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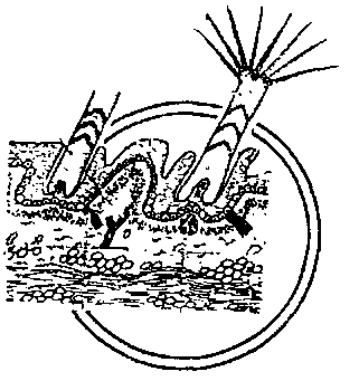

Integument and its Derivatives in Vertebrates

Comparative Anatomy, its Meaning and Purpose of Study

Study of the structure of animals is termed *anatomy*, whereas a comparative study of structure of different animal groups, or animals, is known as *comparative anatomy*. In fact the study of comparative anatomy is more purposeful and dynamic than mere study of the location and structure of different organ systems in different animals. It also determines the phylogenetic origin and modification of their various homologous structures. In a sense, it is the history of the struggle of animals, striving for compatibility with an ever changing environment in the past. Despite their differences, all vertebrates, past as well as present, are built according to the same basic architectural plan. Thus, comparative study of various homologous vertebrate structures offers special evidence in support of the doctrine of organic evolution with the premise that species have been changing.

Integument or Skin

Definition. The term *integument* is applied to the outermost protective covering of the animal body, the *skin*, and its various *derivatives*. Skin also includes the conjunctiva of eyeballs and external surface of eardrums. It is directly continuous with the mucous epithelial lining of mouth, rectum, nostrils, eyelids and urinogenital ducts.

[I] Functions of integument

The integument or skin of vertebrates is truly a 'jack-of-all-trades' since it performs several important functions —

1. **Protection.** The integument or skin separates the animal from its external environment

and helps to maintain a constant internal environment. It has several protective devices—

(1) It protects the body against a variety of mechanical and chemical injuries which may result from pressure, friction, blows, harmful gases and fluids.
(2) Protective derivatives such as scales, bony plates, fat, feathers, hairs, etc. reduce the force of injury, prevent excessive loss of body moisture and do not allow entry of harmful bacteria and fungi, and other foreign bodies.
(3) Pelage (fur), plumage (feathers), bristles or spines, claws, nails, hoofs, antlers, horns, etc. serve for offence and defence.
(4) Protective colouration or camouflage serves to escape detection by enemies.
(5) Skin pigments also protect against solar radiation.

2. Locomotion. Dermal fin rays in the fins of fishes and skin webs in the feet of frogs, turtles, aquatic birds, etc., help in swimming in water. Adhesive pads (Amphibia) and claws (amniotes) on digits assist in climbing. Feathers on wings and short tail of birds and cutaneous patagia or wings of bats and flying lizards and squirrels help in flying.

3. Dermal endoskeleton. Skin contributes to bony dermal armour such as in extinct ostracoderms and placoderms and living sturgeons, crocodiles and turtles. Dermal endoskeleton in head, shields the brain and sense organs. Elsewhere it prevents compression of soft internal organs and also forms parts of teeth.

4. Secretion. Skin glands secrete substances having several uses. (i) Mucous glands in aquatic forms (e.g., fish, frog) keep the skin moist and slippery. (ii) Poisonous, bitter or offensive secretions ward off potential enemies. (iii) Uropygial glands in birds secrete oil for preening feathers. (iv) Oil from sebaceous glands of mammals lubricates the skin and hairs. Moreover, *sebum* contains *fatty acids* and *lactic acids* in it which bring down the pH of skin to 3-A and creates a hostile environment for growth, multiplication and survival of microbes. (v) Mammary glands manufacture milk for nourishment of the young. (vi) Odours of scent glands attract the opposite sex. (vii) Tears from lacrymal glands wash the conjunctiva of mammalian eye ball. (viii) Glands of auditory meatus secrete an carwax, the cerumen, to grease eardrums and to entrap insects that enter the canal.

5. Food storage. Thick fatty layer of blubber under skin of seals and whales serves as insulation as well as reserve food. Animals also accumulate subcutaneous fat prior to hibernation and migration.

6. Temperature control. In warm-blooded animals, fur, feathers and scales insulate and conserve body heat in cold climate. Sweat glands of mammals provide cooling by evaporation in summer. For elimination of heat, integumentary blood vessels dilate so that skin becomes a radiator. For conservation of heat, the vessels constrict. These devices help in homoiothermy or in the maintenance of constant body temperature.

7. Excretion. Excess of water, salts and urea are also eliminated in sweat. Gills of marine fishes contain chloride-secreting cells. Shedding of skin during ecdysis also gets rid off of some metabolic wastes.

8. Sensation. Cutaneous nerve endings and other sense organs are stimulated by touch, pain, changes in pressure and moisture, extremes of heat and cold and chemicals, etc. In their absence, these animals may starve or destroyed by an enemy.

9. Sexual selection. Brilliantly coloured skins, antlers of male deer, long tail coverts of peacock, etc. lead to sexual dimorphism and also serve to attract the females for mating.

10. Miscellaneous. Skin has many other functions not cited above. (i) Vitamin D is synthesized in mammalian skin from sebum of sebaceous glands in ultra-violet light. (ii) Brood pouches under the skin of some fishes and amphibians protect unhatched eggs. (iii) Nasal glands of tetrapods keep nostrils free of water and dirt. (iv) Amphibians and other aquatic animals carry on considerable respiration through their richly vascular skin. (v) Skin shows selective absorption of oils, ointments, iodine, beneficial

sun-rays, etc. (vi) Special types of enzymes are produced by larvae of some fishes and frogs.

[II] Structure of integument in general

The skin of all vertebrates is built according with the same basic plan. It is multicellular and differs from that of the invertebrates in having two layers— (i) an outer *epidermis* developed from ectoderm, and (ii) an inner *dermis* derived from the mesoderm. The related abundance of the two layers differs according to the environment.

