Integumentary System
Unit-1 (ZOOG-CC2-2-TH)

Integument system:

The integumentary system is the largest organ of the body that forms a physical barrier between the external environment and the internal environment that it serves to protect and maintain. The integumentary system includes the epidermis, dermis, hypodermis, associated glands, hair, and nails. In addition to its barrier function, this system performs many intricate functions such as body temperature regulation, cell fluid maintenance, synthesis of Vitamin D, and detection of stimuli. The various components of this system work in conjunction to carry out these functions—for example, body temperature regulation occurs through thermo receptors that lead to the adjustment of peripheral blood flow, degree of perspiration, and body hair.

The integumentary system is composed of the following parts:

1. Skin
2. Skin appendages –
    - Hairs
    - Nails
    - Sweat glands
    - Sebaceous glands
3. Subcutaneous tissue and deep fascia
4. Mucocutaneous junctions
5. Breasts

Function:

Physical protection: Given that the integumentary is the covering of the human body, its most apparent function is physical protection. The skin itself is a tightly knit network of cells, with each layer contributing to its strength. The epidermis has an outermost layer created by layers of dead keratin that

can withstand wear and tear of the outer environment, while the dermis provides the epidermis with blood supply and has nerves that bring danger to attention amongst other functions. The hypodermis provides physical cushioning to any mechanical trauma through adipose storage, and the glands secrete protective films throughout the body. The nails protect the digits, which are prone to repeated trauma by creating a hard covering, and hairs throughout the body filter harmful particles from entering the eyes, ears, nose, etc.

Immunity: The skin is the body's first line of defense as it acts as the physical barrier that prevents direct entry of pathogens. Cells are connected through junction proteins with reinforcement by keratin filaments. Antimicrobial peptides (AMPs) and lipids on the skin also act as a biomolecular barrier that disrupts bacterial membranes. AMPs, such as defensins and cathelicidins, are produced by various cells in the skin, such as dendritic cells, macrophages, glands, etc., and are activated by proteolytic cleavage with stimulation. Lipids, such as sphingomyelin and glucosylceramides, are stored in lamellar bodies found in the stratum corneum and display antimicrobial activity. An additional aspect of the skin's immunity lies in the resident immune cells. Both myeloid and lymphoid cells are present in the skin, and some, such as the Langerhans cells or dermal dendritic cells, possess the capability to travel to the periphery and activate the greater immune system.

Wound healing: When our body undergoes trauma with a resulting injury, the integumentary system orchestrates the wound healing process through hemostasis, inflammation, proliferation, and remodeling. Hemostasis occurs through tissue factor located in subendothelial spaces of the skin, which triggers the coagulation cascade to form a fibrin clot. In the following inflammatory phase, immune cells such as neutrophils and monocytes will infiltrate the injury site to attack pathogens and clear out debris. The proliferative phase involves the multiplication of resident cells such as keratinocytes and fibroblasts that contribute to the formation of granulation tissue. Through a matrix of immune cells and the eventual formation of a collagen network by fibroblasts and myofibroblasts, the new extracellular matrix forms. The final remodeling phase consists of apoptosis as cells are no longer needed and excess structures are broken down in efforts to restore the original architecture. Macrophages secrete matrix metalloproteases that

remove excess collagen, and remaining immature collagen matures to finalize the extracellular matrix.

Vitamin D synthesis: The primary sources of vitamin D are sun exposure and oral intake. With ultraviolet sunlight exposure, 7-dehydrocholesterol converts to vitamin D3 (cholecalciferol) in the skin. Cholecalciferol is then hydroxylated in the liver, then kidney into its active metabolite form,1,25-dihydroxy vitamin D (calcitriol). This metabolite ultimately leads to increased calcium absorption in the gut and is crucial for bone health.

