

THE MICROSCOPIC ANATOMY OF THE
INTEGUMENT OF THE COMMON
AMERICAN GOAT

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**THE MICROSCOPIC ANATOMY OF THE INTEGUMENT OF
THE COMMON AMERICAN GOAT**

By

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INTRODUCTION

Dermatology is a relatively new field in veterinary medicine. Only recently have significant advances been made in the diagnosis of skin diseases. There is a limited amount of research work available on the histology of the integument of domestic animals. Among the domestic animals, the goat is the most neglected species in this particular area of study. In many countries goats are an important economic asset by being a source of food, wool and leather. Knowledge of the normal histology is essential in the diagnosis of histopathological conditions of the integument. The main purpose of this investigation is to supply adequate knowledge of the normal histology which will serve as a useful reference for comparative studies.

REVIEW OF LITERATURE

A careful search of the literature did not reveal any detailed histologic study of the skin of the goat. Microscopic, submicroscopic and histochemical studies have been primarily done on the human integument.

Microanatomy of the integument of domestic animals has been described by Ellenberger (1906), Sisson and Grossman (1953), and Trautmann and Fiebiger (1957). Research on the histologic structure of the skin of some of the domestic animals has been conducted in the Department of Anatomy, Michigan State University. These studies have included the skin of the mongrel dog (Webb and Calhoun, 1954), the cat (Strickland, 1958), cattle (Goldsberry and Calhoun, 1959), the white rat (Holmes, 1960), newborn swine (Smith, 1960), and the fetal pig (Fowler, 1962) and the mature hog (Marcarian, 1962).

Margolena (1959) has described the development and differentiation of the skin and hair follicles of the common American and Toggenburg goats from fetal stages through maturity. Zelenskii (1960a, b) has investigated the breed differences in the coat and the degree of development of the skin in goats and has also presented a histologic method for determining the hair density. Walter (1961) has studied the sensory innervation of the lip and nasal areas, while Kimura and Tsuyoshi (1962) have discussed the innervation of the goat's apocrine glands.

According to Ellenberger (1906) the skin of the goat is thicker, firmer and more elastic than sheep skin. The thickness of the skin and its strata varies according to the species, breed, sex, age and body

region (Trautmann and Fiebiger, 1957). It is thicker on the dorsal and extensor surfaces than on the ventral and flexor surfaces. It is also thicker in males than in females in the human species (Montagna, 1956; Ham, 1957). According to Sisson and Grossman (1953), the skin of the ox is the thickest among all domestic animals.

Trautmann and Fiebiger (1957) mentioned that skin is the thinnest in the eyelid and the thickest on the shoulder and back. Findlay and Yang (cited by Hafez et al., 1955) in 1948 found that in temperate zones the Ayrshire breeds have thinner skin in the ventral region of the body than in the lateral and dorsal regions. Hafez et al. (1955) reported thinner skin in the dorsal and lateral regions of both Egyptian cattle and buffaloes. Goldsberry and Calhoun (1959) have found the skin of the dorsal thorax thicker than that of the lateral thorax in Hereford and Aberdeen Angus cattle. Margolena (1959) described variations in the skin thickness of the common American and Toggenburg goats due to shedding of hairs in different seasons of the year.

Epidermis

The outer layer of the skin, the epidermis, consists of stratified squamous epithelium. It shows variations in thickness and configuration (Creed, 1958). The epidermis is further subdivided into four cell layers (Creed, 1958; Lever, 1961; and Hu and Cardell, 1962). Starting from the innermost layer to the outer surface of the skin they are: (1) stratum basale, (2) stratum spinosum, (3) stratum granulosum, and (4) stratum corneum. An additional layer, the stratum lucidum is generally found in the thick skin of the palms and the soles of human species located between the stratum corneum and the stratum granulosum. This homogeneous and translucent layer usually is not seen in the integument of domestic animals except in the foot pads and the planum nasale of the dog and cat (Webb and Calhoun, 1954; Strickland, 1958) and the ovine foot

(Deane et al., 1955). According to Andrew (1959), the mammalian epidermis is composed of at least two layers, sometimes three, and occasionally even four layers. Ferreira-Marques (1961) divided the epidermis into two metabolic zones, namely, the proximal zone--the stratum oxybioticum, and the distal zone--the stratum anoxybioticum. The stratum oxybioticum lives by respiration whereas the stratum anoxybioticum obtains energy by fermentation or similar process.

Stratum basale: This consists of a single layer of columnar or cuboidal cells (Deane et al., 1955; Trautmann and Fiebiger, 1957; Creed, 1958). Two types of cells, the basal cells and the melanocytes, are found in this layer (Hu and Cardell, 1962). Basal cells are columnar and present desmosomal connections with the adjoining cells. These cells have a deep basophilic cytoplasm and a dark staining oval or elongated nucleus (Lever, 1961). This strong cytoplasmic basophilia is due to the abundance of cytoplasmic nucleoproteins. This basophilia gradually diminishes as the nucleoproteins change into sulfahydryl groups in the upper cell layers (Creed, 1958). Frequently mitotic figures indicating cellular regeneration are seen. In pigmented skin, the basal cells contain melanin granules around the upper pole of the nucleus and these are called supranuclear caps. These granules are elaborated by melanocytes present between the basal cells. It is believed that melanin is transferred in some manner from melanocyte processes into adjacent epidermal cells (Odland, 1958).

Melanocytes are found wedged in between the basal cells of the epidermis. In sections stained with hematoxylin and eosin, melanocytes appear as clear cells having a small dark staining nucleus and a slightly basophilic cytoplasm (Lever, 1961). Formerly, the melanin producing dendritic or clear cells were considered to be modified basal cells. As a result of the work of Rawles (1947) and Dushane (1948), there is now general agreement that they are normal cells that originate in the

neural crest and migrate with nerves to the epidermis during the early fetal life. Clear cells in human epidermis may be either melanocytes or keratinocytes (Clark et al., 1961).

Occasionally a peg cell, triangular in shape with the long axis of the nucleus parallel to the basement membrane and the melanin granules distributed evenly throughout the cytoplasm, is observed under the electron microscope (Hu and Cardell, 1962).

Stratum Spinosum: The cells of this layer are called prickle cells and the layer is often referred to as the prickle cell layer. The cells are polygonal in shape and present intercellular bridges. Phase contrast microscopy reveals that the cytoplasm of the basal and prickle cells contains numerous tonofibrils around the nucleus radiating towards the cell border. These tonofibrils contain sulfahydryl and disulfide groups (Montagna, 1956). These tonofibrils are composed of great numbers of very thin filaments which do not pass through the intercellular bridges into adjacent cells (Bloom and Fawcett, 1962). The intercellular bridges of light microscopy are sites of end-to-end contact of small protoplasmic processes on adjacent cells. At the point of contact the cells are firmly attached by means of surface specializations called desmosomes (Bloom and Fawcett, 1962).

Stratum Granulosum: The fusiform or diamond-shaped cells of the stratum granulosum are arranged in one to five cell layers (Creed, 1958; Lever, 1961) and contain characteristic keratohyalin granules. These granules are coarse, irregular in size and deeply basophilic. The size of these granules varies in different species (Matoltsy, 1962). As the cells from the granular layer gradually keratinize, the keratohyalin granules are not recognizable. However, the exact fate of these granules and the process of keratinization are not well understood (Matoltsy and Matoltsy, 1962). The main constituents of the horny component of

cornified cells are derived from cytoplasmic fibrils' and keratohyalin granules. Keratohyalin granules disintegrate at an advanced stage of cell maturation, and their material mixes with the fibrous constituents of the cell (Matoltsy, 1962).

Stratum Corneum: The superficially formed epidermal layer, stratum corneum, is dry and hard. It consists of dead, cornified flattened cells without nuclei or with degenerative nuclei. The superficial layer of this stratum, which is constantly in the process of desquamation, is called stratum disjunction (Finerty and Cowdry, 1960). The desquamated cells are replaced by the cells from the lower epithelial layer. The horny layer is relatively thicker in the areas where the skin is subject to constant pressure (Kral, 1960).

Dermis

The dermis, or corium, lies directly beneath the epidermis and is divided into a superficial papillary layer and a deeper reticular layer. These two layers are not clearly separated from each other (Bloom and Fawcett, 1962). The inward limit of the papillary layer may be marked by an imaginary line joining the innermost surfaces of the epithelial ridges. This layer is inconspicuous where the epidermis is devoid of rete pegs (Finerty and Cowdry, 1960). The surface of the papillary layer bears cone-shaped papillae which usually contain capillary loops. Trautmann and Fiebiger (1957), in describing different kinds of dermal projections discussed large, slender papillae in hairless areas. Collagenous, elastic and reticular fibers are present in the dermis.

Collagenous fibers: These fibers and their bundles are coarser towards the subcutaneous tissue and finer towards the outermost portion of the dermis. In the papillary layer they are arranged irregularly whereas in the reticular layer they are parallel to the surface of the skin

(Lever, 1961). In the reticular layer the fibroblasts are usually very thin, long and compressed. In the papillary layer they are larger and resemble mesenchymal cells (Montagna, 1956).

Elastic Fibers: Dick (1947) described two types of yellow elastic tissue, large fibers in the deeper part of the dermis and a fine network of small fibers lying close to the epidermis. Dempsey (1948) reported that in cattle, elastic fibers form a considerable portion of the connective tissue in the papillary layer. Creed (1958) observed the presence of fine elastic fibers in both layers of the dermis. Lever (1961) described dense elastic fibers in the lower part of the dermis and irregular and vertical elastic fibers in the upper part. In the ox, sheep and dog some elastic fibers join the collagenous bundles, whereas others form a fine network in the superficial layer of the dermis (Trautmann and Fiebiger, 1957).

Reticular Fibers: These are generally seen between the epithelium and connective tissue (Robb-Smith, 1957). Fibers are found in the upper part of the papillary layer underneath the epidermis and either form the basement membrane or a part of it. They are numerous around the sweat glands and in the connective tissue sheath of hair follicles. In the reticular layer the reticular fibers are well developed around blood vessels and form a basket-like capsule around each fat cell (Montagna, 1956). Dick (1947) has noted that at the dermo-epidermal junction the reticular fibers are distinct from elastic tissues.

In the goat, progressive thickness of the dorsal corium takes place as the kid matures. The male goat has a heavier dermis in both ventral and dorsal regions (Margolena, 1959). The relative depth of the grain layer (papillary layer) to the full thickness of the dermis is small in the ox, greater in the goat, and still greater in sheep (Dempsey, 1948).

Dermo-epidermal Junction: The dermis is separated from the epidermis by a basement membrane which serves to anchor the epidermis according to the views of the light microscopists. This membrane consists of an amorphous intercellular substance enclosing a complex argyrophilic network through the meshes of which the cytoplasmic processes of the basal cell protrude (Medwar, 1953; Montagna, 1956). According to Cooper (1956) the epidermis is attached to the dermis by the continuity of the dermal elastic plexus with the subepidermal basement membrane. This membrane must either be cemented to or incorporated in the cell membrane of each basal cell. By electron microscopy, Odland (1958) confirmed the existence of a moderately dense homogenous structure of the basement membrane which is not penetrated by the dermal collagenous filaments. This membrane is approximately 35 millimicrons thick and is undoubtedly homologous to the membrane which surrounds the capillaries (Hu and Cardell, 1962).

Mast Cells

Mast cells were discovered by Ehrlich in 1877. According to Hellstrom and Holmgren (1950) Brach in 1925 stated that cutaneous mast cells occur more abundantly in children than in adults. Montagna (1956) found them most numerous in the papillary layer and around the capillary beds. Riley (1959) reported a high content of mast cells in the ears of mice and rats. Hansen (1957) described mast cells as large connective tissue cells with a central nucleus and cytoplasm with densely arranged metachromatic granules. Lever (1961) described them as small spindle-shaped cells with oval or round nuclei, resembling fibroblasts in appearance. Hellstrom and Holmgren (1950) observed that the mast cells are arranged predominantly around the blood vessels but they also occur around hair follicles and in the papillary layer of the dermis. These authors further classified two types of cutaneous mast cells. The first

type is always found beneath the epithelium in the papillary layer and is a small polymorphous cell with a small nucleus. The cytoplasm contains fine granules showing conspicuous metachromasia. The second type which is found in the deeper layer of the dermis has more cytoplasm, a large nucleus and contains a varying amount of coarse granules.

Hair

Hairs are horny, cylindrical shafts which develop from the epidermis. Each hair arises from the hair follicle, the walls of which are composed of both epidermis and dermis. In animals, hair grows more rapidly in winter than in summer (Kral, 1960), and the physiological shedding of hair is of great importance, especially in horses, cattle, goats, dogs, cats and also some species of wild animals. The goat has two types of hair, the cover hairs and the lanugo hairs which form the undercoat (Chauveau, 1873; Ellenberger, 1906; Elias, 1944; Trautmann and Fiebiger, 1957). According to Elias (1944), the lanugo hairs present in sheep, goat and some breeds of swine do not contain a medulla and the outer surface of the cuticle is rough. Ellenberger (1906) reported that the thickness of the cover hair is 60-80 microns, whereas the thickness of the lanugo hair is 6-20 microns. The lanugo hairs of the goat are even finer than sheep's wool. The medullary cell of the cover hair is triangular in goats (Trautmann and Fiebiger, 1957).

