INTEGUMENTARY

SYSTEM

- The integumentary system comprises the skin, hair, skin glands, hooves, claws, digital pads, horns and feathers.
- The skin, the body’s external covering and largest organ, is a complex structure which functions as a protective layer against physical, mechanical, chemical and biological injury. In addition, it has a role in body temperature regulation, reception of external sensory stimuli, secretion, immune responses, vitamin D synthesis and body surface pigmentation.
- The skin consists of two layers: a superficial layer, the epidermis, which is derived from ectoderm, and a deeper layer, the dermis, which develops from mesenchyme.
- A number of appendages, including hair, sweat glands, feathers and scales develop from ectoderm. Specification of these derivatives is determined by multiple signalling factors which act in a combinatorial manner.
- Epithelial–mesenchymal interactions determine region-specific appendage identity, a feature which is important in all aspects of ectodermal appendage development.

Epidermis

- The epidermis covering the embryo initially consists of a single layer of cuboidal cells resting on a basal lamina.

- Shortly after neurulation, these ectodermally-derived cells divide and give rise to a superficial layer of flattened cells, the periderm and an underlying layer of cuboidal cells, the basal layer.

- Further proliferation of the cells of the basal layer gives rise to an intermediate layer resulting in a stratified covering, the epidermis.

- The exchange of water, sodium and glucose between amniotic fluid and the epidermis probably involves peridermal cells.

- Close to mid-pregnancy, the basal epidermal cells deep to the periderm undergo differentiation, forming the typical epithelial layers characteristic of postnatal stratified squamous epithelium, consisting of a stratum basale (stratum germinativum), stratum spinosum, stratum granulosum and stratum corneum.

- Cells in these epithelial layers which synthesise the scleroprotein keratin, are termed keratinocytes.

- As the epithelium differentiates into its characteristic layers, the peridermal cells, which undergo apoptosis, are shed into the amniotic fluid.
- Loss of the peridermal layer and formation of the stratum corneum of the stratified squamous epithelium coincide with cessation of exchange of water and electrolytes between amniotic fluid and epidermis.
- This loss of exchange may also be related to the commencement of kidney function and the passing of urine into the amniotic cavity with its accumulation within the amniotic sac.

- During the period of epidermal proliferation, cells of neural crest and mesodermal origin also contribute to the population of cells found in the skin.

- Melanoblasts, derived from the neural crest, migrate to the underlying mesenchyme and later move to the basal layer of the epithelium where they differentiate into melanocytes, cells which synthesise melanin pigment.

- Langerhans cells, derived from the bone marrow, are of the monocyte–macrophage lineage.
- These cells, which are more numerous in the stratum spinosum than in other layers of the epithelium, are present in the epidermis from an early stage in embryonic development.
- Langerhans cells, which act as antigen- presenting cells for T ymphocytes, are a peripheral component of the immune system.

- A third cell type, the Merkel cell, which migrates to the basal layer of the epidermis, functions as a sensory cell through its interaction with free nerve endings.

- Merkel cells originate from epidermal progenitors during development and can detect tactile stimuli and changes in contact pressure.

Dermis

- The dermis, which develops during the late embryonic period, arises from mesenchymal cells derived in part from dermatomal cells and also from somatopleural mesoderm.

- The mesenchyme differentiates into the connective tissue cells which give rise to collagenous and elastic fibres.

Dermis

- The dermis, which is located immediately deep to the epidermis, has areas known as dermal papillae, that project into the overlying epidermis.
- The superficial papillary layer of the dermis is composed of loose connective tissue, while the thicker underlying reticular layer contains dense irregular connective tissue.
- Afferent nerve fibres, which grow into the dermis, innervate both the dermis and epidermis.