1. Epidermis. Epidermis is a stratified epithelium and normally quite thin in comparison to dermis. It is further distinguished into two regions— (i) The outermost region of many layers of dead usually flattened (squamous) cells forms a horny, resistant covering or *stratum corneum* on the skin surface. Its cells accumulate a horny protein, called *keratin*, gradually die and eventually wear off in the form of scurf or dandruff. Since keratin is tough and insoluble in water, the keratinized stratum corneum provides protection against mechanical injuries, fungal and bacterial attacks and loss of body moisture. (ii) The innermost or basal region of epidermis includes a single row of living columnar cells, the *Malpighian layer* or *stratum germinativum*, which is separated from the underlying dermis by a basement membrane. Its cells actively divide and continually replace the worn out cells of the cornified layer.

Epidermis is thin in aquatic vertebrates and rich in mucous glands. It is thicker in land vertebrates and structures such as scales, feathers, hairs, nails, claws, horns and enamel of teeth are derived from its Malpighian layer.

2. Dermis. Dermis or *corium*, which is the inner layer of skin, is comparatively thicker than epidermis. It is composed of fibrous connective tissue and contains many blood capillaries, lymph vessels, muscle fibres, nerve fibres, sense organs and elastic fibres which bring the skin back to its normal shape. Pigment cells or *melanocytes* are mostly located in dermis, although sometimes pigment granules are also found in epidermis. Fat may accumulate as reserve food in special cells, called *adipocytes*, in deeper parts of dermis and in the subcutaneous tissue.

Derivatives of Integument

The skin itself is relatively simple but its derivatives are numerous and complex. Depending on the layer of skin from which they are derived, these structures fall under two broad categories : *epidermal* and *dermal*.

1. Epidermal derivatives. These are formed by the epidermis and comprise : (i) *epidermal glands* and (ii) *hard horny structures* including *epidermal scales, scutes, beaks, horns, claws, nails* and *hoofs, feathers* and *hairs*, etc. All the hard horny structures together form the *exoskeleton* of an animal.

2. Dermal derivatives. These arise from dermis and comprise *bony* or *dermal scales, plates* or *scutes, fin-rays* and *antlers*, etc.

[I] Epidermal glands

Integumental or epidermal glands are formed by the Malpighian layer of epidermis. They arise in epidermis but often invade the dermis. They may be unicellular or multicellular, tubular or alveolar in shape, and simple, compound or branched. They are lined by cuboidal cells or columnar epithelium. They are usually named after their nature or function. The 9 major types described below are : mucous, poison, luminescent, femoral, uropygial, sweat, sebaceous, scent and mammary.

1. Mucous glands. They secrete *mucin* which forms slimy or sticky mucous on coming in contact with water. Mucous keeps the skin moist and slippery and protects against harmful bacteria and fungi. They are abundant in amphibian skin. They may be unicellular or multicellular eg., granular cells, beaker cells of amphioxus, cyclostomes, fishes etc.

2. Poison glands. Many fishes and amphibians have poison glands. These are modified multicellular cutaneous glands, larger but fewer than mucous glands. The parotid glands behind the head of toads are aggregations of poison glands. Secretion of poison glands may be bitter, irritating and even dangerous to the predators. Poison

glands of amphibians are granular glands collected into masses called, *Parotid glands*. The poison secreted by it is *alkaloid* and similar in action like digitalis.

3. Luminescent glands or photophores. In deep sea luminous teleost fishes, certain multicellular epidermal glands serve as light-emitting organs, known as *photophores*. In one type of photophore, the superficial layer of mucous cells forms a magnifying lens, lower or basal part consists of luminous cells surrounded below by reflecting pigment cells. The reflector is made of *guanine* crystals. Light emitted is not intense, may be of many hues, and serves to attract preys. They can be flashed on and off, by *sympathetic nerves*. Injections of *adrenaline* produce flashes in some species like *Spinax*.

4. Femoral glands. These are found in male lizards (e.g. *Uromastix*) on the ventral surface of each thigh, in a single row 12-18 *femoral pores* from knee to cloacal aperture. Their sticky secretion hardens in air to form temporary tiny spines that serve to hold the female during copulation.

5. Uropygial gland. It is one of the few integumentary glands found in birds, forming a prominent swelling just above the tail or uropygium. It is branched and alveolar and exudes an oily secretion used for lubricating beak, preening feathers and attracting the opposite sex during breeding season due to odoriferous nature. The oil secreted by it contains *pomatum* which is picked up by beak and used for preening and water proofing.

6. Sweat glands. Sweat glands or sudoriferous glands (*sudor* = sweat) are abundant in the skin of most mammals. They are slender coiled tubes embedded deep in the dermis, with their long ducts opening on skin surface. A little urea and some salts are eliminated dissolved in water in the sweat produced by these glands. Evaporation of watery perspiration also helps to cool and regulate body temperature in hot environments.

Sweat glands are absent in spiny scaly anteaters and marine forms such as Sirenia and Cetacea. In many mammals their distribution is restricted. They may occur only on the soles of feet (cats and mice), lips (rabbits), muzzle and skin between toes (ruminants), sides of head (bats), ears (hippopotamus), etc. Male giant Kangaroo (*Macropus rufus*) and hippopotamus secrete red-coloured sweat. *Ciliary glands* in eyelashes and along margins of eyelids are modified sweat glands.

7. Sebaceous glands. These are branched alveolar glands opening into hair follicles of mammals. They may open directly onto skin surface such as around the genital organs, tip of nose or edges of lips. Their oily secretion, called *sebum* (=grease), keeps the skin and hairs soft, greasy, water-proof and glistening.

Sebaceous glands absent in pangolins and marine mammals (Sirenia, Cetacea) which are practically devoid of hairs. *Ceruminous glands* of external ear canals are modified sebaceous glands. Their waxy or greasy secretion, called *cerumen*, helps trap insects or dust particles. Similarly, *meibomian glands* of eyelids, which spread their oily secretion over the exposed surface of eyeball, are modified sebaceous glands.

8. Scent glands. These are modifications either of sebaceous or sudoriferous glands of mammals. Their odorous secretions serve to repel foes or attract members of opposite sex. Scent glands may occur between toes on feet (goat, rhino, horse), near eyes on head (deer family), navel on abdomen (musk deer), mid-dorsally on back (Kangaroo rats *Dipodomys*), around anus (skunks, many carnivores and rodents), etc.

In a zoo, many foul odours may not be due to unhygienic conditions but caused by the scent glands of mammals in the pens and cages.