Hair follicle: The hair follicles appearing earliest are referred to as primary follicles and in goats they are characterized by the accessory structures--the sebaceous and sudoriferous glands and the arrector pili muscle. The primary follicles develop in groups of three (Margolena, 1959) and remain distinguishable throughout their lives. The development of secondary follicles in goats extends through fetal and early postnatal life. These follicles can be distinguished from the primary follicles by

their small size (Margolena, 1959; Ryder, 1960). They also lack the accessory structures except the sebaceous gland, which may be absent occasionally (Carter, 1955). According to Ryder (1960) Auber and Ryder in 1956 described compound hair follicles in sheep which are characterized by more than one secondary follicle opening into a single follicular lumen.

Hair muscle: The arrector pili muscle, a band of smooth muscle fibers, attaches to the hair follicle just below the level of the sebaceous gland and runs obliquely upwards to terminate in the papillary layer of the dermis. These muscles are rich in elastic tissue (Trautmann and Fiebiger, 1957; Bloom and Fawcett, 1962). Dempsey (1948) described elastin fibers attaching the arrector pili muscle at one end to the wall of the hair follicle and at the other to the surface of the dermis. Copenhaver and Johnson (1958) described the smooth muscle fibers ending in delicate elastic bands which are continued by the general elastic network of the corium. Contraction of this muscle causes the simultaneous erection of the hair and the compression of the sebaceous glands (Kral, 1960). The tactile hair and the vibrissae lack the smooth arrectores pilorum muscles (Vincent, 1913; Davidson and Hardy, 1952; Helen and Montagna, 1953). However, they are attached to striated muscle fibers (Trautmann and Fiebiger, 1957).

Follicular folds: Follicular folds in cover hair follicles just below the opening of the sebaceous duct to the hair follicle were observed in cattle by Goldsberry and Calhoun (1959). Montagna (1956) described similar follicular folds in the mouse, rat and sheep. Later, these folds were reported by Strickland (1958) in the cat, Smith (1959) in newborn swine, Holmes (1960) in the rat, Fowler (1962) in the fetal pig and Marcarian (1962) in adult Yorkshire hogs. These authors have attributed various functions to these folds but the functional significance of their presence is not clearly understood.

Tactile Hair

Vincent (1913) reported that Dietl as early as 1873 demonstrated two kinds of sinus hairs, one with a ringwulst and a ring sinus as in the cat and rat, and the other without a ringwulst, found in the horse and cow. In 1897 Botezat described two types of tactile hairs in swine, with and without a ringwulst (Davidson and Hardy, 1952). Friedenthal (1911) furnished an excellent description of sinus hairs of domestic animals including the goat in his "Tierhaaratlas." According to Trautmann and Fiebiger (1957), vibrissae are not sinus hairs and they are restricted to the nostrils. "Vibrissae or sinus hairs" are defined as sensory hairs by Davenforth in 1925 (cited by Davidson and Hardy, 1952) and can be distinguished from other types of hair by the presence of erectile tissue in their follicle.

The connective tissue capsule of the tactile hair is highly developed and rich in elastic tissue. A blood sinus lined with endothelium intervenes between the outer and internal layer of the dermal sheath. In ungulates the sinus is traversed by numerous fibro-elastic trabeculae from the dermal sheath and resembles a cavernous structure (Trautmann and Fiebiger, 1957). According to Helen and Montagna (1953) the dermal sheath of the sinus hair extends to the level of the sebaceous gland. Due to its structural resemblance to embryonic tissue the authors also named it the mesenchymal sheath. Vincent (1913) reported the absence of the ringwulst in the tactile hair of apes. Davidson and Hardy (1952) reported the presence of one small sebaceous gland but no sweat glands on the vibrissa of the mouse. Attachment of the skeletal muscle fibers to the tactile hair follicle was reported by Vincent (1913) and Holmes (1960) in the rat, Davidson and Hardy (1952) in mice, and Strickland (1958) in cats. Vincent (1913), Helen and Montagna, (1953), and Dixon (1961) described the innervation of the tactile hair follicle.

Sebaceous Glands

These are simple or branched alveolar holocrine glands which arise in the fetus by the proliferation of the outer epithelial root sheath of the hair follicle (Copenhaver and Johnson, 1958). The size of these glands varies according to the species, breed, and skin area. They are small in young animals and increase both in size and activity at maturity when larger amounts of sex hormones are produced (Kral, 1960). They open to the surface of the skin by way of a pilosebaceous canal with the exception of a few body areas, where they are independent of hair follicles. In ungulates, two to six sebaceous glands empty into one hair follicle. The excretory ducts of sebaceous glands are lined by stratified squamous epithelium continuous with the external root sheath of the hair and with the Malpighian layer of the epidermis (Bloom and Fawcett, 1962). Goldsberry and Calhoun (1959) gave an account of highly developed sebaceous glands in the perianal region, at the horn, hoof and muzzle margin in cattle. These glands are absent in the hairless areas.

Ellenberger (1906) reported better developed sebaceous glands in goats than sheep and described sebaceous glands with long ramified excretory ducts in the beard hair follicle of the goat and also large sebaceous glands in the interdigital skin. Trautmann and Fiebiger (1957) mentioned the presence of branched alveolar horn glands, caudomedial to the base of the horn. These authors further reported the absence of sebaceous glands from the planum nasale of goats.

Sebaceous acini are composed of closely packed large central cells and smaller peripheral cells which are undifferentiated and which resemble epidermis (Montagna and Kenyon, 1949). The secretion of the sebaceous gland called sebum appears to be the product of disintegration of the alveolar cells. Various stages of secretory activity are seen in the different cell layers (Copenhaver and Johnson, 1958).

Sweat Glands

The majority of the tubular skin glands of domestic animals are apocrine and they are associated with hair follicles, except the tactile hair follicles (Trautmann and Fiebiger, 1957). The tubules of the apocrine glands have wide lumina and the cytoplasm of the lining cells contains many secretory granules (Hibbs, 1962). These glands are covered with a denser layer of myoepithelial cells, the peristaltic contraction of which helps to empty the secretion of the glands (Hurley and Shelley, 1954). Hibbs (1962) noted that the principal mode of secretion in human axillary glands is by droplet secretion through the apex of the cell. Trautmann and Fiebiger (1957) described two types of secretory tubules in apocrine glands, whereas Hafez, et al. (1955) noted two types of secretory activities of apocrine glands both in cattle and buffaloes. Goldsberry and Calhoun (1959) observed saccular-coiled, saccular-noncoiled and compound tubular apocrine glands in cattle. Nay (1959) reported tubular, baggy and club-shaped apocrine sweat glands in cattle. According to Ellenberger (1906) the sweat glands of goats are similar to that of the sheep but are less developed. In sheep the secretory tubule is glomiform, whereas in goat it is serpentine (Trautmann and Fiebiger, 1957).

The planum nasale of sheep and goat bears modified tubular serous glands (Trautmann and Fiebiger, 1957). Macalister (1878) reported the absence of interdigital glands in goats. Kimura and Tsuyoshi (1962) investigated the functional activity of the apocrine sweat glands in the hairy skin of the goat.

MATERIALS AND METHODS

Source of Animals

Ten common American goats including six females and four males were used in this investigation. These animals were obtained from the Department of Physiology and Pharmacology, Michigan State University. The age of nine animals varied from seven months to four years, and the age of one was not determined. Sections from two additional animals were procured for the special glandular structure of the planum nasale.

Technique

The goats were killed by electrocution and the skin from thirty-one body regions (Plate 1) was removed immediately and fixed in a mixture of commercial formalin, 95% ethyl alcohol, glacial acetic acid, and distilled water (Lavdowsky's mixture, Guyer, 1949). The tissues were removed from this fixative after 5 days and kept in 70% ethyl alcohol until the time of dehydration and infiltration.

After fixation, the tissues were dehydrated and cleared by four changes of dioxan (Bucher and Blackely, 1936) and infiltrated in paraffin using the vacuum method for one hour and fifteen minutes. The tissues were embedded in Bioloid¹ (melting point 56-58° C).

Horizontal and vertical sections were cut at six microns. The following stains were employed: (1) Harris hematoxylin and eosin (Malewitz and Smith modification, 1955), (2) Mallory's triple stain (Crossman's modification, 1937), (3) Weigert and Van Gieson's connective tissue stain, (4) Gomori's reticulum stain, (5) 0.5 percent aqueous

¹Will Corporation and Subsidiaries Laboratory Supplies, Rochester 3, New York.

toluidine blue solution for mast cells, (6) Alcian Blue--Periodic Acid Schiff stains for mucins in the glands of the planum nasale, and (7) Alcian Blue with nuclear fast red as a counterstain to demonstrate acid mucopolysaccharides according to the technique described in "Manual of Histology and Special Staining Technique (1957)."

Measurements

The thickness of the epidermis and dermis was measured by means of an ocular micrometer. Measurements were taken at five different places including the highest and lowest points in a representative field of the skin sections and the average thickness was determined. As the thickness of the skin varied from place to place the range of the thickness was recorded. Average skin thickness for male and female goats was determined separately.

PLATE I

Body areas from which skin specimens were taken

Section No.

A. Head

1. Forehead	1
2. Junction of the horn with the skin	23
3. Muzzle	24
4. Base of the ear	25
5. Tip of the ear	26
6. Base of beard	27
7. Eyelid--upper	30

B. Neck

1. Dorsal neck	2
2. Lateral neck	12
3. Ventral neck	6
4. Wattle	28

C. Thorax

1. Dorsal thorax	3
2. Lateral thorax	13
3. Ventral thorax	7

D. Trunk

1. Dorsal abdomen	4
2. Lateral abdomen	14
3. Ventral abdomen	8
4. Flank	11
5. Udder or scrotum	9
6. Teat	29
7. Base of tail--dorsal	5
8. Perianal region--dorsal	21a
9. Perianal region--ventral	21b

E. Pectoral Limb

1. Axillary region	10
2. Lateral antebrachial region	16
3. Lateral metacarpophalangeal joint	17
4. Junction of the hoof with skin	22

F. Pelvic Limb

1. Hip region	15
2. Lateral hock joint	20
3. Lateral crural region	18
4. Lateral metatarsal region	19
5. Interdigital region	31

Table 1. Skin thickness of general body regions of common American goats in millimeters.

Body areas	Goat No. Age	Female goats							Male goats				
		1	2	3	4	6	7	Av.	5	8	9	10	Av.
		17m	17m	15m	17m	15m	17m	17m	Adult	4yrs	7m	7m	7m
Forehead		2.6	2.6	3.0	-	3.1	-	2.9	3.7	2.4	2.3	1.8	2.6
xDorsal neck		3.5	5.7	2.9	3.5	2.3	-	3.6	3.4	1.6	1.4	2.2	2.1
Lateral neck		3.5	3.2	1.9	3.1	2.7	2.6	2.8	2.1	1.5	1.4	1.7	1.7
oVentral neck		2.0	3.2	3.2	2.6	2.2	2.8	2.7	3.4	2.0	1.7	1.7	2.2
xDorsal thorax		3.3	3.6	4.9	4.9	2.6	2.5	3.6	2.1	2.6	1.6	1.4	1.9
oLateral thorax		2.6	3.2	2.5	1.8	2.1	2.6	2.5	2.9	2.0	1.1	1.3	1.8
Ventral thorax		3.2	2.8	2.7	2.1	2.9	3.5	2.9	1.7	2.0	1.1	1.4	1.6
xDorsal abdomen		2.9	2.7	4.2	3.2	3.4	3.1	3.2	2.7	2.6	1.0	1.5	1.9
Lateral abdomen		2.8	3.1	4.1	2.7	2.2	4.1	3.2	2.3	-	1.0	1.3	1.5
Ventral abdomen		2.8	3.2	1.8	3.4	2.1	3.2	2.8	2.0	1.8	1.6	1.3	1.7
oFlank		2.7	2.6	2.5	2.9	1.7	3.0	2.5	3.0	1.7	1.1	1.3	1.8
Axillary region		2.7	3.6	2.5	2.7	2.2	3.1	2.8	2.7	2.0	1.3	1.9	2.0
oAntebrachium (Lat.)		2.2	2.4	2.4	2.2	3.5	3.6	2.7	2.2	1.3	1.1	0.7	1.3
oHip		3.0	2.7	1.9	2.2	3.1	-	2.6	2.5	1.3	1.1	1.5	1.6
Crural region (Lat.)		2.7	2.7	2.6	2.1	3.3	3.1	2.8	1.5	1.4	1.1	1.3	1.3
Average		2.9	3.1	2.9	2.8	2.6	3.1	2.9	2.5	1.9	1.3	1.5	1.8

x = Region of thickest skin.

o = Region of thin skin.

Table 2. Skin thickness of special body regions of common American goats in millimeters.