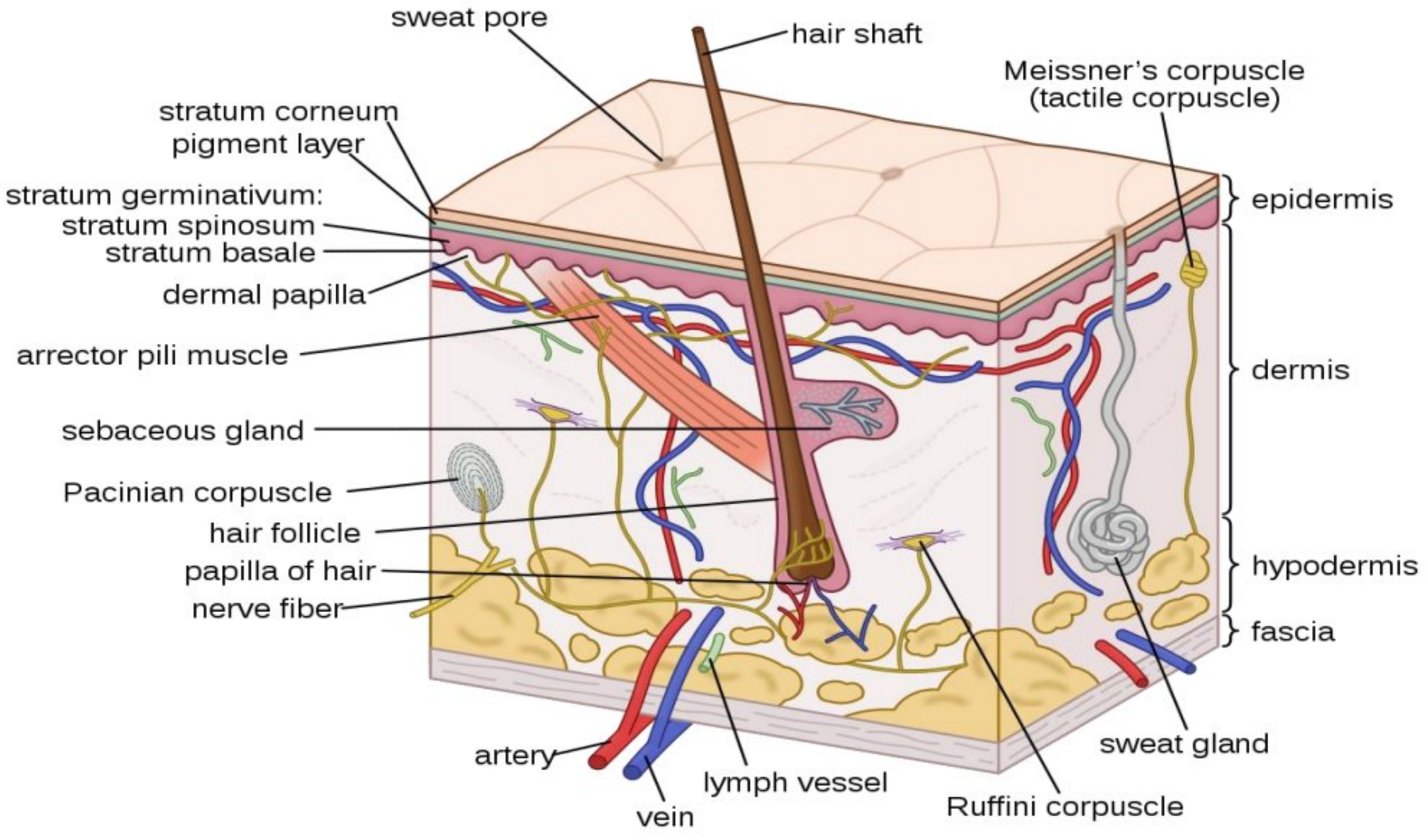
Regulation of body temperature: The skin has a large surface area that is highly vascularized, which allows it to conserve and release heat through vasoconstriction and vasodilation, respectively. When body temperatures rise, blood vessels dilate to increase blood flow and maximize the dissipation of heat. In conjunction with this method, the evaporation of sweat secreted by the skin allows for greater heat loss. The hair on the body also affects the regulation of body temperature as erect hair can trap a layer of heat close to the skin. Various inputs from central and skin thermoreceptors provide fine-tuning for this thermoregulatory system.