9. Mammary glands. Characteristic of mammals, these are compound tubular glands that produce milk during lactation period for feeding the young ones. Usually they occur only on females, but are also present on males in monotremes, primates and some others. In monotremes, the mammary glands lack nipples or teats and resemble modified sweat glands. In other mammals, they possess nipples and are modifies sebaceous glands.

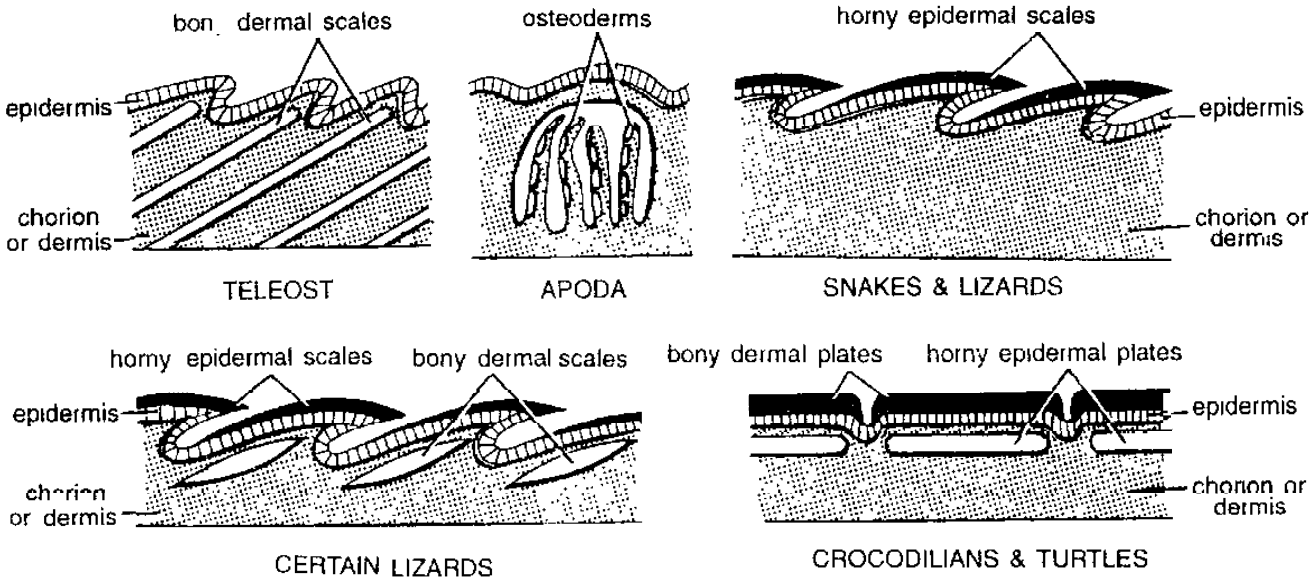

Fig. 1 Diagrammatic V.S through skins of various vertebrates showing relationship of various types of scales.

Distribution and number of mammary glands and nipples vary with the species. A *nipple* is a raised conical or elongated elevation of body surface bearing the opening of milk gland. In *true teats* (man, apes), ducts of mammary glands open separately on the nipple. In *false teats* (ungulates), all ducts empty into one cistern from which a single tube leads to the tip of the nipple.

[II] Epidermal scales and scutes

All the hard horny structures develop by the accumulation of a scleroprotein, known as *keratin*, in the cells of epidermis. Such cells are said to be keratinized or cornified, and they become dead. All stratum corneum cells are cornified and form hard horny exoskeletal structures like scales, beaks, horns, claws, nails, hoofs, feathers, hairs, etc. in different vertebrates.

Reptiles have a continuous outer covering of horny epidermal scales that prevents water loss through skin surface. In lizards, scales are thin, small, overlapping and periodically moulted in small pieces. In snakes also the scales are overlapping, enlarged on head, called *shields*, and on ventral surface, called *scutes*, which aid in locomotion. In most snakes and some lizards, the stratum corneum of entire body is periodically shed in one piece at the time of ecdysis or moulting. Crocodilians and turtles have large, thick, rectangular *scutes*, not overlapping but touching each other, and supported beneath by dermal bones. Scutes of crocodilians are sloughed or shed in patches at intervals. The toothless horny *beak* of turtles, the *rattle* at the end of the tail of rattle snakes and *horns* of the horned toad (a lizard) are other modifications of stratum corneum in reptiles.

In birds, small epidermal scales are present on the lower leg, foot and base of beak. The sheath of beak (*rhamphotheca*) is also a modification of stratum corneum.

Reptile-like epidermal scales occur in some mammals also, such as on the feet and tails of rats and beavers, etc. The *large scales* on the body of a scaly anteater undergo ecdysis individually. In armadillos, large body scales become fused into *plates* and *bands*. They are supported beneath by dermal bony scales and do not moult.

[III] Dermal scales and scutes

Bony structures develop within the dermis and are mesodermal in origin (Fig. 1). Thick bony scales and plates formed a heavy armour in the extinct ostracoderms. But they have been retained in reduced form in most living fishes, reptiles and others. In contrast to the horny epidermal scales, the bony dermal scales are not shed but increase in size during life by the addition of new bone.

1. Dermal scales of fishes. As mentioned above bony or dermal scales develop in the dermis. In fishes, the overlying epidermis wears off so that the scales become exposed forming the *exoskeleton.* Five types of dermal scales are known, depending on their structure, in fishes. (i) *Cosmoid* scales occurred in extinct lobe-finned fishes (Crossopterygii). (ii) *Placoid* scales are characteristic of elasmobranchs (Chondrichthyes). (iii) *Ganoid* scales are present in ganoid fishes (chondrosteans and holosteans). (iv) *Cycloid* and (v) *Ctenoid* scales are characteristic of modern teleosts. For more details, readers may refer to Chapter 18 and Figure 5.

2. Dermal scales and scutes of tetrapods. Dermal scales or bony plates measuring 1 to 2 mm, called *osteoderms*, are found embedded in the pockets of dermis below epidermis, in some caecilians or Apoda (Amphibia). They also occur in the back of some tropical toads.