Body areas	Goat No. Age	Female goats							Male goats				
		1	2	3	4	6	7	Av.	5	8	9	10	Av.
		17m	17m	15m	17m	15m	17m	17m	Adult	4yrs	7m	7m	7m
Wattle		2.9	2.2	3.0	2.4	2.1	-	2.5	-	-	1.3	2.0	1.7
**Horn junction		3.0	2.9	2.9	1.3	2.6	2.2	2.5	3.1	1.7	1.1	1.8	1.8
**Muzzle		2.3	2.1	2.2	2.5	1.8	2.3	2.2	1.9	1.9	1.8	1.8	1.8
Base of ear		2.1	1.9	2.1	2.1	2.3	2.5	2.1	2.2	1.5	1.4	1.6	1.6
*Tip of ear		0.8	0.7	0.6	0.8	1.0	1.0	0.8	-	0.6	0.7	0.7	0.7
Base of beard		3.5	3.1	2.4	2.5	2.2	3.0	2.8	-	3.0	1.2	2.2	2.1
Eyelids, upper		1.6	2.1	2.0	2.8	1.8	2.0	2.1	-	1.8	1.4	2.0	1.8
Udder or scrotum		2.7	1.9	1.7	1.6	3.5	1.9	2.2	2.6	1.2	2.2	1.7	1.9
Teat		2.3	1.6	1.7	2.0	2.3	2.2	2.0	-	-	-	-	-
Base of tail		3.3	1.3	2.3	3.2	2.7	3.3	2.7	3.4	-	1.4	1.6	2.2
*Perianal region (dorsal)		-	1.0	1.7	1.1	1.6	1.2	1.3	-	1.4	1.5	1.5	1.5
Perianal region (ventral)		2.0	1.9	1.4	1.3	2.2	2.5	1.9	1.5	1.5	-	-	1.5
Hock joint		2.1	1.2	2.0	1.6	2.3	2.6	2.0	1.8	1.2	1.1	1.1	1.3
Metacarpophalangeal joint (lat.)		1.7	1.6	2.0	1.4	1.9	1.9	1.7	2.4	2.3	1.3	1.3	1.6
**Hoof junction		2.6	1.7	2.1	2.0	2.5	2.6	2.2	2.4	1.9	1.3	1.1	1.7
Metatarsal region (lateral)	1.8	1.4	2.0	2.0	1.7	2.6	2.2	2.0	2.2	1.5	1.1	1.5	1.6
Interdigital skin		2.5	1.6	1.9	2.0	2.2	2.9	2.2	-	1.6	1.1	1.6	1.4
Average		2.3	1.8	2.0	1.9	2.2	2.3	2.1	2.3	1.6	1.3	1.5	1.6

*The thinnest skin in the body.

**Areas of the thickest epidermis in the body.

RESULTS AND DISCUSSION

Skin Thickness

In the present investigation variation in the thickness of the skin and its strata was observed with relation to sex, age, body regions and individuals of the same age groups. Among the thirty-one body areas considered for the measurements of skin thickness, the thickest skin was found in the region of the forehead, dorsal neck, dorsal thorax, and the base of the tail (dorsal) both in male and female goats (table 1, 2). Gradual thinning of the skin from dorsal to ventral body regions was noticed in the region of the neck, thorax, and abdomen. Strickland (1958) found the thickest skin in the dorsal neck, lumbar, and sacral regions of the cat. Goldsberry and Calhoun (1959) reported the skin of Hereford and Angus cattle was thickest in the head, neck, and brisket. According to the views of Hafez et al. (1955), in temperate zone the thick skin of dorsal and lateral regions protects the animals from cold. The pinna in both sexes (table 2) and the dorsal perianal region in females (table 2) have the thinnest skin. The skin was comparatively thicker in female goats. This difference in skin thickness may be attributed to the age of the animals, as the female goats were older than the males. Probably for the same reasons variation in skin thickness occurred among individual male goats. No such variations in skin thickness were observed in female goats. The average skin thickness of the general body areas of adult goats was 2.9 mm. From the previous work done on swine (Marcarian, 1962) and cattle (Goldsberry and Calhoun, 1959), it would appear that the skin of the goat is thicker than the skin of swine (2.2 mm) and considerably thinner than that of cattle (6 mm).

The thickest epidermis was found on the planum nasale (Plate III), muzzle (Plate VIII), forehead, at the junction of the horn and hoof, perianal region, interdigital skin and the udder. Somewhat thinner epidermis was observed on the ventral abdomen, thorax, neck, axilla, flank and the thinnest on the pinna. Thick epidermis was not necessarily evident on the thick skin. However, the epidermis was invariably thicker on the dorsal neck, thorax and abdomen than on the lateral and ventral regions. These findings were in agreement with the observations of Margolena (1959), who reported thicker epidermis (30 microns) in the mid-dorsal than in the mid-ventral region (21 microns) in adult goats.

In the present study the average epidermal thickness varied from 24.6 to 95.6 microns in male and 37.1 to 228.3 microns in female goats. The maximum epidermal thickness was 484.5 microns on the muzzle. The ratio of the epidermal thickness to the total skin thickness varied markedly in different body areas and no constant figure was obtained. Zelenskii (1960b) reported the epidermal percentages in the skin of Tajik, Angora and Tajik coarse breeds as 1.10, 0.70, and 1.60, respectively.

The thickest dermal areas were usually present on the forehead, dorsal neck, thorax and abdomen, base of the tail, and lateral crural region whereas the thinnest dermis was observed on the pinna. The gradual decrease of dermal thickness from dorsal to ventral through the lateral body region was marked in the thoracic and abdominal areas.

Epidermis

The epidermis of the goat generally consisted of four layers, stratum corneum, stratum granulosum, stratum spinosum and stratum basale, since the stratum lucidum was present only in the thick epidermis of the muzzle and the junction of the hoof with the skin.

Stratum corneum. The stratum corneum was present in all body regions studied and was most prominent in the interdigital skin, hoof and horn margin, muzzle and the planum nasale (Plate III, VIII). The pinna, having the thinnest epidermis, also showed a distinct layer of stratum corneum (Plate V). Clear-cut membranes of individual cells were not observed and nuclei were absent (Plate VIII). According to the views of Steigleder and Wolfgang (1962), the disappearance of nuclei in the horny layer in human skin was caused by RNase activity.

Stratum lucidum. The stratum lucidum, a shiny, translucent, homogenous, acidophilic layer was best seen in the muzzle (Plate VIII), planum nasale and the hoof margin. This observation was partly in agreement with the finding of Webb and Calhoun (1954) in the planum nasale of the dog and of Strickland (1958) in the planum nasale of the cat. The cell boundaries were difficult to make out and in most cases nuclei were not visible. In some cases vacuoles were seen in place of nuclei. This layer was not found in other body regions.

Stratum granulosum. The stratum granulosum, lying immediately beneath the stratum corneum except when the stratum lucidum came between, consisted of one to five layers of diamond-shaped cells containing characteristic keratohyalin granules. In some of the body areas this layer was not readily noticeable and was represented only by an occasional cell. The nuclei of these cells were undergoing karyolysis while the cytoplasm contained the dark staining granules. Finerty and Cowdry (1960) reported similar findings in human skin. In the thick epidermis of the planum nasale, muzzle, interdigital skin and junction of hoof with the skin this layer was more prominent and even more than five layers were visible (Plate VIII). Goldsberry and Calhoun (1959) could not find a distinct granular layer in the thick epidermis of the muzzle in Hereford and Aberdeen Angus cattle.

The long axis of the cells of this layer was parallel to the skin surface (Plate VIII). The basophilic granules of these cells were not uniform in size and shape. Matoltzy (1962) also reported a variation in size and shape of the keratohyalin granules in rat skin. These granules were larger and more condensed towards the stratum corneum than towards the stratum spinosum and they suddenly disappeared in the deepest layer of the stratum corneum. The cell boundaries of these cells were not sharp and nuclei were not distinct in all cells. The enzymic activity of acidophosphatase in the stratum granulosum may be associated with the lysosomes characterizing the degenerating cells of this layer (Maeir and Angrist, 1962).

Stratum spinosum. The stratum spinosum consisting of several layers of polyhedral cells with rounded nuclei was present in all the body regions. Where there were prominent rete pegs present, as many as eight to ten cell layers were common (Plate VIII). The cells of these layers were characterized by the presence of desmosomes which were more pronounced in the muzzle, planum nasale, interdigital skin and the hoof and horn margins (Plate IX). Keratohyalin granules were lacking in these cells. However, in some of the cells of the upper layer basophilic granules were distributed in the cytoplasm. Occasionally cells with pyknotic nuclei and acidophilic cytoplasm were observed indicating degenerated cells. Mitotic figures were common in the cells of the deeper layer.

Stratum basale. The stratum basale, the deepest layer of the epidermis, consisted of a single layer of columnar or cuboidal cells. The long axis of these cells was perpendicular to the basement membrane (dermo-epidermal junction). These cells had dark staining nuclei with basophilic cytoplasm. In some of the body regions, especially in the pigmented skin of the ear and planum nasale, these cells contained

cytoplasmic melanin granules at the upper pole of the nucleus. Hu and Cardell (1962) described these granules as a "supranuclear cap" in human skin. The basal cells had numerous cytoplasmic processes extending into the dermo-epidermal junctions. A second type of cell containing melanin granules with dendritic processes was wedged between the cells of the basal layer. These cells were probably the melanocytes or dendrocytes (Horstmann, 1960) or the peg cells (Hu and Cardell, 1962). Clear cells with clear cytoplasm and condensed basophilic nuclei were observed frequently. Cell divisions were noticed among the basal cells denoting multiplication.

Dermis

The dermis was composed of two layers, the papillary layer and the reticular layer. There was no sharp distinction between these two layers in most of the body regions as they blended with each other without demarcation (Plate II, VII).

Papillary layer. This layer was characterized by the presence of dermal papillae (Plate III, VIII). Large, well-developed papillae marked the hairless skin of the planum nasale, muzzle, interdigital region, perianal region and hoof and horn margins. Smaller papillae were present in the hairy skin. Compound papillae with branching were found in the perianal regions of female goats (Plate IV) and in the planum nasale (Plate III).

The collagenous fibers of the superficial layer of the dermis were fine, loosely arranged and irregularly distributed. These fibers were thick and densely arranged in the reticular layer and they formed bundles which usually paralleled the skin surface (Plate II). The fibroblasts present in the superficial layer were larger than the thin, long, compressed fibroblasts of the deeper layer.

Fine elastic fibers were distributed in the superficial part of the dermis and they showed branching and some fibers extended to the sub-epidermal surface. A network of these fibers also was observed. These findings were in agreement with the description of elastic fibers by Dick (1947), Dempsey (1948), Creed (1958), and Lever (1961) in other species. Some of these elastic fibers joined the collagenous bundles in the dermis. Similar observations were reported in the ox, sheep and dog (Trautmann and Fiebiger, 1957). Particularly in the papillary layer, the direction of some of these fibers was perpendicular to the skin surface. These fibers were presumably the vertical fibers described by Lever (1961).

In the deeper part of the dermis these fibers were thick and less numerous. Some of them were parallel to the skin surface. Most of these fibers were arranged around the hair follicle in the form of a close network (Plate X). Some of them were also found in the sub-cutaneous tissue.

Elastic fibers were more abundant in the younger goats. As the goats became older the number of elastic fibers decreased. No specific sex differences were established in the content and distribution of elastic fibers. Few elastic fibers were seen in the interdigital skin, and junction of the hoof and horn with the skin. The distribution of elastic fibers was more pronounced in the neck and thoracic regions.

Reticular fibers were seen in the deeper part of the dermis, around the sweat glands, sebaceous glands, wall of the blood vessels, in the connective tissue capsule of the hair follicles and at the dermo-epidermal junction (Plate XI).

Dermo-epidermal junction

Sections stained with Gomori's modified reticulum stain revealed the presence of a fine meshwork of argyrophilic reticular fibers at the

dermo-epidermal junction (Plate XI). According to the views of histologists this meshwork of reticular fibers is a part of the basement membrane.

Mast cells

Mast cells were distributed throughout the dermis but they were invariably more abundant around the capillary beds (Plate VII). Similar observations were made by Hellstrom and Holmgren (1950) in human dermis. It was not uncommon to find these cells around the hair follicles and along the course of the arrectores pilorum muscles (Plate VII). Large numbers of mast cells appeared to be increased in the ear, neck, ventral abdomen and scrotal skin of the goat. Riley (1959) reported large numbers of mast cells in the ear of mice and rats.

Two types of mast cells were found. One type resembling fibroblasts was a small spindle-shaped cell with an oval nucleus and contained fine metachromatic granules. These cells were located just below the epidermis. The second type of mast cells was commonly seen in the deeper part of the dermis. They had more cytoplasm, a large oval nucleus and a considerable amount of coarse metachromatic granules. The distribution of these two types of mast cells was not strictly limited to any particular layer. The metachromatic activity of these cells was due to the storage of acid mucopolysaccharides within the cell itself (Montagna, 1962). No age or sex differences in the concentration and the distribution of mast cells were noticed.

Hair

The microscopic structure of the hair and the hair follicle was similar to the description given by the histologists. In goats two types of hair follicles were present--the primary and the secondary follicles

(Plate II, VI). Accessory structures, the sweat gland, sebaceous glands and the arrector pili muscle were associated with the primary follicle (Plate II, VI). No accessory structures except sebaceous glands were observed in secondary follicles (Plate VI). The diameter of these primary hair follicles was larger than the secondary ones. The hair roots of the secondary follicles were located higher in the dermis than the primary ones (Plate II). The primary follicles were arranged in groups of three as previously reported by Margolena (1959) in the Toggenberg and the common American goats. Secondary hair follicles three to six in number were associated with the arrangement of three primaries or within the trio of the primaries (Plate XII). Cover hairs of the goats were developed from the primary hair follicles, whereas lanugo or wool hairs were developed from the secondary follicles. A group of lanugo hairs was seen emerging from a common follicle and thus formed a compound hair follicle. Ryder (1960) made similar observations in sheep. Elastic fibers were abundant in the connective tissue capsule of the hair follicle (Plate X). The outer layer of this capsule blended with corium without any sharp demarcation. This layer was highly vascular and rich capillary plexuses were distributed around the capsule (Plate XIII).

