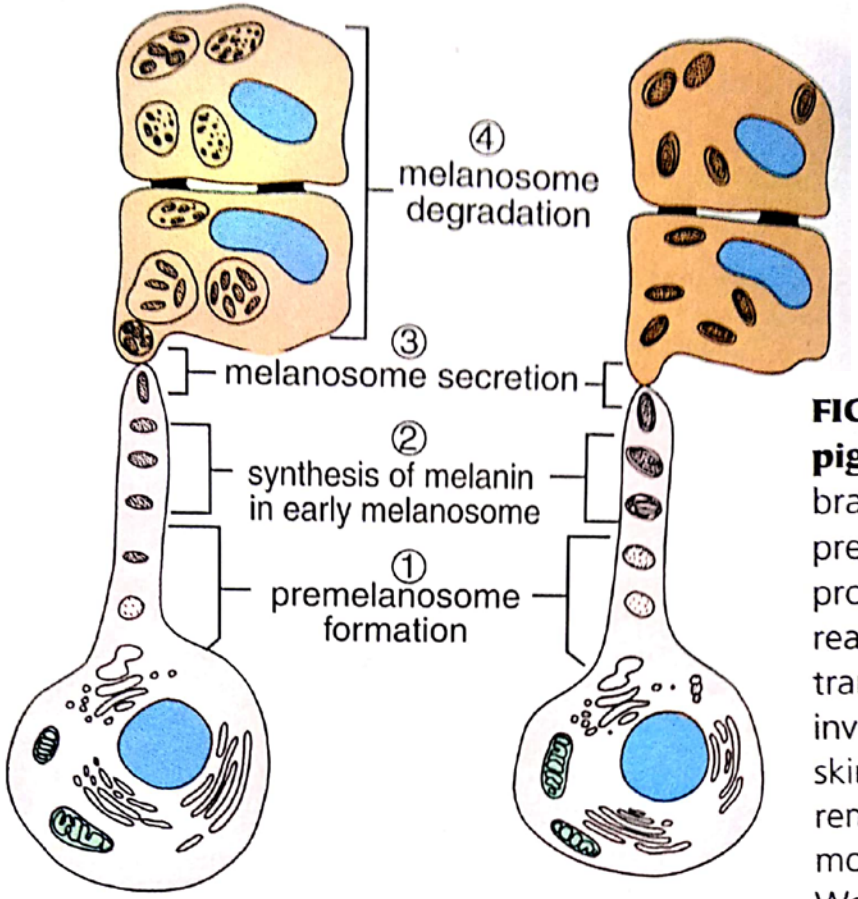

FIGURE 15.9. Formation of melanin pigment and secretion of pigment granules into keratinocytes. Melanocytes produce membrane-bounded structures that originate in the Golgi apparatus as premelanosomes ①. Within the early melanosomes, as maturation proceeds, melanin is produced from tyrosine by a series of enzymatic reactions ②. Mature melanosomes and their melanin contents are transferred to neighboring keratinocytes by pigment donation, which involves the phagocytosis of the tips of the melanocyte ③. In darker skin (on the right), the melanin is degraded slowly, and melanosomes remain discrete; in lighter skin (on the left), the melanin is degraded more rapidly ④ through the process of macroautophagy. (Based on Weiss L, Greep RO. Histology. New York: McGraw-Hill, 1977.)

Langerhans cells

1. **Langerhans cells, dendritic cells, are the skins first line defenders and play a significant role in antigen presentation.**
2. **These cells need special stains to visualize, primarily found in the stratum spinosum.**
3. **These cells are the mesenchymal origin, derived from CD34 positive stem cells of bone marrow and are part of the mononuclear phagocytic system.**
4. **They contain Birbeck granules, tennis racket shaped cytoplasmic organelles.**
5. **These cells express both MHC I and MHC II molecules, uptake antigens in skin and transport to the lymph node.**