Sensation: Skin innervation is by various sensory nerve endings that discriminate pain, temperature, touch, and vibration. Mediation of innocuous touch in glabrous skin by four types of mechanoreceptors—Meissner corpuscle, Pacinian corpuscle, Ruffini endings, and Merkel cells. Meissner corpuscles can detect movement across the skin, Pacinian corpuscles detect high-frequency vibration, Ruffini endings detect stretch, and Merkel cells aid in spatial imaging. In hairy skin, tactile stimuli are picked up by three types of hair follicles and their associated longitudinal and circumferential lanceolate endings. Noxious stimuli in both glabrous and hairy skin are detectable by free nerve endings located in the epidermis. Each type of receptor and nerve fiber varies in its adaptive and conductive speeds, leading to a wide range of signals that can be integrated to create an understanding of the external environment and help the body to react appropriately.

Derivatives of Integumentary system:

Among the notable changes that have taken place during the course of evolution is the development in vertebrates of a variety of glands, pigmentary structures, scales, claws, nails, horns, feathers, and hairs as adaptations to

their changing environments. Both the epidermis and dermis layers of integument have given rise to various types of derivatives. The epidermis gives rise to integumentary glands, epidermal scales, horns, digital structures, different corneal structures, feathers, and hairs. The dermis forms dermal scales of fishes and of some reptiles, plates or scutes in reptiles, fin rays in fishes and antlers in mammals.



EPIDERMIS AND ITS DERIVATIVES -

The epidermis, derived from somatic ectoderm, is the exterior-most covering of the chordate body. It provides protection against the invasion of microorganisms, provides flexibility in motion, and seals in moisture. As will be seen, it also gives rise to a variety of differentiated structures such as feathers, hair, horns, claws, nails and glands. Begin by looking at a cross-section of Amphioxus (Branchiostoma) integument. Amphioxus possesses the simplest possible form of epidermis - a single layer of columnar epithelium covered by a thin film of cuticle. All true vertebrates, however, have developed a multi-layered epithelium. Note the simple, multicellular, epithelium of the lamprey, which has no scales. Fishes and amphibians have

a mucus layer for bacterial and mechanical protection and to prevent drying on land. See frog skin. Terrestrial vertebrates have replaced the cuticle with keratin. See the snake skin.

THE DERMIS AND ITS DERIVATIVES –

The dermis is generally much thicker than the epidermis and lies more deeply. It is made of a fibrous mass of connective tissue (collagen) and is of mesodermal origin. It may directly produce dermal (membrane) bone. The dermis is important in defence against injury and in the maintenance of body heat. Deeper regions of the dermis often contain fatty deposits, smooth muscle, blood vessels and nerves. Chromatophore cells are sometimes epidermal, but usually dermal in origin. They secrete melanin, which can be passed to the stratum corneum of skin and to hair shafts to produce colour and block harmful sunlight.

Glands in Birds:

Uropygial gland - Avian skin as a whole acts as a sebaceous secretory organ, but it is specialized for this purpose in the uropygial gland and the ear glands. The uropygial gland (preen gland) is a bilobed structure on the base of the tail, situated between the dorsal skin and the body muscles. Inside a connective tissue capsule, each lobe is composed of numerous holocrine secretory alveoli that open into a central cavity. The secretion passes through ducts to openings at the tip of a papilla on the posterior end of the gland. When a bird preens, the sebum is smeared on the bill and the head plumage, either directly or by a tiny feather tuft on the papilla. From there, it is rubbed onto the rest of the plumage and the podotheca. The uropygial gland may be homologous with small, oily, sebaceous-like glands in crocodilian skin. Present in most birds, it is relatively large in many aquatic species, weakly developed in pigeons, herons, and the Kagu (*Rhynochetos jubatus*), and absent in ratites, bustards, and some parrots. The uropygial secretion consists chiefly of monoester waxes, and also contains other waxes, triglycerides, and