Shedding of hair usually takes place in goats as in most mammals. Occasionally different stages in the replacement of hair were observed (Plate XIV). The new hair grew out alongside the old hair and finally replaced it.

Follicular folds. Follicular folds in primary hair follicle were found just below the opening of the sebaceous duct into the hair follicle (Plate VI, XV). These folds are formed by the inner epithelial root sheath (Henle's layer, Huxley's layer and the cuticle of the sheath) on both sides of the follicle and project horizontally and obliquely into the follicular lumen. Goat skin presented variations in the number and size

of these folds, but the reasons for those variations were not determined. No follicular folds were found superior to the opening of the sebaceous duct into the follicle as Smith (1960) and Marcarian (1962) described in newborn and mature swine. The inner epithelial root sheath extends upward with the hair from the papilla as far as the opening of the sebaceous glands where it terminates (Trautmann and Fiebiger, 1957). These follicular folds apparently result from the contraction of the internal epithelial root sheath below the opening of the sebaceous gland. These contractions of the inner epithelial root sheath may be attributed to two factors: 1. Sudden constriction of follicular lumen superior to the opening of the sebaceous duct may produce the contraction of the inner epithelial root sheath. 2. Pressure induced by the discharge of sebum through the duct to the follicle may produce contraction of the inner epithelial root sheath. The number and size of these folds may possibly depend on the extent of contraction produced by those factors. These folds may be formed as the intermediate stage in the process of disintegration of the inner epithelial root sheath.

Arrector pili muscle. The arrectores pilorum muscles were attached to the lower third of the primary hair follicles obliquely and extended to the papillary layer of the dermis passing around the sebaceous gland (Plate VI). Branching of these muscles was often seen in the papillary layer. Large numbers of elastic fibers were found at the attachment of these muscles to the connective tissue capsule of the hair follicle. The elastic fibers at the papillary end of the arrector pili muscle showed branching and some of these fibers extended to the sub-epidermal surface. Arrectores pilorum muscles were well developed on the dorsal neck, thorax, abdomen and tail regions. No arrectores pilorum muscles were associated with the secondary hair follicles in the goat. This agrees with the findings of Ryder (1960) for the sheep.

Smooth muscles not associated with hair follicles were distributed in the dermis of the udder, teat and scrotum.

Tactile hair

The characteristic ungulate type of tactile or sinus hair without an annular sinus and ringwulst was present on the muzzle, eyelid, and beard of the goat. These tactile hairs were surrounded by a well developed thick connective tissue capsule (Plate XVI, XVII, XVIII). A blood sinus was enclosed between the outer and inner layer of the connective tissue sheath (Plate XVI, XVII, XVIII). The inner layer was similar to mesenchymal connective tissue and was rich in elastic fibers. Numerous fibroelastic trabeculae were seen connecting the outer and internal layer of the connective tissue, thus dividing the sinus into many compartments and giving the appearance of a cavernous structure (Plate XVI, XVII, XVIII). Instead of arrectores pilorum muscles, skeletal muscle fibers from the underlying body muscles inserted on the connective tissue capsule of the sinus hair (Plate XVIII). Similar observations were reported by Vincent (1913) and Holmes (1960) in the rat, Davidson and Hardy (1952) in mice and Strickland (1958) in the cat. Small sebaceous glands were associated with these tactile hair follicles (Plate XVI, XVII), but no tubular apocrine skin glands were found with relation to these follicles.

Sebaceous glands

The sebaceous glands in goats were simple or branches alveolar glands and were distributed throughout all the body areas. With few exceptions these glands were associated with hair follicles and opened into the follicular lumen through a long or short duct below the opening of the sweat duct (Plate XXIX). In the eyelid, perianal region and lips

they opened independently of hair follicles (Plate XXII). Sometimes one duct on each side opened into the follicle. The shape and the size of these glands varied considerably in different body regions. Well developed branched alveolar sebaceous glands were found at the junction of the hoof with the skin, base of the ear, base of the horn and perianal region. The horn glands at the base of the horn described by Trautmann and Fiebiger (1957) were large, branching, alveolar sebaceous glands which completely encircled the hair follicle (Plate XIX, XX). Typical branching sebaceous acini characterized the perianal region (Plate IV, XXI). The large tarsal glands of the eyelid were surrounded by a connective tissue capsule and drained through one or more excretory ducts to the margin of the lid (Plate XXII). These glands were arranged in linear series as described by Strickland (1958) in the cat. The author could not find the large sebaceous glands in the corium of the interdigital skin as reported by Ellenberger (1906).

The animals used in this investigation were of different age groups and the sex differences were not ascertained.

The glandular portion of the sebaceous acinus was composed of several layers of cells bound peripherally by a basement membrane. A central lumen was observed in some of these acini. The basal acinar cells were polygonal in shape and contained large light staining nuclei and nucleoli. The central cells were undergoing degeneration and appeared vacuolated. The cells between the basal and central cells were intermediate in structure. Variable amounts of dense granules were present in their cytoplasm. In the neck of the gland there was a gradual transition from the glandular cells to ductal cells and then to the outer epithelial root sheath of the hair follicle.

Sweat glands

With the exception of the compound tubular sweat glands in the planum nasale (p. 32), coiled tubular apocrine sweat glands were found in all the body areas investigated. The size of these glands varied considerably in different body regions. Large coiled glands were mainly found in the skin of the udder, teat, scrotum, perianum and the eyelid (Plates XXIII, XXVI and XXVIII). Especially large glands were present in the skin of the udder (Plate XXIII). In some of these secretory tubules the epithelium was columnar with spherical nuclei and the apical portion of the cells projected into the lumen, presenting a star-like appearance. Other tubules had wide lumina and the cells were cuboidal or flattened with small nuclei (Plate XXIII). These dissimilarities in the structure of the secretory cells may be related to the functional state of the glands. Homogenous material was occasionally seen in the lumen of these secretory tubules suggesting apocrine secretion. The small coiled apocrine glands characteristic of other body regions were located deep in the corium below the sebaceous glands and sometimes were clustered around the base of the hair follicle (Plate XXIV). Their long excretory ducts opened into the neck of the hair follicle above the opening of the sebaceous glands (Plate VI). The secretory tubules were wide and sac-like and narrowed abruptly as they passed into the excretory ducts (Plate XXV).

Longitudinally oriented myoepithelial cells were interposed between the basement membrane and the tubular cells (Plates XXIII and XXX). The excretory duct was lined by two layers of cuboidal cells and lacked myoepithelial cells. Goldstein (1961) described transitional cells intermediate in appearance between myoepithelial cells and the basal cells of the duct in the apocrine sweat glands of the adult ear in human and vervet monkey.

No specialized glandular structure was found in the interdigital skin except the small coiled tubular apocrine glands.

Special Body Areas

Planum nasale. The thick epidermis of the planum nasale consisted of five layers as described before and the cells of the basal layer were highly pigmented (Plate III). Mitotic figures were seen in this layer. Well developed, prominent dermal papillae extended to the stratum corneum (Plate III).

The glands of the planum nasale were multilobular and tubulo-acinar. They were made up of acini joined by intercalated ducts leading to interlobular striated ducts which in turn opened into interlobular ducts (Plate XXVII). The interlobular connective tissue septa were derived from the connective tissue capsule surrounding the glands of the planum nasale. Bands of skeletal muscle were seen in the glandular and interlobular septa in some regions (Plate XXVII).

These glands revealed structures similar in character to serous glands. However, some of these acini indicated the presence of acid mucopolysaccharides. They were also P.A.S. negative (method of Pearse, 1961). In contrast to the goat the nasolabial glands of the ox are mucus secreting according to recent investigations by Mackie and Nisbet (1959).

Many sensory nerve endings were found in the skin sections of planum nasale and lip stained by the Bielschowsky modified method (Cauna, 1959). In the dermis between the glands of planum nasale and the epidermis these structures resembled lamellar corpuscles or terminal bulbs of varying sizes and shapes (Plate XXXI). These lamellar structures had a well developed connective tissue capsule.

The inner bulb was represented either by oval or elongated structures with endings of nerve fibers contained within them. In some of these elongated structures a knob or brush-like expansion of the terminal end was seen (Plate XXXII).

The round or oval shaped corpuscles with few lamellae (2 to 4) were found either singly or in groups of four to six nerve endings within a connective tissue capsule (Plate XXXIII). The connective tissue covering of the nerve fiber was continuous with the capsule of the lamellated structures. These specialized nerve endings were presumably similar in structure to the Golgi-Mazzoni corpuscles. In longitudinal section the axis-cylinder and the inner bulb were found terminating into long brush-like tapered endings surrounded externally by the lamellar corpuscle. Occasionally a complicated network of nerve fiber was seen within the capsule. Fine branching nerve filaments of nerve fibers were found in the dermal papilla of the planum nasale.

Pinna. The pinna consisted of a central core of elastic cartilage covered by skin on both surfaces. The skin was thinnest of all the body regions studied (table 2). Rete pegs were present only on the convex side. Pigment granules in the form of supranuclear caps were visible in the basal cells of both surfaces. With the exception of the tip of the ear, density of the hair follicle on the convex surface was more marked in comparison to the concave surface, where very few hair follicles were noticeable (Plate V). No skeletal muscle on either side of the elastic cartilage was observed in the tip of the pinna.

Wattle. The wattles of the goat are skin appendages present at the neck region. They consisted of a central piece of elastic cartilage, blood vessels, large nerve trunks, subcutis, and skin with its associated structures (Plate XXXIV). The morphological characteristics of

the glandular structures of the wattle were the same as in other body areas. These findings were similar to the observation of Myezkowski (1960) except for the additional cartilage plate reported by him. In the present study the author observed a band of smooth muscle within the stroma of the wattle, instead of skeletal muscle described by Trautmann and Fiebiger (1957).

Teat. The skin of the teat of the goat contained hairs and consisted of four layers of epidermal cells (Plate XXXV). Pigment granules were present in the cytoplasm of the basal cells. The dermis contained large amount of collagenous and elastic fibers with dermal papillae. The smooth muscle fibers were irregularly arranged in the connective tissue below the level of the skin glands (Plate XXXV). No distinct muscular layer was evident as was described in the cow (Trautmann and Fiebiger, 1957). Large sebaceous glands associated with hair follicles and well developed coiled apocrine glands with prominent myoepithelial cells were present in the teat of the goat (Plate XXVIII). The stroma of the teat was rich in blood vessels and nerve plexuses.

SUMMARY AND CONCLUSIONS

Ten common American goats including six females and four males varying from seven months to four years of age were used in this investigation.

Variation in skin thickness was observed with relation to sex, age, body regions and individuals of the same age group. The thickest skin was found on the forehead and the dorsal aspect of the body and diminished in thickness towards the lateral and ventral body regions. The thinnest skin was observed in the pinna. Thick epidermis was not consistently present on the thick skin.

The epidermis of the goat generally consisted of four layers: stratum corneum, stratum granulosum, stratum spinosum and stratum basale. The stratum lucidum was observed only in the muzzle, the planum nasale and the hoof margin. The stratum granulosum characterized by keratohyalin granules was prominent in the region of thick epidermis. The shape and the size of these granules were not uniform. Occasionally basophilic granules distinct from keratohyalin granules were observed within the cells of the stratum spinosum. Melanocytes and clear cells in addition to basal cells were frequently encountered in the basal layer.

The papillary and reticular layers of the dermis were not clearly separated from each other in thin-skinned areas where rete pegs were absent. The content of elastic fibers in the dermis varied in different body regions. These fibers were more abundant in younger goats.

Two kinds of mast cells were found and their distributions were not limited to any particular layer of the dermis. However, large numbers of mast cells were located along the course of the arrectores pilorum muscles.

In goats both primary and secondary hair follicles were present. The primary hair follicle was characterized by accessory structures, which included the sweat gland, sebaceous glands, and the arrector pili muscle. The secondary follicle was distinguished from the primary by its small diameter and the absence of two accessory structures, the sweat gland and the arrector pili muscle. The secondary follicles, 3 to 6 in number, were arranged within a group of three primaries.

Follicular folds formed by the inner epithelial root sheath of the primary hair follicle were found just below the opening of the sebaceous duct into the hair follicle. These folds may either result from the contraction of the inner epithelial root sheath or represent an intermediate stage in the process of disintegration of the inner epithelial root sheath.

Arrectores pilorum muscles were prominent on the dorsal neck, thorax, abdomen, and tail regions and were rich in elastic tissue. Smooth muscles in addition to those associated with hair follicles were observed in the dermis of the udder, teat and scrotum.

The characteristic ungulate type of tactile hair without an annular sinus and ringwulst was present on the muzzle, eyelid and beard of the goat. Skeletal muscle fibers arising from the underlying body muscles were inserted into the connective tissue capsule of the sinus hair. Small sebaceous glands, but no tubular apocrine skin glands, were associated with these hair follicles.

Especially large branched alveolar sebaceous glands were located at the hoof margin, base of the ear, base of the horn (horn gland), in the eyelid (tarsal gland) and the perianal region.