In addition to epidermal scales and scutes, reptiles also retain traces of bony dermal armour of their ancestors. A few lizards exhibit small *dermal scales*. Crocodiles and alligators have many oval *bony plates* embedded in the dermis of their back and neck. In turtles, below horny epidermal scutes, are present large *bony plates* or *osteoderms*, forming a box-like continuous rigid dermal skeleton around trunk and including a dorsally arched *carapace* and a ventral flattened *plastron.*

Amongst mammals, bony plates or osteoderms occur in armadillos and whales.

3. Dermal fin rays. Supporting the fins of fishes are long, flexible fin rays embedded in dermis. In Chondrichthyes, they are horny, hair-like, made of fibrous connective tissue and called *ceratotrichia* (*cerato* = horn + *tricho* =hair). In Osteichthyes, they are branched, made of a series of segments or scales, and called *lepidotrichia* (*lepido* = scale). Unsegmented, sharp and spine-like fin rays are termed *actinotrichia.*

[IV] Digital cornifications

All digital cornifications, that is, claws, nails and hoofs, are built on the same plan (Fig. 2). They are modification of stratum corneum at the tips of digits and grow parallel to the skin.

1. Claws. Claws of reptiles, birds and mammals are identical in structure. A claw is made by a hard, pointed, narrow, curved, horny dorsal plate, called *unguis*, and a less hard ventral plate, called *subunguis*, both enclosing the tip of the digit covering the last tapering phalanx.

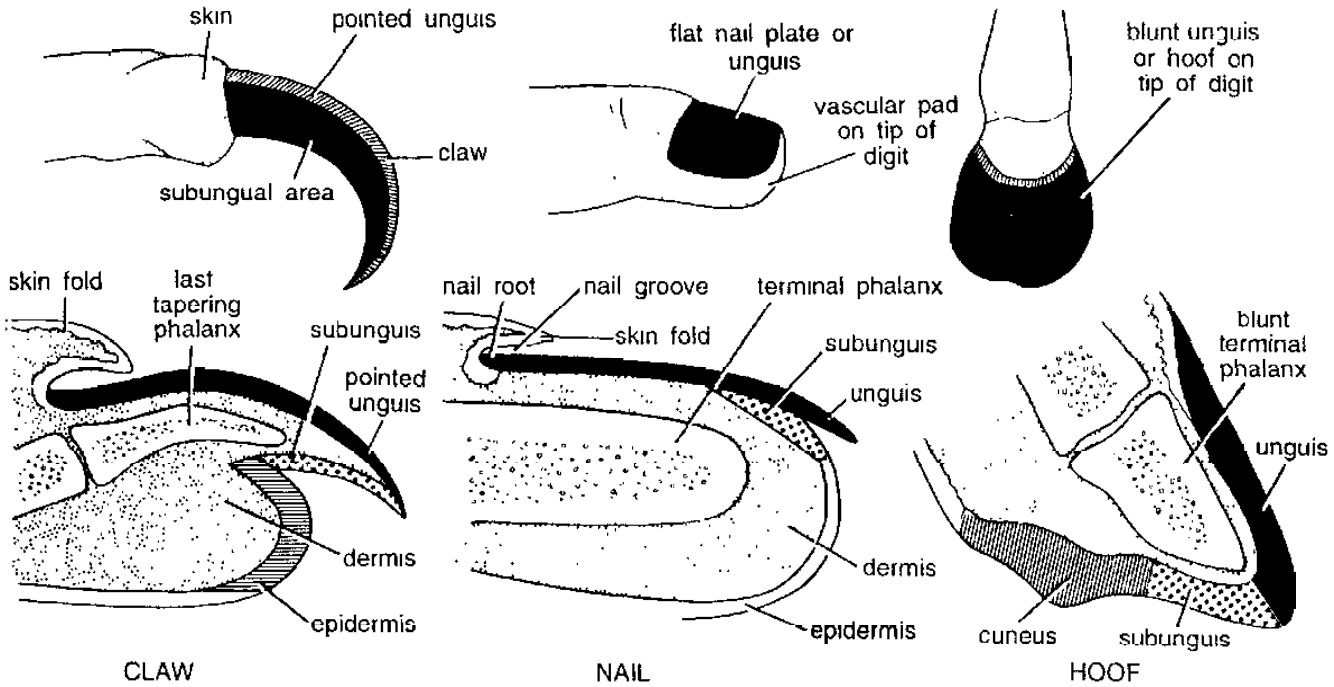

Fig. 2. Relation between claw (eagle), nail (human) and hoof (horse). Digital tips shown complete above and in sagittal sections below