hydrocarbons. It can be distinguished chemically from the skin secretion. The composition of the uropygial sebum further varies among avian species, but the functional significance of these differences has not been studied. Both uropygial and skin secretions are deposited on the feathers, their relative amounts varying among species. The functions of the uropygial secretion, although much studied, ought to be re-examined with regard to the skin secretion, which was long unknown. Together, the two substances keep the keratin of the integument and its derivatives flexible and in good condition. This is particularly important for the feathers, whose waterproofing depends chiefly on tiny air bubbles held within the meshwork of their barbs. In order for that to work, the barbs and their branches must be pliable and properly spaced apart. Uropygial waxes have the optimal properties both for impermeability and the flexibility of feather parts. The uropygial secretion also has antibacterial and anti-mycotic properties and hence is thought to regulate the microflora of the plumage. It also has an odorant and/or pheromonal function in petrels, Musk Ducks (*Biziura lobata*), Kakapos (*Strigops habroptilus*) and other species. Since the sense of smell is better developed in birds than was formerly realized, these roles deserve more study.

Ear glands - Shallow acinar holocrine sebaceous glands are located in a fold of skin on the floor of the ear canal. Their structure at all levels and their secretion differ greatly from those of the uropygial gland and the epidermis. Their metabolic pattern is oriented toward lipogenesis and their cells do not disintegrate completely. The ear wax, a mass of partially lysed cells, appears to trap extraneous particles and to keep the ear canal clear. Vent glands Many birds possess small, simple, tubular glands on the lips of the vent, either outside or deeper within. The glands open directly onto the surface of the stratified, squamous epithelium. Unlike the uropygial and ear glands, the vent glands secrete only mucoproteins. During the breeding season, they hypertrophy and undergo histochemical changes which suggest that the secretion serves in reproduction, possibly in the mechanics of internal fertilization.

Glands in Mammals:

The skin glands of mammals are of three major types. Associated with hair follicles are oil-secreting **Sebaceous glands** as well as **Tubular glands**, which produce an aqueous secretion. Sebaceous glands are termed holocrine because their secretion involves complete disintegration of their cells, which are constantly replaced. Tubular, or merocrine, glands extrude their secretion into a central lumen. The tubular glands of the hair follicle are usually classified as apocrine because it is believed that, in some glands at least, secretion involves a breaking off of part of the gland cells. A second type of merocrine gland, not associated with hair follicles, is termed **Eccrine** because the cells remain intact during secretion. Eccrine glands occur in hairy skin only in humans and some primates; but the footpad glands, which increase friction and thus prevent slipping in many mammalian species, are of a similar type. A major function of skin glands is the production of odours for sexual or social communication. Many species in all but a few mammalian orders have specialized aggregations of glandular units for this purpose. These occur in almost every area of the body. Some, like the chin and anal glands of the rabbit, contain only tubular units; others, like the abdominal gland of the gerbil, are purely sebaceous; still others, like the side glands of shrews, contain batteries of both holocrine and tubular units.

In some large mammals an important function of merocrine glands is temperature control. Horses and cattle, for example, have apocrine glands for this purpose, but the superbly effective cooling system of humans is served by eccrine sweat glands.

Sweat glands: In humans, there are two kinds of sweat glands which differ greatly in both the composition of the sweat and its purpose

Eccrine (Merocrine) –

Eccrine sweat glands are exocrine glands distributed over the entire body surface but are particularly abundant on the palms of hands, soles of feet, and on the forehead. These produce sweat that is composed chiefly of water

(99%) with various salts. The primary function is body temperature regulation. Eccrine sweat glands are coiled tubular glands derived leading directly to the most superficial layer of the epidermis (out layer of skin) but extending into the inner layer of the skin (dermis layer). They are distributed over almost the entire surface of the body in humans and many other species, but are lacking in some marine and fur-bearing species. The sweat glands are controlled by sympathetic cholinergic nerves which are controlled by a center in the hypothalamus. The hypothalamus senses core temperature directly, and also has input from temperature receptors in the skin and modifies the sweat output, along with other thermoregulatory processes.