Tubular coiled apocrine sweat glands were found in all the body regions examined with the exception of the planum nasale, where modified glands resembling serous salivary glands were present. Especially large coiled apocrine glands were found in the skin of the udder, teat, scrotum,

perianum and eyelid. The secretory tubules of these glands were of two structural types suggestive of the different stages of apocrine secretion. A dense layer of myoepithelial cells was interposed between the basement membrane and the single layer of the secretory cells of the tubule.

The glands of the planum nasale were serous, and their interglandular septa contained skeletal muscle. Many sensory nerve endings resembling lamellar corpuscles were encountered in the skin of the planum nasale.

The concave surface of the pinna contained few hair follicles and large sebaceous glands. A band of smooth muscle fibers was found within the stroma of the wattle but skeletal muscle previously described by Trautmann and Fiebiger (1957) was not observed. The skin of the teat contained large sebaceous and coiled tubular apocrine skin glands.

LITERATURE CITED

- Andrew, W. 1959. Textbook of Comparative Histology. Oxford Press.
- Bloom, W. A. and D. W. Fawcett. 1962. Textbook of Histology. 8th ed. W. B. Saunders Co.
- Bucher, C. J. and R. D. Blackely. 1936. The use of dioxane in the preparation of histological sections by the paraffin method. Arch. Path. 22:225.
- Carter, H. B. 1955. The hair follicle group in sheep. Animal Breed. Abst. 23:101-116.
- Cauna, N. 1959. The mode of termination of the sensory nerves and its significance. J. Comp. Neurol. 113:169-210.
- Chauveau, A. 1873. Comparative Anatomy of the Domestic Animals. Translated and edited by George Fleming, New York. W. R. Jenkins.
- Clark, W. H., M. C. Watson, and B. E. Watson. 1961. Two kinds of "clear" cells in the human epidermis, with a report of a modified Dopa reaction for electron microscopy. Amer. J. Path. 39:333-344.
- Cooper, J. H. 1956. The basement-membrane-elastic system of the dermoepidermal junctions. Nature, Lond., 178:643-644.
- Copenhaver, W. M. and D. D. Johnson. 1958. Bailey's Textbook of Histology. 14th Ed. The Williams and Wilkins Company, Baltimore.
- Creed, R. F. S. 1958. The histology of the mammalian skin with special reference to the dog and cat. Vet. Rec. 70:171-175.
- Crossmon, G. 1937. Crossmon's modifications of Mallory's triple stain. Anat. Rec. 69:33-38.
- Davidson, P. and M. H. Hardy. 1952. The development of mouse vibrissae in vivo and in vitro. Jour. Anat. 86:342-356.

- Deane, H. M., R. W. Davis, G. P. Epling, and Rue Jensen. 1955. The anatomy of the integument of the ovine foot. *Amer. Jour. Vet. Res.* 16:197-202.
- Dempsey, M. 1948. The structure of the skin and leather manufacture. *J. Roy. Microscop. Soc.* 67:21-26.
- Dick, J. C. 1947. Observations on the elastic tissue of the skin with a note on the reticular layer at the junction of the dermis and epidermis. *J. Anat.* 81:201-211.
- Dixon, A. D. 1961. The innervation of hair follicles in the mammalian lip. *Anat. Rec.* 140:147-158.
- Dushane, G. A. 1948. The development of pigment cells in vertebrates. In *The Biology of Melanomas*. Spec. Pub. New York Acad. Sci. 4:1-4.
- Elias, H. 1944. *Histology of Domestic Animals*. 2nd ed. Middlesex University. Waltham, Massachusetts.
- Ellenberger, W. 1906. *Handbuch der Vergleichenden Mikroskopischen Anatomie der Haustiere*. Paul Parey, Berlin, 1:173-175.
- Ferreira-Marques, J. 1961. A contribution to the biology of the epidermis: Stratum oxybioticum and stratum anoxybioticum. *J. Invest. Derm.* 36:63-64.
- Finerty, J. C. and E. V. Cowdry. 1960. *A Textbook of Histology. Functional Significance of Cells and Intercellular Substances*. 5th ed. Lea and Febiger, Philadelphia.
- Fowler, E. H. 1962. The developmental histology of the integument of fetal pigs. Thesis. Michigan State University.
- Friedenthal, H. 1911. *Tierhaaratlas*. Jena, Verlag Von Gustav Fischer.
- Goldsberry, S. and M. L. Calhoun. 1959. The comparative histology of the skin of Hereford and Aberdeen Angus cattle. *Amer. Jour. Vet. Res.* 20:61-68.
- Goldstein, D. J. 1961. On the origin and morphology of myoepithelial cells of apocrine sweat glands. *Jour. Invest. Derm.* 37:301-309.

- Guyer, M. F. 1949. *Animal Micrology*. University of Chicago Press. Chicago.
- Hafez, E. S. E., A. L. Badreldin, and M. M. Shafei. 1955. Skin structures of Egyptian buffaloes and cattle with particular reference to sweat glands. *Jour. Agri. Sci.* 46:19-30.
- Ham, A. W. 1957. *Histology*. J. P. Lippincott Co. Philadelphia.
- Hansen, A. G. 1957. On the structure and functions of the mast cells. *Connective tissue symposium*. Edited by R. E. Tunbridge, C. C. Thomas, Springfield, Illinois.
- Helen, P. M. and W. Montagna. 1953. The tactile hair follicles in the mouse. *Anat. Rec.* 115:129-149.
- Hellstrom, B. and H. Holmgren. 1950. Numerical distribution of mast cells in the human skin and heart. *Acta Anat.* 10:81-107.
- Hibbs, R. G. 1962. Electron microscopy of human apocrine sweat glands. *Jour. Invest. Derm.* 38:77-84.
- Holmes, R. A. 1960. The microscopic anatomy of the skin of *Mus Norvegicus Albinus*. Thesis. Michigan State University.
- Horstmann, E. 1960. Die elektronenmikroskopische Struktur der Haut. (Translated by the Translating Section, Library Branch, Division of Research Services, National Institutes of Health, Bethesda, Maryland, No. 12-23-62.) *Arch. f. klin. u. exper. Dermat.* 211:18-35.
- Hu, F. and R. R. Cardell. 1962. Observations on the ultrastructure of human skin. *Henry Ford Hosp. Med. Bull.* 10:63-87.
- Hurley, H. J. and W. B. Shelley. 1954. The role of myoepithelium of the human apocrine sweat gland. *J. Invest. Derm.* 22:143.
- Kimura, S. and A. Tsuyoshi. 1962. Functional activity of the apocrine sweat glands in the goat. *Tohoku Jour. Exptl. Med.* 76:8-22.
- Kral, F. 1960. *Compendium of veterinary dermatology*. Chas. Pfizer and Co., Inc. New York.
- Lever, F. W. 1961. *Histopathology of the Skin*. 3rd ed. J. B. Lippincott Co., Philadelphia.

- Macalister, A. 1878. An introduction to the systematic zoology and morphology of vertebrate animals. Dublin University Press Series.
- Mackie, A. G. and A. G. Nisbet. 1959. The histology of the bovine muzzle. J. Agri. Sci. 52:376-379.
- Maeir, M. D. and A. A. Angrist. 1962. Comparative enzymatic histochemistry of various stratified squamous epithelia. Lab. Invest. 11:440-451.
- Malewitz, T. D. and E. M. Smith. 1955. A nuclear stain employing dilute Harris hematoxylin. Stain Techn. 30:311.
- Manual of Histologic and Special Staining Technique. 1957. Armed Forces Institute of Pathology. Washington, D. C.
- Marcarian, H. Q. 1962. The microscopic anatomy of the integument of mature female and mature castrated male Yorkshire hogs. Thesis. Michigan State University.
- Margolena, L. A. 1959. Skin and hair follicle development in dairy goats. Virg. Jour. Sci. 10:33-47.
- Matoltsy, A. G. 1962. Mechanism of keratinization. Fundamentals of Keritinization. A.A.A.S. Washington, D. C.
- Matoltsy, A. G. and M. Matoltsy. 1962. A study of morphological and chemical properties of keratohyalin granules. Jour. Invest. Derm. 38:237-247.
- Medawar, P. B. 1953. The microanatomy of the mammalian epidermis. Quart. Jour. Microscop. Sci. 94:481-506.
- Montagna, W. 1956. The Structure and Function of skin. Academic Press Inc. New York.
- Montagna, W. 1962. The Structure and Function of Skin. 2nd ed. Academic Press. New York and London.
- Montagna, W. and P. Kenyon. 1949. Growth potentials and mitotic divisions in the sebaceous glands of the rabbit. Anat. Rec. 103:365-380.

- Myezkowski, K. 1960. [Development and morphology of neck skin appendages in domestic animals, including pig, goat and sheep.] Polish-English Summary. *Weterynaria*, Wroclow 7:77-98.
- Nay, T. 1959. Sweat glands in cattle; histology, morphology and evolutionary trends. *Aust. Jour. Agric. Res.* 10:121-128.
- Odland, G. F. 1958. The fine structure of the interrelationship of cells in the human epidermis. *J. Biophys. and Biochem. Cytol.* 4:529-538.
- Pearse, A. G. E. 1961. *Histochemistry. Theoretical and Applied.* 2nd ed. Little, Brown and Company. Boston.
- Rawles, M. E. 1947. Origin of pigment cells from the neural crest in the mouse embryo. *Physiol. Zool.* 20:248.
- Riley, J. F. 1959. *The Mast Cells.* E. and S. Livingstone Ltd., Edinburgh and London.
- Robb-Smith, A. H. T. 1957. What is reticulin? Connective tissue. symposium. 177-183. C. C. Thomas, Springfield, Illinois.
- Ryder, M. L. 1960. A study of the coat of the Mouflon *Ovis Musimon* with special reference to seasonal change. *Proc. Zool. Soc. Lond.* 135:387-408.
- Sisson, S. and J. D. Grossman. 1953. *The Anatomy of the Domestic Animals.* 3rd ed. W. B. Saunders Company. Philadelphia.
- Smith, J. L. 1960. The microscopic anatomy of the integument of newborn swine. Thesis. Michigan State University.
- Steigleder, G. K. and P. R. Wolfgang. 1962. The localization of ribonuclease and deoxyribonuclease activities in normal and psoriatic epidermis. *Jour. Invest. Derm.* 38:209-214.
- Strickland, J. 1958. The microscopic anatomy of the skin and external ear of *Felis domesticus*. Thesis. Michigan State University.
- Trautmann, A. and J. Fiebiger. 1957. *Fundamentals of Histology of Domestic Animals.* Translated and revised by R. E. Habel and E. L. Biberstein. Comstock Publishing Associates. Ithaca, New York.

Vincent, S. B. 1913. The tactile hair of the white rats. Jour. Comp. Neur. 23:1-36.

Walter, P. 1961. Die sensible Innervation Des Lippen-nasenbereiches von Rind, Schaf, Ziege, Schwein, Hund und Katze. Z. Zellforsch Mikroskop. Anat. 53:394-410.

Webb, A. J. and M. L. Calhoun. 1954. The microscopical anatomy of the skin of mongrel dogs. Amer. Jour. Vet. Res. 15:274-280.

Zelenskii, G. G. 1960a. Histological method for determining hair density in goats. (R) Vestn. Zelskokhozi Nauki 10:76-79.

Zelenskii, G. G. 1960b. Breed differences in coat and degree of development of the skin in goats. (R) Trudy. Inst. Morfologii Zhivotrykh, 31:149-157.

PLATES

Plate II

A vertical section through the skin at the base of the tail (dorsal) showing the normal structures.

H. and E. stain. 68X

1. Epidermis
2. Dermis (reticular layer)
3. Hair (primary follicle)
4. Hair bulb
5. Hair papilla
6. Secondary hair follicles
7. Sebaceous glands
8. Sweat gland
9. Follicular folds
10. Subcutaneous fat cells



Plate III

A vertical section of the planum nasale showing the compound papillae and the multilobular and the tubulo-acinar glands.