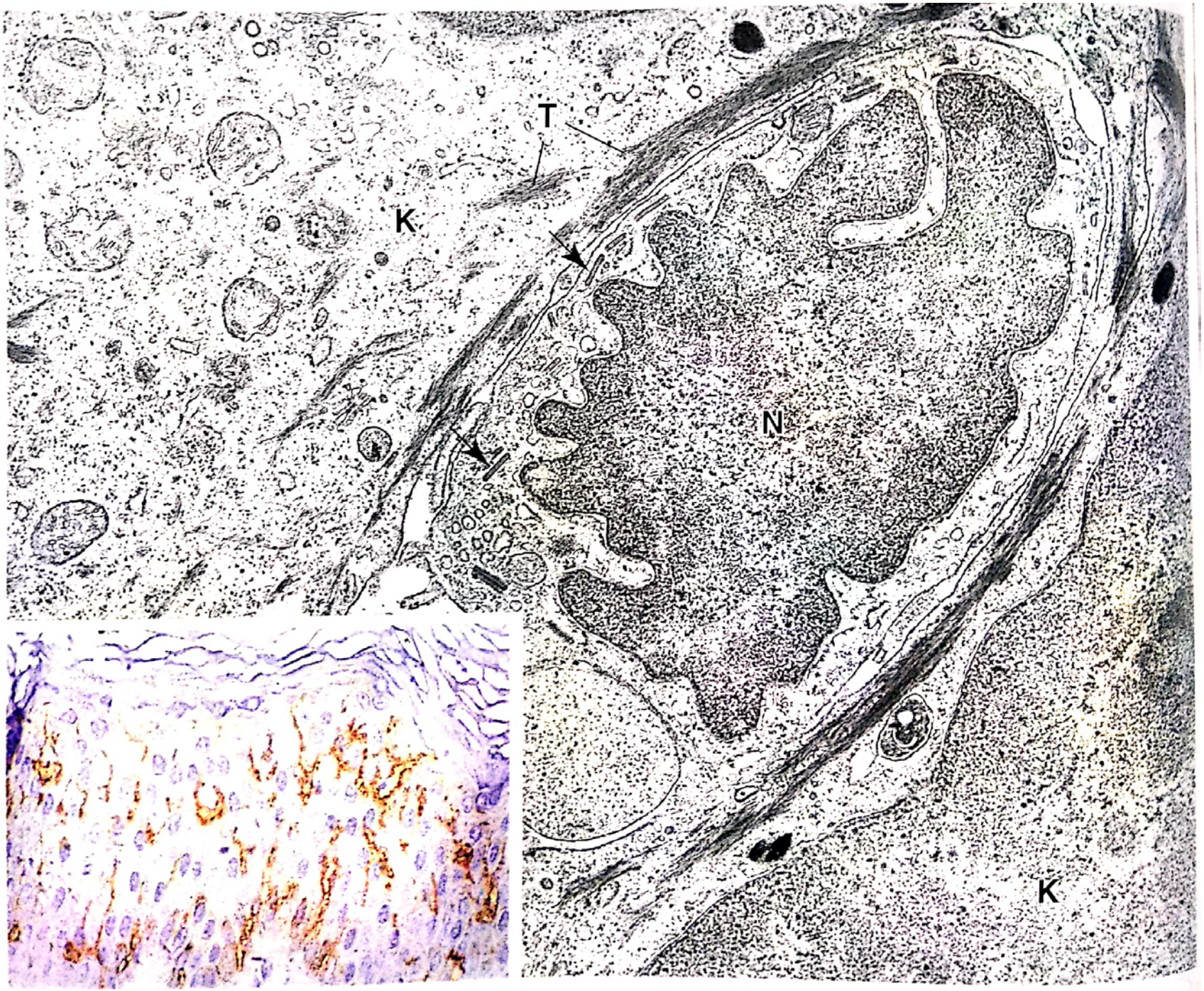
T
K
N
K

Fig. **Electron micrograph of a Langerhan's cell**. The nucleus (N) of a Langerhan's cell is characteristically indented in many places and the cytoplasm contains distinctive rod shaped bodies (arrows). Note the presence of tonofilaments (T) in adjacent keratinocytes (K) but the absence of these filaments in the Langerhan's cell.X 19,000. Inset. Photomicrograph of the epidermis shows the distribution and dendritic nature of the Langerhan's cell that were stained via immunostaining techniques with antibodies against CD1a surface antigen. X 300.

Merkel cells

1. **Merkel cells are oval-shaped modified epidermal cells found in stratum basale, directly above the basement membrane.**
2. **These cells serve a sensory function as mechanoreceptors for light touch, and are most populous in fingertips, though also found in the palms, soles, oral, and genital mucosa.**
3. **They are bound to adjoining keratinocytes by desmosomes and contain intermediate keratin filaments and their membranes interact with free nerve endings in the skin.**

Fig. Electron micrograph of a Merkel's cell. The cell has small neurosecretory granules in the cytoplasm and makes contact with a peripheral terminal (NT) of a neuron. The dermis (D) is in the lower part of the micrograph X 14,450 (Courtesy of Dr. Bryce L. Munger)

Dermis

1. **The dermis is connected to the epidermis at the level of the basement membrane and consists of two layers, of connective tissue, the papillary and reticular layers which merge together without clear demarcation.**
2. **The papillary layer is the upper layer, thinner, composed of loose connective tissue and contacts epidermis.**
3. **The reticular layer is the deeper layer, thicker, less cellular, and consists of dense connective tissue/ bundles of collagen fibers.**
4. **The dermis houses the sweat glands, hair, hair follicles, muscles, sensory neurons, and blood vessels.**

Hypodermis

The hypodermis is deep to the dermis and is also called subcutaneous fascia. It is the deepest layer of skin and contains adipose lobules along with some skin appendages like the hair follicles, sensory neurons, and blood vessels.