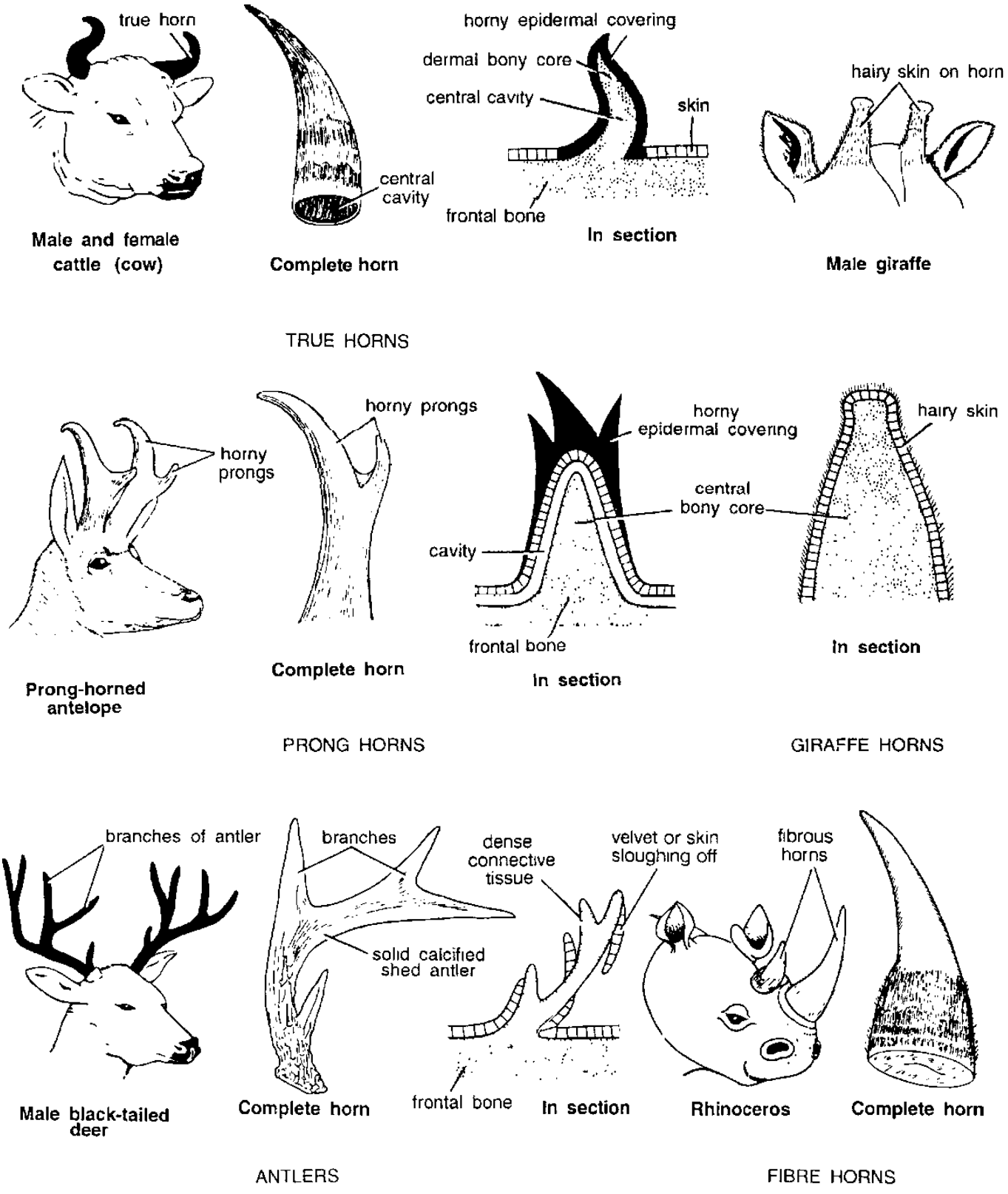

Fig 3. Types of mammalian horns and antlers.

2. Nails. Claws are modified into nails which are characteristic of Primates (mammals). Dorsal plate or unquis is broad and flat, while subunguis is softer and much reduced. The tip of the digit forms a greatly sensitive and highly vascular *pad* over which the epidermis invaginates to form a *nail groove* containing the nail root.

3. Hoofs. Hoofs are characteristic of ungulates (hoofed mammals). The horny unguis is neither pointed nor flat, but U- or V-shaped. Subunguis is also U-shaped, greatly thickened and touching ground. The horse's shoe can be nailed into it. Subunguis surrounds a softer horny substance, the *cuneus*. The tip of digit forms a pad and contains a blunt phalanx.

Other modifications of stratum corneum include the *whalebone plates* of toothless whales, and the *horny coverings* of horns of sheep and cattle and prong horns of antelopes.

[V] Horns

Horns are found in hoofed mammals (Artiodactyla and Perissodactyla) only (Fig. 3). They are present on their head and form organs of offense and defense. At least 5 types of horns are recognized, but all are not true horns, that is, product of stratum corneum.

1. True horns. True or hollow horns usually occur in both the sexes in goats, sheep, cattle and others. They are unbranched, cylindrical and tapering. They are permanent structures that continue to grow throughout life and are never shed. The true horn is made of a hollow dermal bony core arising from frontal bone of skull, and covered by an epidermal horny hollow cap.

2. Prong horns. The horns of prong-horned antelope (*Antilocapra*) are also true horns. It is formed by a small central permanent bony core arising from frontal bone and covered by a thin hollow and horny epidermal horn. But the horny sheath of a prong horn bears 1 to 3 branches or prongs, and it is shed every year. The permanent bony core becomes the base around which a new horn is developed the following year.

3. Antlers. Antlers are characteristic of deer family. They are found only on males but on both the sexes in reindeer and caribou. Antlers are annual growths and not true horns. An antler is a branching solid outgrowth of dense connective tissue connected basally to the frontal bone of skull. Deposition of calcium salts makes the antler hard. During growth, it is covered on the surface with typical hairy and vascular skin, or 'velvet'. When growth is complete, the velvet wears off, exposing the naked, branched antler. After the breeding season is over, the antlers are also shed and new antlers develop the following year.

4. Giraffe horns. Horns of giraffes are stunted, unbranched and permanent antlers present in both sexes. Each consists of a short bony dermal core, projecting from frontal bone and remains covered with simple unmodified skin or velvet which is never shed.

5. Hair horns. Hair horns or fibre horns are found in rhinoceros of both sexes. Perched upon a roughened area of nasal bones. Indian rhino has a single horn, while the African species has two, one behind the other. These horns are entirely made of thick hairy and keratinized epidermal fibres fused together. These are permanent structures and if broken they again grow out. Rhinoceroses are still slaughtered illegally because these horns are in great demand in Oriental countries as a love charm.

[VI] Feathers

Birds are covered by feathers which are not found in any other group of animals. They are dry, non-living and cornified products of stratum corneum of epidermis. These unique structures are light in weight, but strong, elastic and water-proof. They show different colours due to presence of pigments of various shades and structural arrangement. They mainly streamline and protect the body, conserve body heat and make broad surfaces of wings and tail used for flight. The mode of development of feathers is like that of scales. Feathers are moulted and replaced seasonally.

Generally, three types of feathers are recognized : countour, down (plumules) and filoplumes (hair-like). For a detailed treatment of

the structure, development, kinds and uses of feathers, readers may refer to Chapter 27.

[VII] Hairs

Hairs are characteristic of mammals. They may cover the entire body (furred animals) or may be reduced to patches (man) or to scattered hairs (whales). Like scales and feathers, hairs are also cornified epidermal products of the integument. Collectively, all the hairs covering the body of a mammal, are known its *pelage*. It is periodically lost by moulting and replaced by a new one.