H. and E. stain. 80X

1. Stratum corneum
2. Dermal papilla
3. Papillary layer
4. Skeletal muscle
5. Glands of the planum nasale
6. Interglandular connective tissue septa
7. Ducts of the glands of the planum nasale
8. Blood vessels

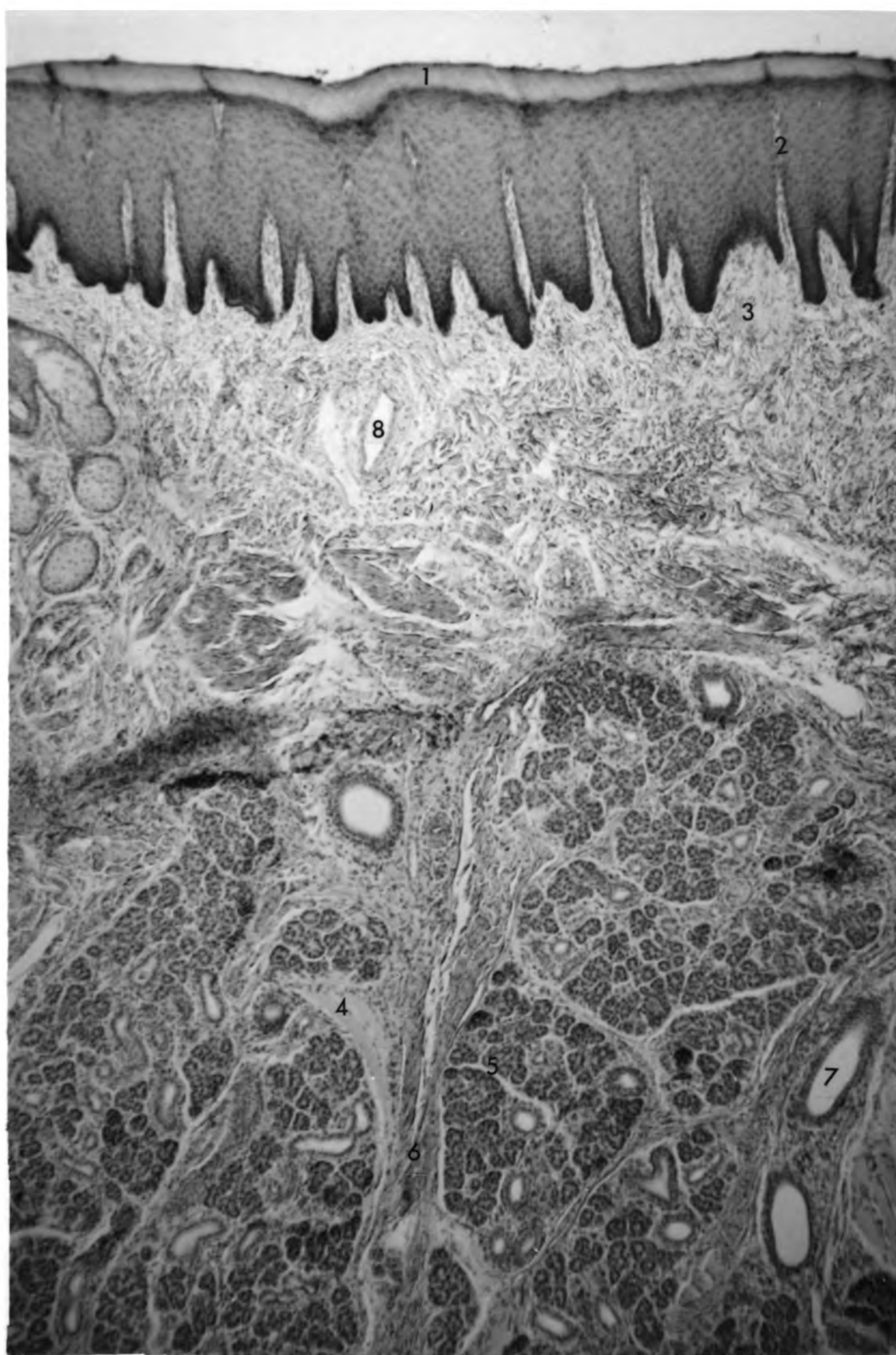


Plate IV

Oblique section through the dorsal perianal region showing the large sebaceous glands and the coiled tubular apocrine glands (female).

Mallory's triple stain. 66X

1. Epidermis
2. Dermis
3. Hair follicle
4. Sebaceous glands
5. Coiled tubular apocrine glands
6. Skeletal muscle
7. Compound papillae

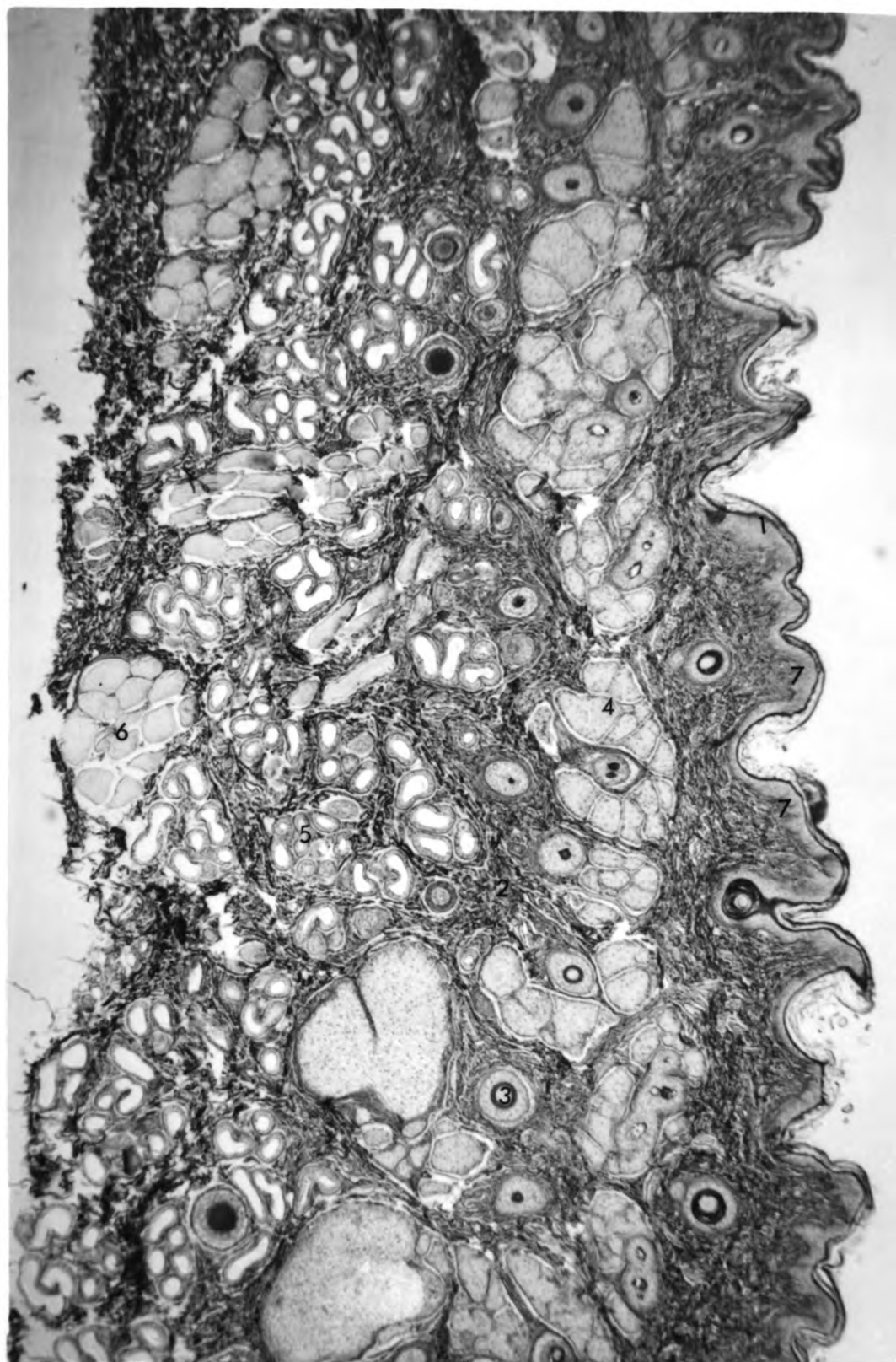


Plate V

Vertical section through the pinna showing a few hair follicles and large sebaceous glands on the concave surface (arrow).

H. and E. stain. 84X

- 1. Epidermis**
- 2. Dermis**
- 3. Elastic cartilage**
- 4. Hair follicle**
- 5. Sebaceous glands**
- 6. Sweat glands**
- 7. Stratum corneum**

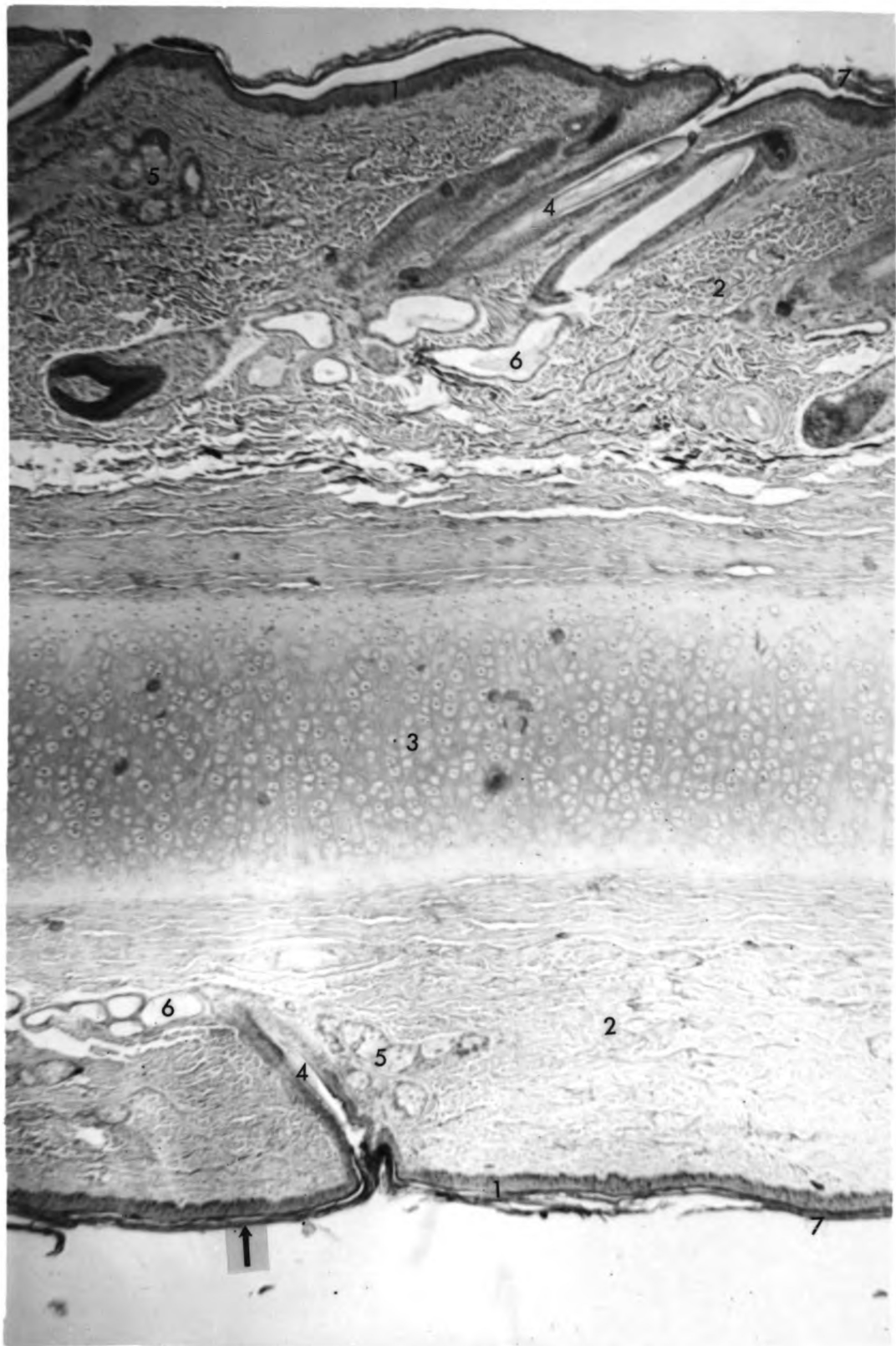


Plate VI

Vertical section through the dorsal abdominal skin showing the primary and the secondary hair follicles with their accessory structures.

H. and E. stain. 170X

1. Primary hair follicle
2. Secondary hair follicles
3. Follicular folds
4. Sebaceous glands
5. Duct of the sweat gland
6. Opening of the duct of the sweat gland into the hair follicle
7. Arrector pili muscle
8. Common opening of the secondary hair follicles