Hypodermis

- Beneath the dermis in most regions of the body, mesenchymal cells form a layer of loose connective tissue, the hypodermis, consisting of irregular bundles of collagen fibres interspersed with elastic fibres and adipocytes.
- This layer of subcutaneous connective tissue anchors the skin to underlying structures. Hypodermis is not present in particular regions such as the lips, cheeks, eyelids, auricles of the ears and anus.
- Bundles of skeletal muscle, the subcutaneous muscle, develop in the hypodermis in specific regions of the body, such as the thoracic and cervical regions.
- The nature and depth of the hypodermis vary considerably with species.

- The skin contains a variety of nerve endings which are more numerous in hairless areas than in hair-covered areas.

- While sensory fibres are prominent in the dermis and hypodermis, they also extend to the external root sheaths of hair follicles and between the cells of the deeper layers of the epidermis.

- Nerve endings in the skin can be divided morphologically into free nerve endings and encapsulated nerve endings.

- Three vascular networks parallel to the skin surface, the subcutaneous, cutaneous and superficial plexuses, provide the arterial blood supply to the skin.

a) The subcutaneous plexus is derived from arterial branches to superficial cutaneous structures.
b) The cutaneous plexus, which supplies the hair follicles and sweat glands, arises from branches of the subcutaneous plexus.
c) The superficial plexus, which develops from branches of the cutaneous plexus, supplies the papillary processes.

Hair

- One of the features which distinguishes mammals from other vertebrates is the presence of hair.
- Slightly raised elevations on the smooth bare skin in areas around the lips, periorbita, cheeks and lower jaw of the foetus are the first macroscopic evidence of hair development.
- With the exception of notable anatomical regions, the entire body surface of domestic animals is covered by closely spaced hairs.
- Areas devoid of hair include the muzzle, muco-cutaneous junctions, hooves and digital pads.
- Marked variation in hair density, type, distribution pattern and colour is evident among species and, within species, hair characteristics are breed related.

- The primordial structures from which hairs develop arise during the early foetal period when the epidermis is composed of three layers.

- Solid proliferations from the basal layer of the epidermis project into the underlying mesenchyme, forming hair buds or pegs.

- As the hair peg extends into the dermis at an oblique angle, an aggregation of mesenchymal cells, known as the hair papilla, projects into the tip of the peg.

- The epidermal cells of the peg grow around the hair papilla like an inverted cup, forming the hair bulb.
- The structure formed from the epidermal ingrowth, together with the hair papilla, is referred to as a hair follicle.
- The inner layer of epidermal cells of the hair bulb which gives rise to the hair shaft and epithelial root sheaths is known as the germinal matrix.
- The formation of hair follicles requires interactions between cells in the basal layers of the epidermis and the underlying mesoderm.

- On contraction, these muscle bands, known as arrector pili muscles, decrease the greater angle between the hair follicle and the skin surface, thereby moving the hair shaft into an erect position. Arrector pili muscles are especially well developed along the dorsal midline of dogs where they cause the hair to become erect in response to a threat of aggression.

- Primordia of sebaceous glands form as cellular outgrowths from the basal epithelial layer of the walls of developing hair follicles at levels closer to the surface than the points of attachment of arrector pili muscles. Smaller epidermal outgrowths, superficial to sebaceous gland primordia, may develop from the follicular wall forming the primordia of sweat glands.

Mammalian skin glands

- Based on their morphology and secretions, two distinctly different types of glands, sweat glands and sebaceous glands, can be identified in mammalian skin.

- In particular species of animals, special skin glands located in different regions of the body develop either as a modification of one of these basic types or from a combination of both types.

Sebaceous glands

- Glands referred to as sebaceous glands are distributed in the skin of domestic animals in association with hair follicles.

- These glands usually develop later than sweat glands and arise as lateral outgrowths of the basal epithelium of the developing follicles deep to the sweat gland primordia.

- These glands develop as pear-shaped lobular structures with clusters of acini opening into a single short wide duct. As a consequence of repeated mitotic division within sebaceous glands, small basal cells give rise to cells which migrate into and fill the acinar lumen.

Sweat glands

- Based on their modes of secretion, mammalian sweat or sudiferous glands are considered to be of two types, apocrine and eccrine.