Each hair originates from the bottom of a tubular invagination, or *hair follicle*, of germinative layer of epidermis into dermis. A *dermal* or *hair papilla*, containing blood vessels and nerves, nourishes the swollen *root* or *bulb*, adding new cells forming the *shaft* of the hair. The cells of the shaft become keratinized, har ened and soon d e, so that the hair protruding above the skin is a dead structure. It is lubricated by the only secretions of a *sebaceous gland* into follicle. A smooth arrector pili muscle is associated with each follicle. Typically, the hair shaft consists of three layers : an external *cuticle* made up of overlapping microscopic scales, middle *cortex* containing shrivelled cells and pigments, and inner *medulla* containing air spaces in larger hairs.

Chief functions of hairs seem to serve for insulation of body and as sensitive tactile organs (e.g. vibrissae). Hairs have several modifications (bristles, quills or spines, scales, horns, etc.) and variously used in industry.

Integument in Different Classes of Chordates

Although fundamental structure of skin remains similar in all vertebrates, yet variations occur in different classes involving : (i) presence or absence of dermal bones, (ii) relative abundance of glands in aquatic forms, and (iii) specializations of stratum corneum or surface layer of epidermis in terrestrial forms.

1. Lower chordates (Protochordata). In *Balanoglossus* and *Branchiostoma*, the integument *(Z-3)*

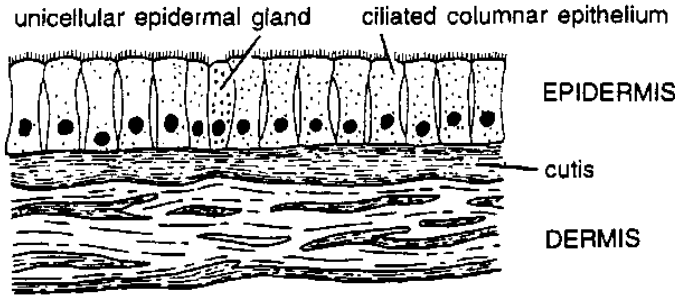

Fig. 4. Skin of a young *Amphioxus* in V. S.

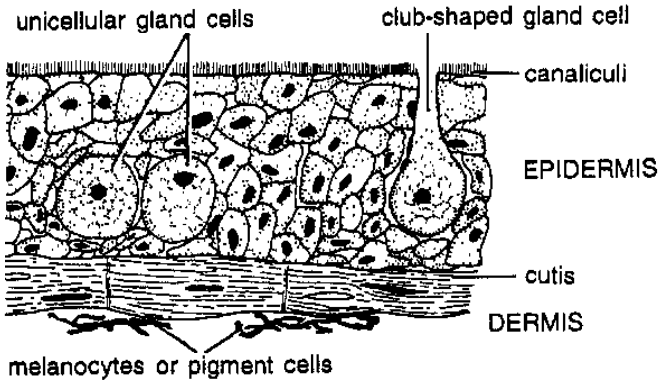

Fig. 5. Skin of a larval cyclostome in V. S.

or skin is quite simple and lacks keratin (Fig. 4). The outer epidermis is thin, made of a single layer of tall or columnar and often ciliated cells. Thus it is similar to that of invertebrates because it is stratified in all higher chordates. There are numerous unicellular epidermal gland cells, secreting a thin cuticle in amphioxus. Dermis or corium is gelatinous in amphioxus.

2. Cyclostomata. Keratin does not occur in epidermis which differs from that of protochordates (*Branchiostoma*) but resembles that of higher chordates in being multi-layered and more durable (Fig. 5). Epidermis contains three types of secretory cells or unicellular glands : *mucous glands* secrete slime, elongated *club cells* with hyaline cytoplasm are probably neural or scab-forming, and *granular cells* are of unknown function. Below epidermis, a layer of collagen and elastic fibres forms *cutis*, which also contains star-shaped *pigment cells*. They have power of migration and also present in dermis.

3. Fishes. The epidermis is several-layered but simple, thin and without a typical stratum corneum

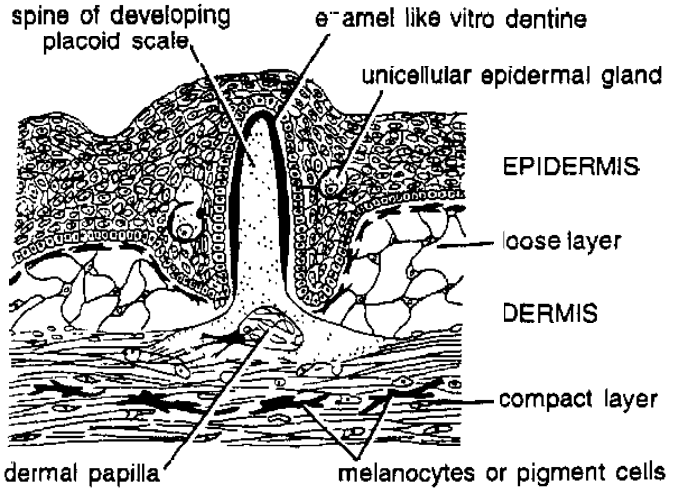

Fig. 6. Skin of dogfish embryo in V. S.

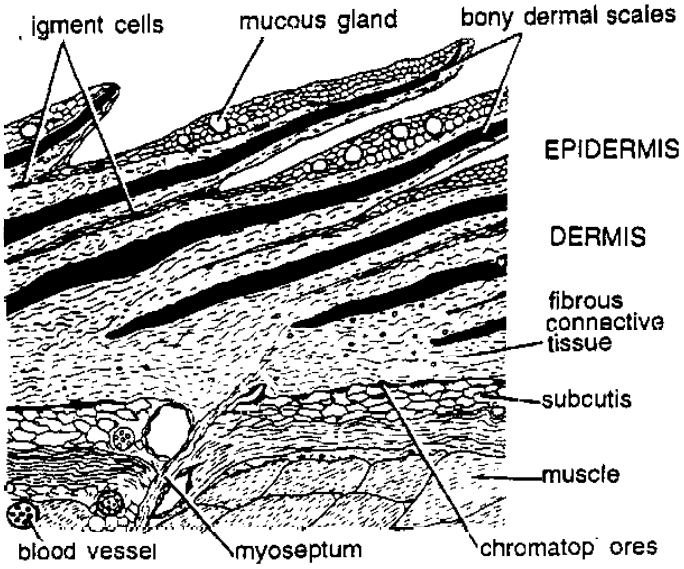

Fig. 7 Skin of a teleost fish in V. S.

as an adaptation to life in water (Figs. 6, 7 & 8). Epidermis is quite rich in unicellular *goblet* or *mucous gland cells* secreting mucous which reduces friction between body surface and water, protects from fungal or bacterial infections and controls osmosis. A few multicellular epidermal *glands*, such as *poison glands* and light-emitting organs or *photophores*, may also be found.