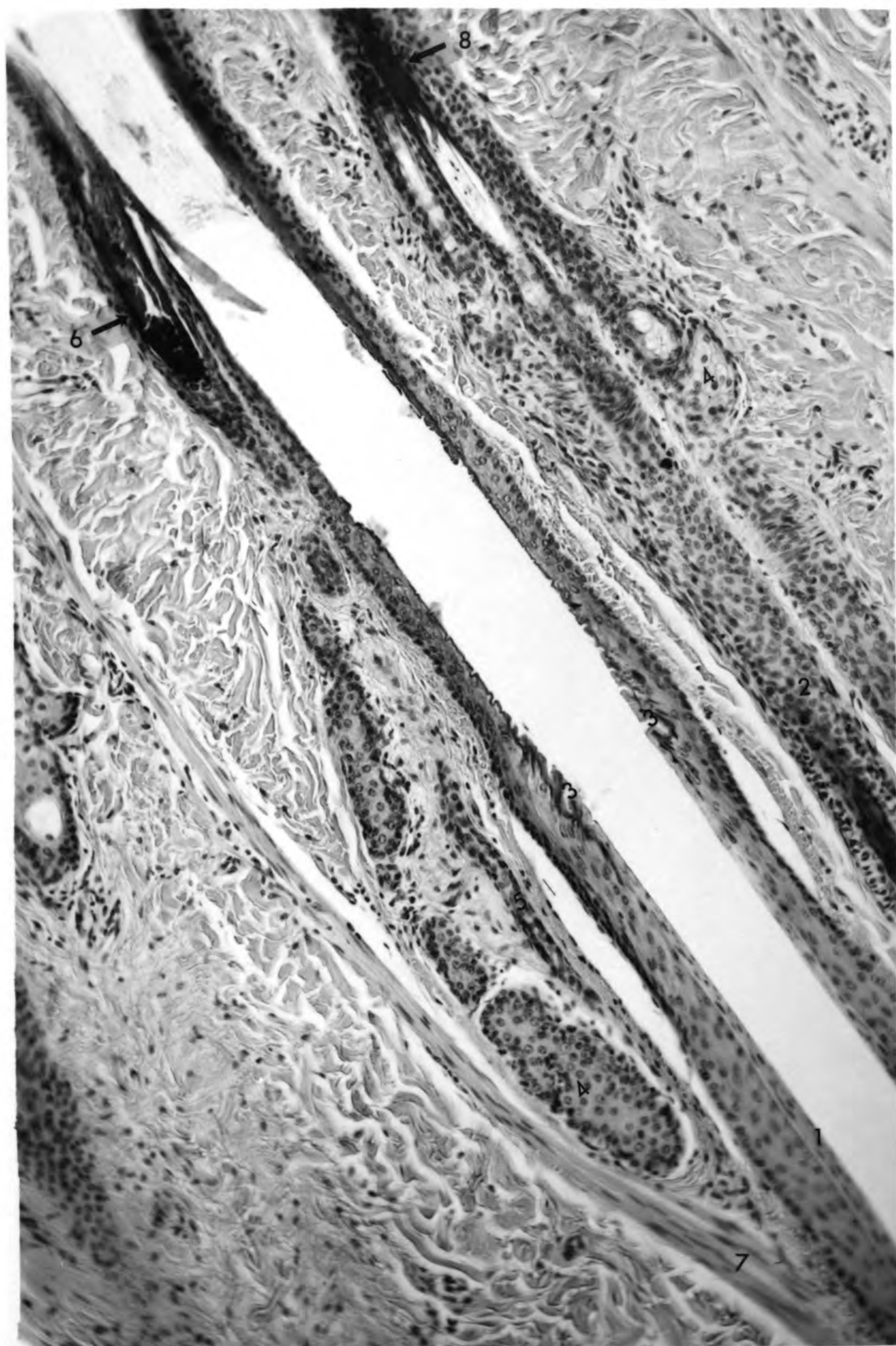


Plate VII

Vertical section through the skin of the lateral hock joint showing the distribution of mast cells around the capillary beds and along the course of the arrectores pilorum muscles.

Toluidine blue stain. 188X

1. Epidermis
2. Follicular lumen
3. Arrector pili muscle
4. Capillary
5. Mast cells

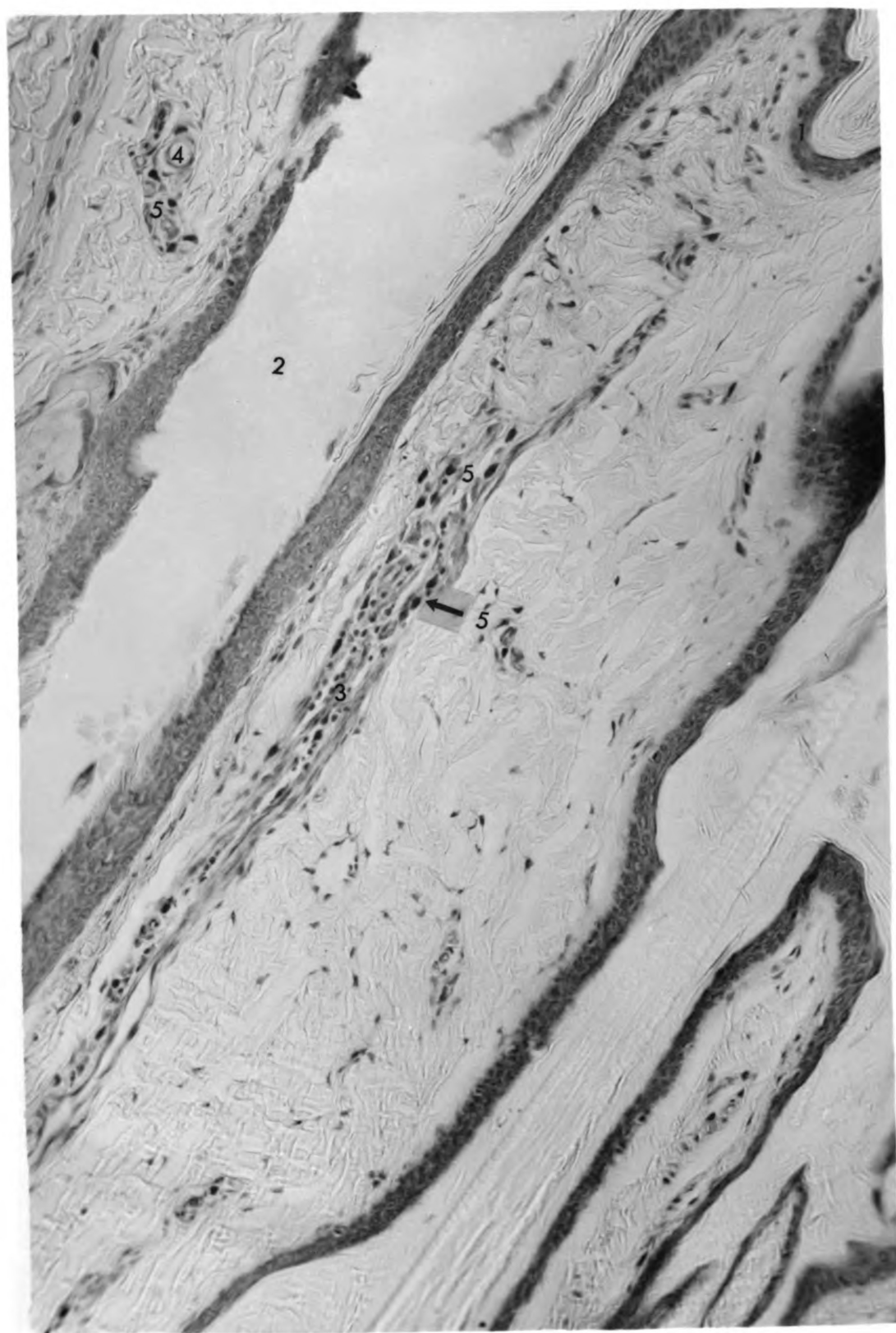


Plate VIII

Vertical section through the muzzle showing the different epidermal layers.

H. and E. stain. 490X

1. Stratum corneum
2. Stratum lucidum
3. Stratum granulosum
4. Stratum spinosum (intercellular bridges)
5. Stratum basale
6. Dermal papilla
7. Papillary layer

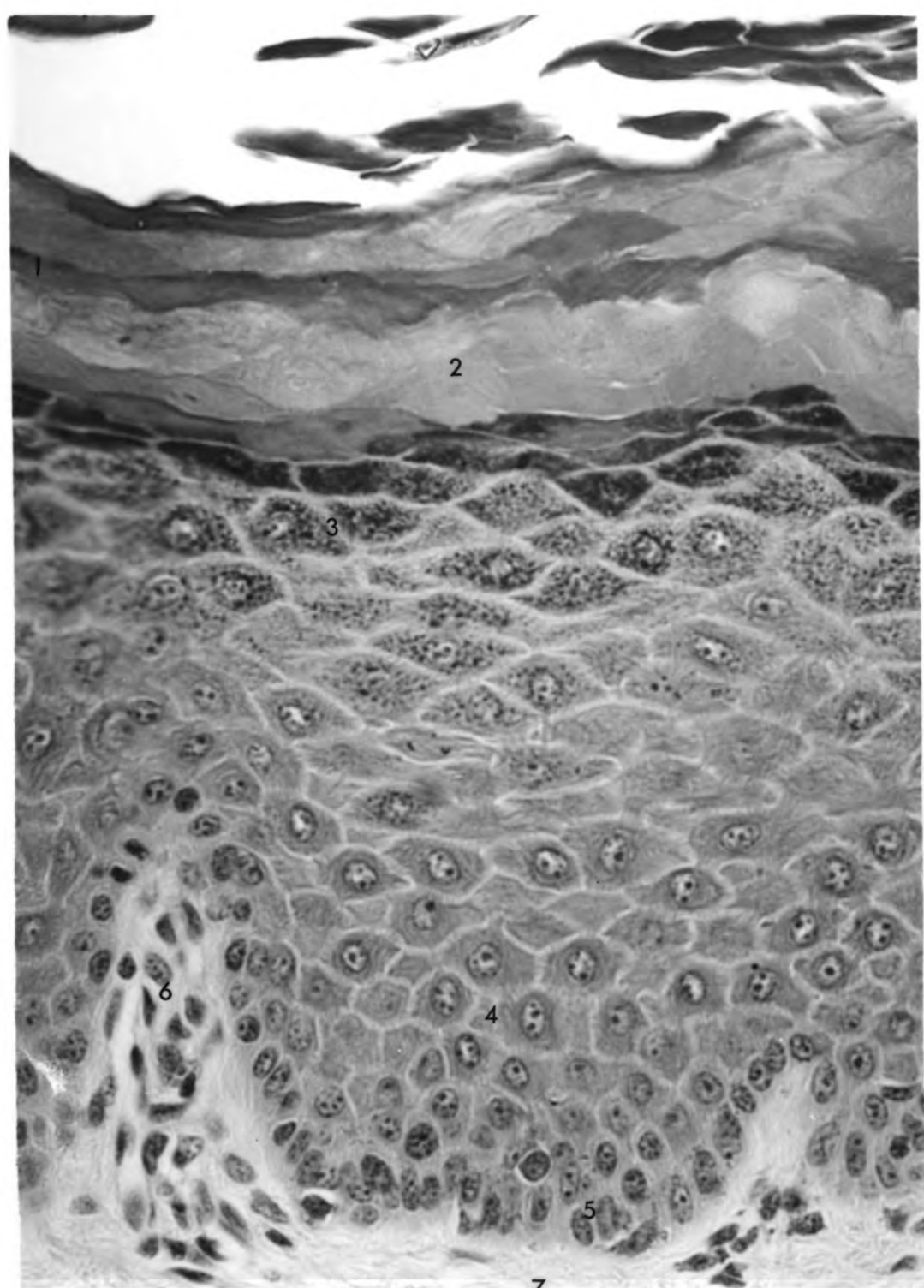


Plate IX

Vertical section through the muzzle showing the intercellular bridges.

Mallory's triple stain. 1410X

1. Stratum lucidum
2. Stratum granulosum cells showing keratohyalin granules
3. Stratum spinosum with intercellular bridges at 4 (desmosomes).

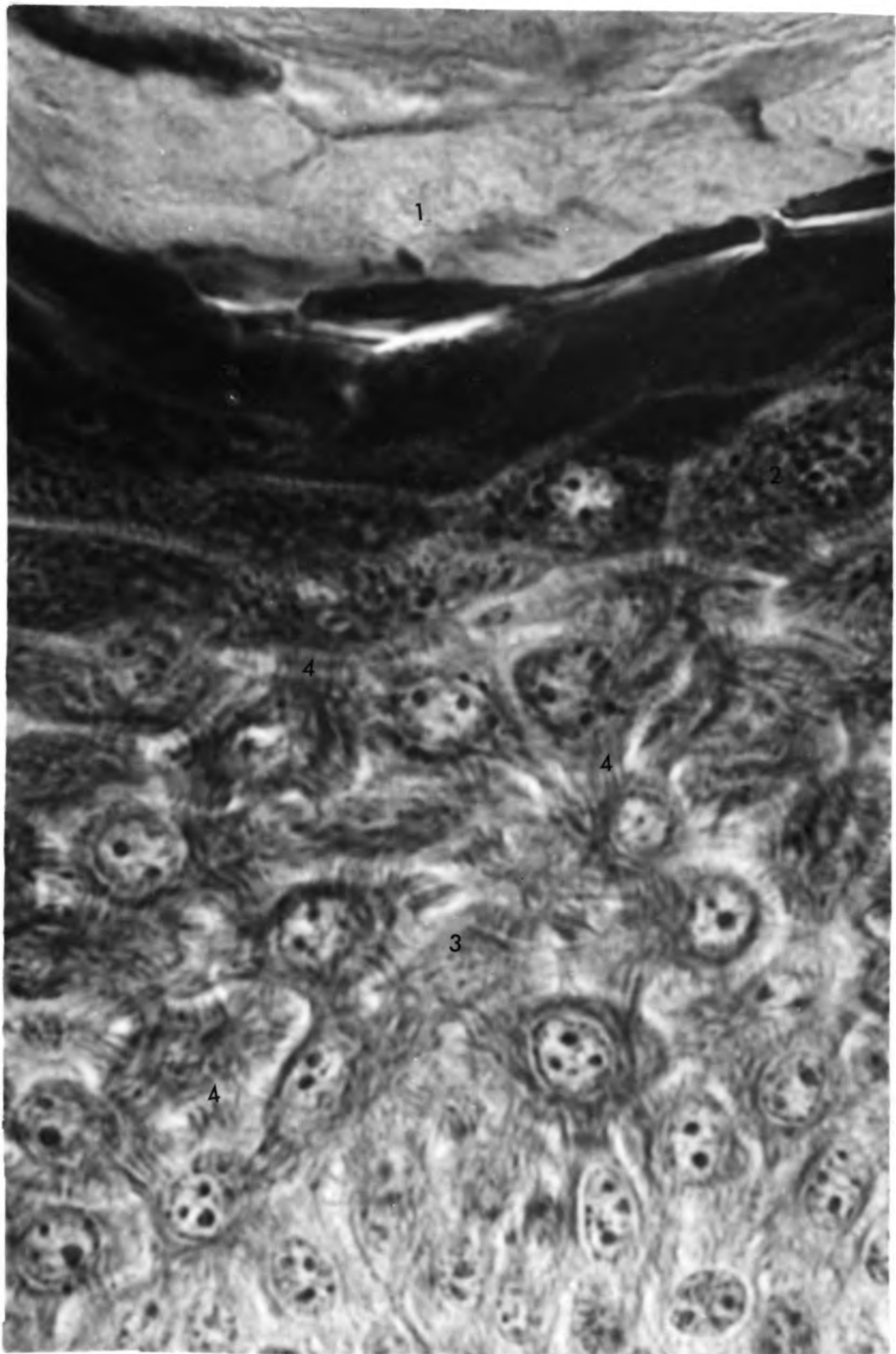


Plate X

Frontal section through the dorsal thoracic skin showing the network of elastic fibers around the hair follicles and in the dermis.