Function:

The integumentary system has many functions, most of which are involved in protecting you and regulating your body's internal functions in a variety of ways

1. **Protects the body's internal living tissues and organs**
2. **Protects against invasion by infectious organisms**
3. **Protects the body from dehydration**
4. **Protects the body against abrupt changes in temperature**
5. **Helps dispose of waste materials**
6. **Acts as a receptor for touch, pressure, pain, heat, and cold**
7. **Stores water and fat**

HOW DOES THE INTEGUMENTARY SYSTEM WORK WITH OTHER SYSTEMS?

Your body is a complicated system that consists of many subsystems that help to keep it functioning properly. These subsystems serve a variety of purposes and require needed materials to function properly, as well as means of communicating information to other parts of the body. Thus, the skin and other parts of the integumentary system work with other systems in your body to maintain and support the conditions that your cells, tissues, and organs need to function properly.

1. **The skin is one of the first defense mechanisms in your immune system. Tiny glands in the skin secrete oils that enhance the barrier function of the skin. Immune cells live in the skin and provide the first line of defense against infections.**
2. **By helping to synthesize and absorb vitamin D, the integumentary system works with the digestive system to encourage the uptake of calcium from our diet. This substance enters the bloodstream though the capillary networks in the skin. Healthy functioning of your skin also is related to the digestive system because the digestion and assimilation of dietary fats and oils are essential for the body to be able to make the protective oils for the skin and hair.**

3. **The integumentary system also works closely with the circulatory system and the surface capillaries through your body. Because certain substances can enter the bloodstream through the capillary networks in the skin, patches can be used to deliver medications in this manner for conditions ranging from heart problems (nitroglycerin) to smoking cessation (nicotine patches).**
4. **The skin also is important in helping to regulate your body temperature. If you are too hot or too cold, your brain sends nerve impulses to the skin, which has three ways to either increase or decrease heat loss from the body's surface: hairs on the skin trap more warmth if they are standing up, and less if they are lying flat; glands under the skin secrete sweat onto the surface of the skin in order to increase heat loss by evaporation if the body is too hot; capillaries near the surface can open when your body needs to cool off and close when you need to conserve heat.**

5. **Your skin plays a vital role in your body as regards the sense of touch. The nervous system depends on neurons embedded in your skin to sense the outside world. It processes input from your senses, including touch, and initiates actions based on those inputs. For example, when you stub your toe, nerve cells in the foot send signals up the leg, through the spinal cord, and up into the brain. The nerve cell connections in the brain sense these signals as pain.**
6. **As well as interacting with the body systems as explained above, the integumentary system also contributes to numerous physiological processes, especially those involved in the regulation of the body's internal environment so as to maintain a stable condition. An example is provided by the way that the skin helps in temperature regulation by changes in the pattern of blood supply to the skin and by sweating, as mentioned above.**

VITAMIN D SYNTHESIS:

The epidermal layer of human skin synthesizes vitamin D when exposed to UV radiation. In the presence of sunlight, a form of vitamin D called cholecalciferol is synthesized from a derivative of the steroid cholesterol in the skin. The liver converts cholecalciferol to calcidiol, which is then converted to calcitriol (the active chemical form of the vitamin) in the kidneys. Vitamin D is essential for normal absorption of calcium and phosphorous, which are required for healthy bones. The absence of sun exposure can lead to a lack of vitamin D in the body, leading to a condition called rickets, a painful condition in children where the bones are misshapen due to a lack of calcium, causing bowleggedness. Elderly individuals who suffer from vitamin D deficiency can develop a condition called osteomalacia, a so?ening of the bones.

In present day society, vitamin D is added as a supplement to many foods, including milk and orange juice, compensating for the need for sun exposure. In addition to its essential role in bone health, vitamin D is essential for general immunity against bacterial, viral, and fungal infections. Recent studies are also finding a link between insufficient vitamin D and cancer.