Dermis is typical but all the connective tissue fibres forming it run parallel to the surface. A peculiarity is the presence of atleast 5 types of *dermal scales* projecting above the surface. Of these -cartilaginous fishes (elasmobranchs) have *placoid scales*. Chondrostei and Holostei have

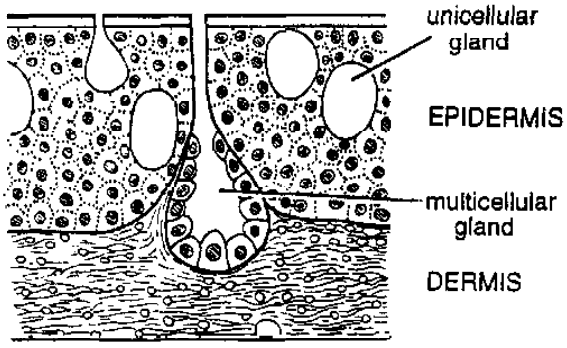

Fig. 8. Skin of a dipnoan (*Protopterus*) in V. S.

ganoid scales, while Teleostei have *cycloid* and *ctenoid scales*. *Cosmoid scales* are known from extinct Crossopterygii. Patterns and brilliance of colouration are perhaps greatest in fishes than in any other group of chordates. This is because of -i—e-t -ell- --lled *ch-----at--h--e-* --d *iridophores* containing guanin, which are found in the dermis.

4. Amphibians. Typical amphibian skin is shown by frog (Figs. 9 & 10). It is thin and less intimately attached to the underlying muscles due r rg *ubcutane u ly p pace* b-n--t- d-—is. T--ic-l ---hibi-- ski- is modified from that of fishes in atleast 3 rimar respects. (i) In aquatic forms, stratified epidermis often exhibits a *thin stratum corneum* of flat and dead keratiniz cells w ic co y g shed in patches and replaced. (ii) Amphibians are the lowest vertebrates having abundant *multicellular skin glands*, rather than unicellular. The mucous secreted keeps the skin moist and also permits respiratory gaseous exchange through richly vascular skin thus compensating for the poor development of lungs. However, the warty skin of land forms, such as toads, with heavier stratum corneum and less number of glands, resembles that of reptiles. Many amphibians have cutaneous *poison glands* (parotid glands of toad) whose toxic secretions serve toward off enemies. (iii) Skin of extinct Labyrinthodontia (stem Amphibia) was heavily armoured with *dermal scales* which are absent in modern Amphibia. However, remnants of dermal bony scales are found embedded in the skin of some

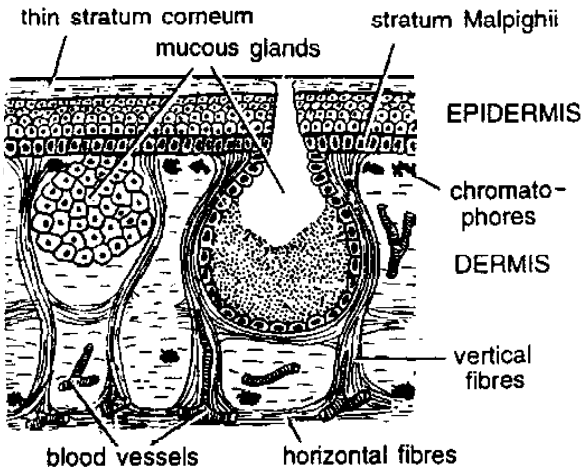

Fig. 9. Frog. V. S. skin.

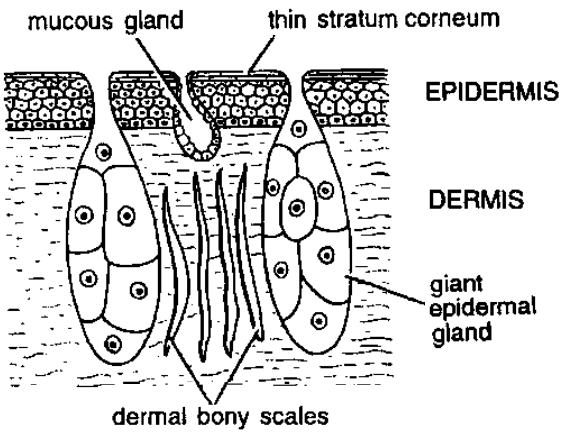

Fig. 10. *Ichthyophis*. V. S. Skin showing structure and dermal scales.

Gymnophiona and a few tropical toads. Some amphibians have the power to change body colour with the help of pigment cells or chromatophores present in dermis.

5. Reptiles. Reptiles are the first true land vertebrates and their integument shows many terrestrial adaptations (Fig. 11). (i) *Stratum corneum* is relatively thicker making the skin dry and prevent any loss of body moisture. It is variously modified to form overlapping horny *epidermal scales* covering the body, *spines, shields, scutes, plates, claws, horns, beaks, rattles* etc., forming the *exoskeleton.* These are periodically shed in small bits or even in a single piece (ecdysis or moulting). (ii) In addition to horny epidermal structures, reptiles also retain the bony dermal armour of their ancestors, in the form

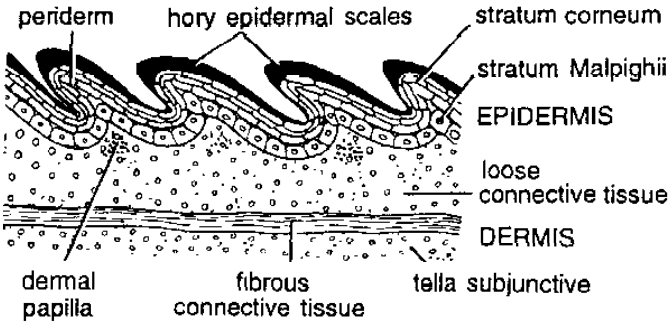

Fig. 11. Lizard. V. S. skin.

of *bony dermal scales, scutes* or *plates* called *osteoderms*, in their dermis. (iii) Reptiles exhibit relatively few *integumentary glands*, with the exception of *scent glands* for sexual attraction near cloaca in some snakes, *femoral glands* on the thighs of male lizards, and *musk glands* of musk-turtles and alligators. (iv) Some lizards and snakes exhibit elaborate *colour patterns* for concealment from predators and preys, or as warning signals. Some lizards (e.g. chamaeleons) have marked capacity to change their body colouration with the help of *chromatophores* present in dermis.