- Secretion from eccrine glands, merocrine secretion, is through exocytosis, a process whereby small secretory granules are discharged into the gland ducts.

- Apocrine glands discharge large granules within secretory vesicles which contain a portion of the cell’s cytoplasm. This process of secretion is referred to as apocrine secretion.

- Apocrine sweat glands develop as nodular outgrowths of the basal layer of the epithelium of the hair follicle closer to the skin surface than sebaceous glands.

- The dense cellular proliferation extends into the connective tissue, and the base of the gland may be located deep to the hair bulb.

- A lumen develops in the distal region of the apocrine gland and extends to the site of origin of the gland where it opens into the hair follicle as the gland duct.

- Following formation of the lumen, the gland is lined by a double layer of cells; the inner layer forms the secretory acini and the outer layer differentiates into myoepithelial cells located between the secretory cells and the basal lamina.

Development of mammary glands in domestic animals

- In higher mammals, the fully functioning mammary gland is a compound tubulo-alveolar structure demarcated by connective tissue into lobes and lobules.
- In domestic animals, mammary glands arise from two epithelial thickenings on the ventral body wall of the embryo, the mammary lines, which extend from the axillary region to the inguinal region.
- The number of glands and their location vary with individual species. Among domestic species, dairy cattle occupy a particularly important position as milk-producing animals, a purpose for which they have been selectively bred.
- Accordingly, the development of the bovine mammary gland will be used to illustrate the sequential stages of differentiation of this secretory organ.

- It is usual to consider mammary gland development in two stages, prenatal differentiation and postnatal development.
- In the bovine embryo at approximately 30 days of gestation, the mammary line extends from the forelimb buds to the hindlimb buds.
- Changes which occur in the epidermis during the development of the mammary line are induced by the underlying mesoderm.
- That portion of the mammary line caudal to the umbilicus marks the area in which future mammary gland development takes place.
- Two distinct epidermal thickenings, mammary crests, form on each mammary line and initially appear lenticular in cross-section

- With continued epidermal proliferation, the thickenings, which project into the mesenchyme, acquire a semilunar appearance and are referred to as mammary buds.
- The buds are separated from the mesenchyme by well-developed basement membranes. Cellular changes subsequently occur at the centre of the buds.
- The cells at the periphery become columnar with their long axes pointing towards the centre of the buds, while cells at the central zone are not as densely packed and appear to undergo cornification.
- During this stage of development, the portions of the mammary line not incorporated into the mammary crests or buds gradually regress. Up to the mammary bud stage, the process of mammary development is similar in male and female embryos.
- Thereafter, the mammary buds in the female embryo become ovoid, with their long axes perpendicular to the surface, while in the male embryo they tend to become spherical.

- Proliferation of mesenchymal cells surrounding the mammary bud causes outward projection of the tissues forming a conical papilla or primitive teat.

- The epidermal cells of the bud proliferate and move into the mesenchymal tissue forming a club-shaped structure with the narrower portion pointing towards the tip of the developing teat.

- This structure is referred to as the primary sprout.

- The epidermal cells at the apex of the teat become cornified, forming a slight depression at the tip.

- At approximately the fourth month of gestation, the primary sprout becomes canalised at its proximal end, forming the gland sinus (gland cistern).

- As the canalisation continues towards the apex, the teat sinus (teat cistern) and the papillary duct (teat duct) form.

- The vascular supply, muscle and connective tissue components of the teat wall are of mesenchymal origin.

- After the fourth month of gestation, 8 to 12 secondary sprouts radiate from the gland sinus into the surrounding tissue.

- When canalised, these secondary sprouts form the lactiferous ducts, which in later development drain the lobes into the gland sinus.

- Tertiary sprouts arise from the lactiferous ducts which complete the primitive duct system.

- The rudimentary duct system, which continues to develop until birth, is confined to the body of the gland in the region of the gland sinus.