Human eccrine sweat is composed chiefly of water with various salts and organic compounds in solution. It contains minute amounts of fatty materials, urea, and other wastes. The concentration of sodium varies from 35–65 mmol/l and is lower in people acclimatised to a hot environment. The sweat of other species generally differ in composition.

Apocrine

Apocrine sweat glands only develop during early- to mid-puberty (approximately age 15) and release more than normal amounts of sweat for approximately a month and subsequently regulate and release normal amounts of sweat after a certain period of time. **Apocrine sweat glands** produce sweat that contains fatty materials. These glands are mainly present in the armpits and around the genital area and their activity is the main cause of sweat odor, due to the bacteria that break down the organic compounds in the sweat from these glands. Emotional stress increases the production of sweat from the apocrine glands, or more precisely: the sweat already present in the tubule is squeezed out. Apocrine sweat glands essentially serve as scent glands.

Sebaceous Glands:

The **Sebaceous glands** are glands found in the skin of mammals. They secrete an oily substance called sebum (Latin, meaning *fat* or *tallow*) that is made of fat (lipids) and the debris of dead fat-producing cells. These glands exist in humans throughout the skin except in the palms of the hands and soles of the feet. Sebum acts to protect and waterproof hair and skin, and keep them from becoming dry, brittle, and cracked. It can also inhibit the

growth of microorganisms on skin. Sebaceous glands can usually be found in hair-covered areas where they are connected to hair follicles to deposit sebum on the hairs, and bring it to the skin surface along the hair shaft. The structure consisting of hair, hair follicle and sebaceous gland is also known as pilosebaceous unit. Sebaceous glands are also found in non haired areas of lips, eyelids, penis, labia minora and nipples; here the sebum reaches the surface through ducts. In the glands, sebum is produced within specialized cells and is released as these cells burst; sebaceous glands are thus classified as holocrine glands.

Sebum is odorless, but its bacterial breakdown can produce odors. Sebum is the cause of some people experiencing "oily" hair if it is not washed for several days. Earwax is partly sebum, as is mucopurulent discharge, the dry substance accumulating in the corners of the eye after sleeping. The composition of sebum varies from species to species; in humans, the lipid content consists of about 25% wax monoesters, 41% triglycerides, 16% free fatty acids, and 12% squalene. The activity of the sebaceous glands increases during puberty because of heightened levels of androgens. Sebaceous glands are involved in skin problems such as acne and keratosis pilaris. A blocked sebaceous gland can result in a sebaceous cyst. The prescription drug isotretinoin significantly reduces the amount of sebum produced by the sebaceous glands, and is used to treat acne. The extreme use (up to 10 times doctor prescribed amounts) of anabolic steroids by bodybuilders to prevent weight loss tend to stimulate the sebaceous glands which can cause acne.The sebaceous glands of a human fetus *in utero* secrete a substance called vernix caseosa, a "waxy" or "cheesy" white substance coating the skin of newborns.

The preputial glands of mice and rats are large modified sebaceous glands that produce pheromones.

Ceruminous glands

Earwax, also known by the medical term **cerumen**, is a yellowish, waxy substance secreted in the ear canal of humans and many other mammals. It plays a vital role in the human ear canal, assisting in cleaning and lubrication, and also provides some protection from bacteria, fungus, and insects. Excess

or impacted cerumen can press against the eardrum and/or occlude the external auditory canal and impair hearing.

Mammary Glands

Mammary glands are the organs that, in the female mammal, produce milk for the sustenance of the young. These exocrine glands are enlarged and modified sweat glands and are the characteristic of mammals which gave the class its name. Humans normally have two complex mammary glands, one in each breast, and each complex mammary gland consists of 10–20 simple glands. (The presence of more than two nipples is known as polythelia and the presence of more than two complex mammary glands as polymastia). One distinguishes between a *simple mammary gland*, which consists of all the milk-secreting tissue leading to a single lactiferous duct, and a *complex mammary gland*, which consists of all the simple mammary glands serving one nipple.