6. Birds. Skin of birds, Fig. 12 like that of other vertebrates, is composed of stratified epidermis and dermis. But, skin is thin and loosely attached to achieve maximum freedom of movement for flight. Modifications of stratum corneum, other than feathers, include horny sheaths of beaks. *Scales* are restricted to lower legs, feet, webs and base of beaks. *Claws* usually present on toes may also occur on one or two fingers (ostrich, hoatzin, geese, etc.). Like beaks, claws are also diversified and adapted to different habitats. Rest of the body is covered with *feathers* which undoubtedly evolved from epidermal scales. They protect and insulate the body. Feathers are shed and replaced seasonally. Three usual types of feathers are contour, down and filoplumes. No skin glands occur in birds with the exception of a *uropygial* or *preen gland* on tail, which is particularly well developed in aquatic birds. Its oily or waxy secretion is coated on feathers and beaks during preening. Bird skin has no chromatophores. *Melanocytes* containing pigments

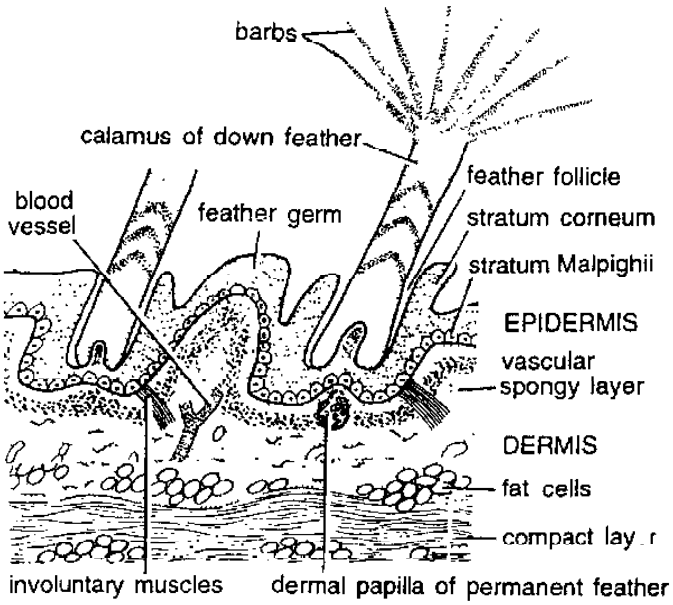

Fig. 12. Skin of a bird in V. S.

migrate into feathers and scales. Body colours are mainly due to reflection and refraction of light from feathers.

7. Mammals. Skin of mammals is elastic, water-proof, thickest of all vertebrates and variously modified (Fig. 13). The two layers, epidermis and dermis, have reached their highest specialization in mammals. The thick epidermis is differentiated into 5 layers from outside. These are *stratum corneum, stratum lucidum, stratum granulosum, stratum spinosum and stratum germinativum* or *Malpighian layer.* Stratum corneum containing keratin is particularly thicker on palms and soles having maximum friction and wear and tear. Modifications of stratum corneum include horny epidermal *scales, hairs, bristles, claws, nails, hoofs, horns,* etc.

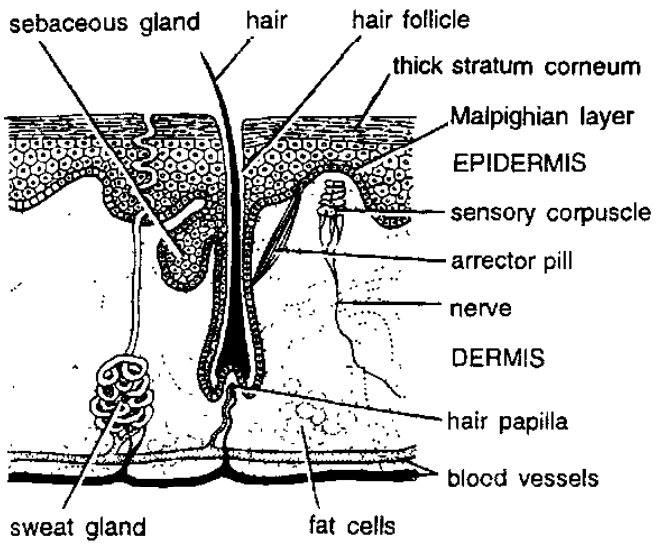

Fig. 13. Skin of a mammal in V. S.

Mammalian skin has a wide variety of *glands* which are all multicellular. Based on function there are 5 major types : *sebaceous, sweat, mammary, lacrimal* and *scent.* Of these mammary, sebaceous and sweat glands are found only in mammals. *Mucous glands* do not occur in the epidermis of mammals.

Dermis of mammals is proportionately much thicker than in other vertebrates. Except in armadillos, *dermal scales* do not occur in mammals. *Hair colour* is due to the presence of varying intensities of brown or black pigment granules between and within the hair cells. *Skin colour* is due to varying concentrations of melanin granules in basal layers of epidermis, or due to pigment-containing melanocytes located in dermis just beneath the epidermis. *Albinism* results from lack of pigments, while *melanism* results from the presence of an excess of black pigments.

IMPORTANT QUESTIONS

» ***Long Answer Type Questions***

1. What is integument? Describe the integument and its derivatives in vertebrates.
2. Give an account of the integument in vertebrate you have studied and explain its functions.
3. Discuss how the integuments of reptiles and birds are adapted to their respective modes of life.
4. Give a comparative account of integument of reptiles, birds and mammals.
5. Describe the exoskeletal structures in vertebrates you have studied.