Weigert and Van Gieson's stain. 520X

1. Hair follicles
2. Elastic fibers (black)
3. Arrector pili muscle

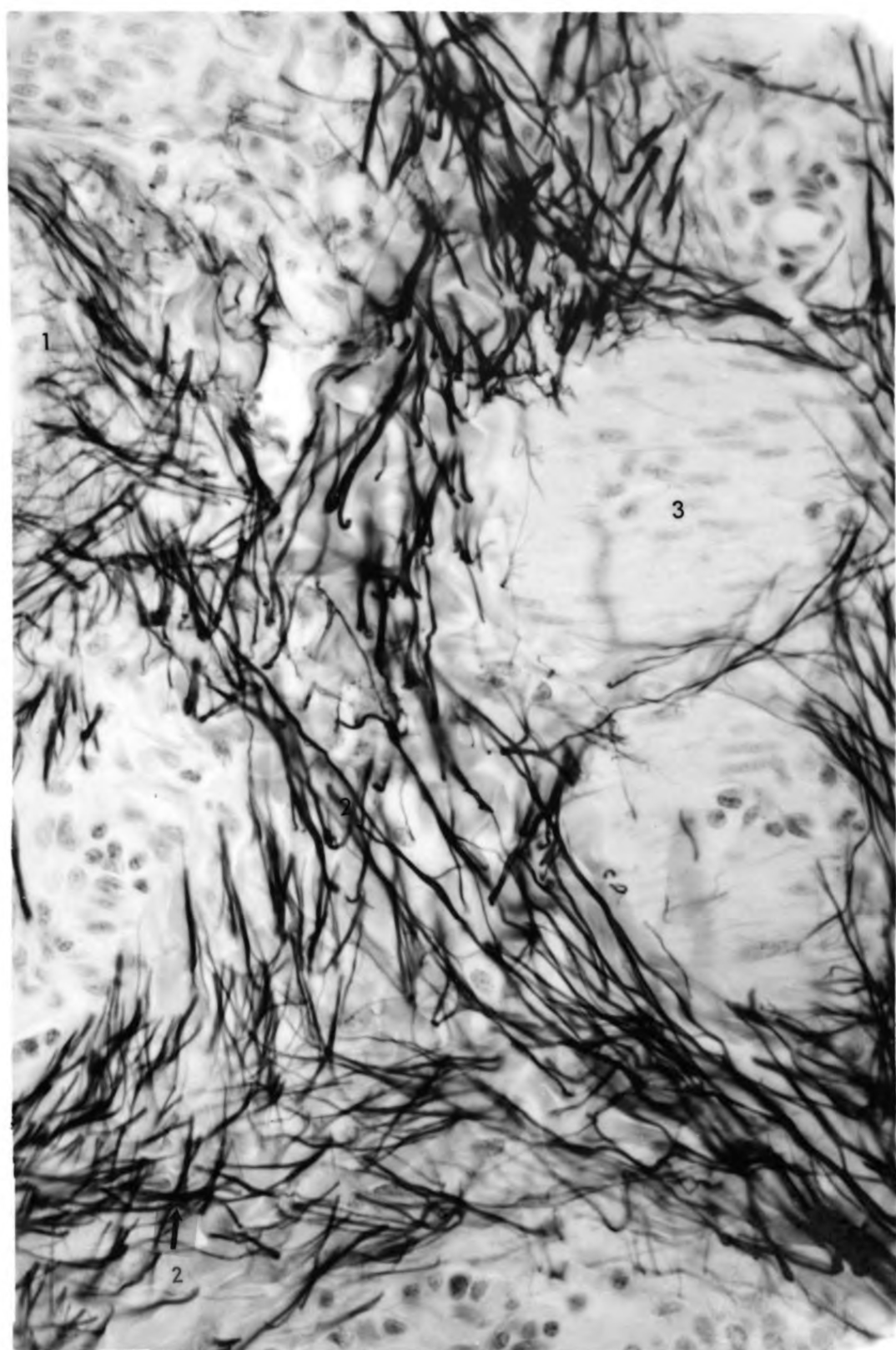


Plate XI

Vertical section through the skin of the base of the horn showing the meshwork of reticular fibers at the dermo-epidermal junction.

Gomori's reticulum stain. 2500X

1. Epidermis
2. Reticular fibers penetrating
the basement membrane
3. Dermis

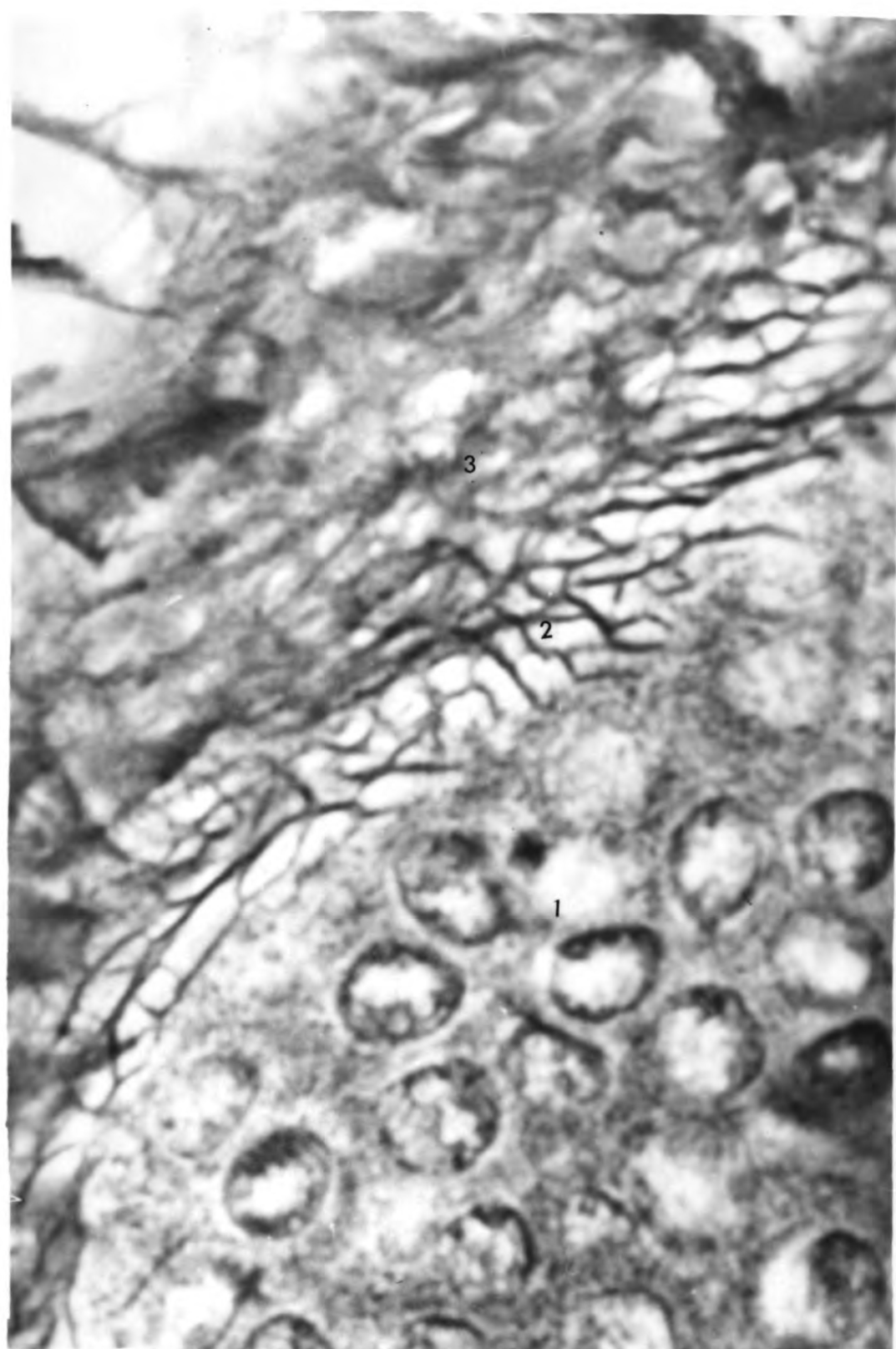


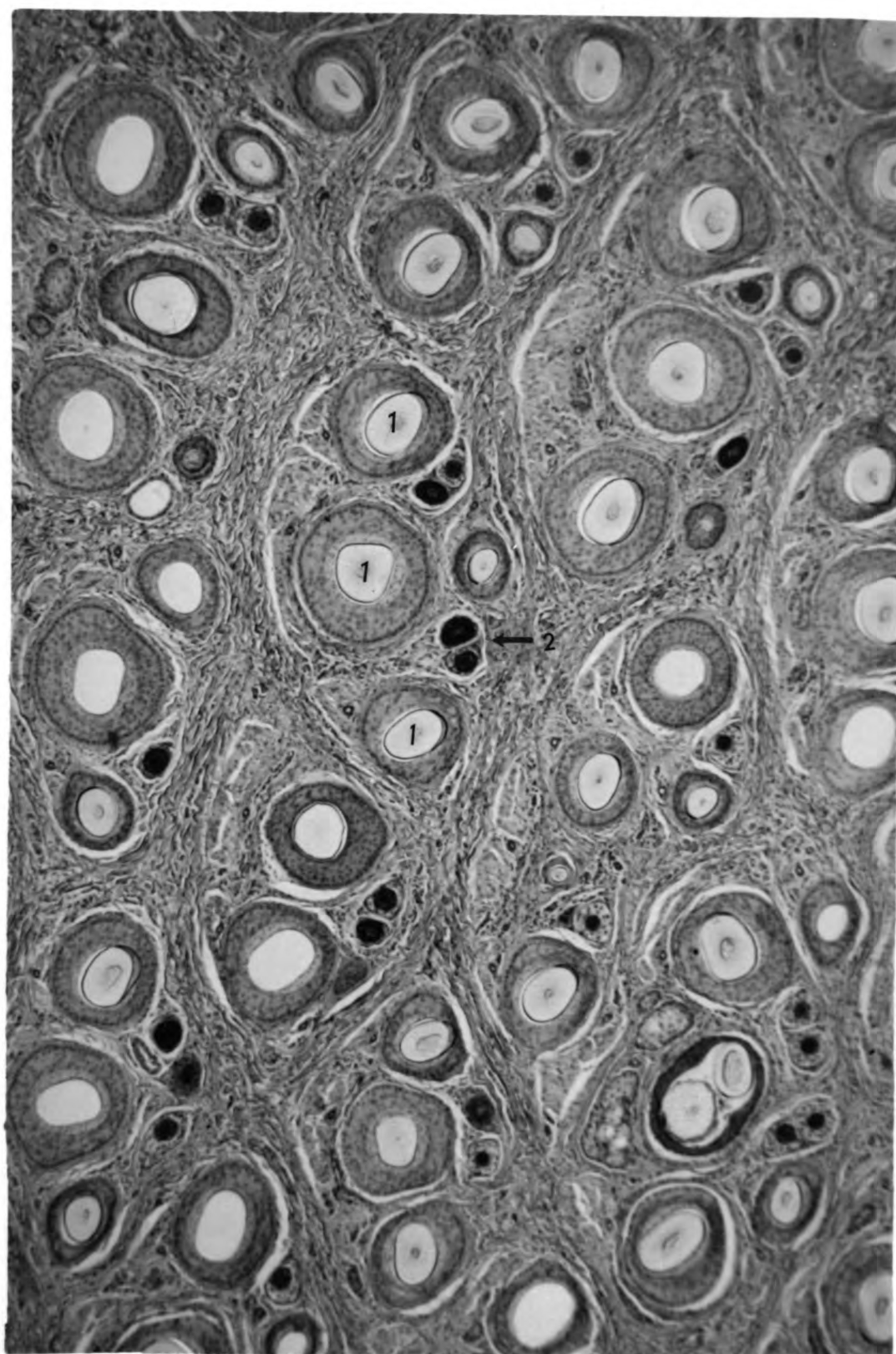
Plate XII

Frontal section through the skin of the dorsal tail region showing the arrangement of three primary hair follicles in a group.

H. and E. stain. 76X

1. Primary hair follicle

2. Secondary hair follicle



H. and E. stain. 227X

1. Medullary substance
2. Cortical substance
3. Hair cuticula
4. Huxley's layer) Inner root sheath
5. Henle's layer)
6. Outer root sheath
7. Glassy membrane
8. Connective tissue capsule
9. Capillaries

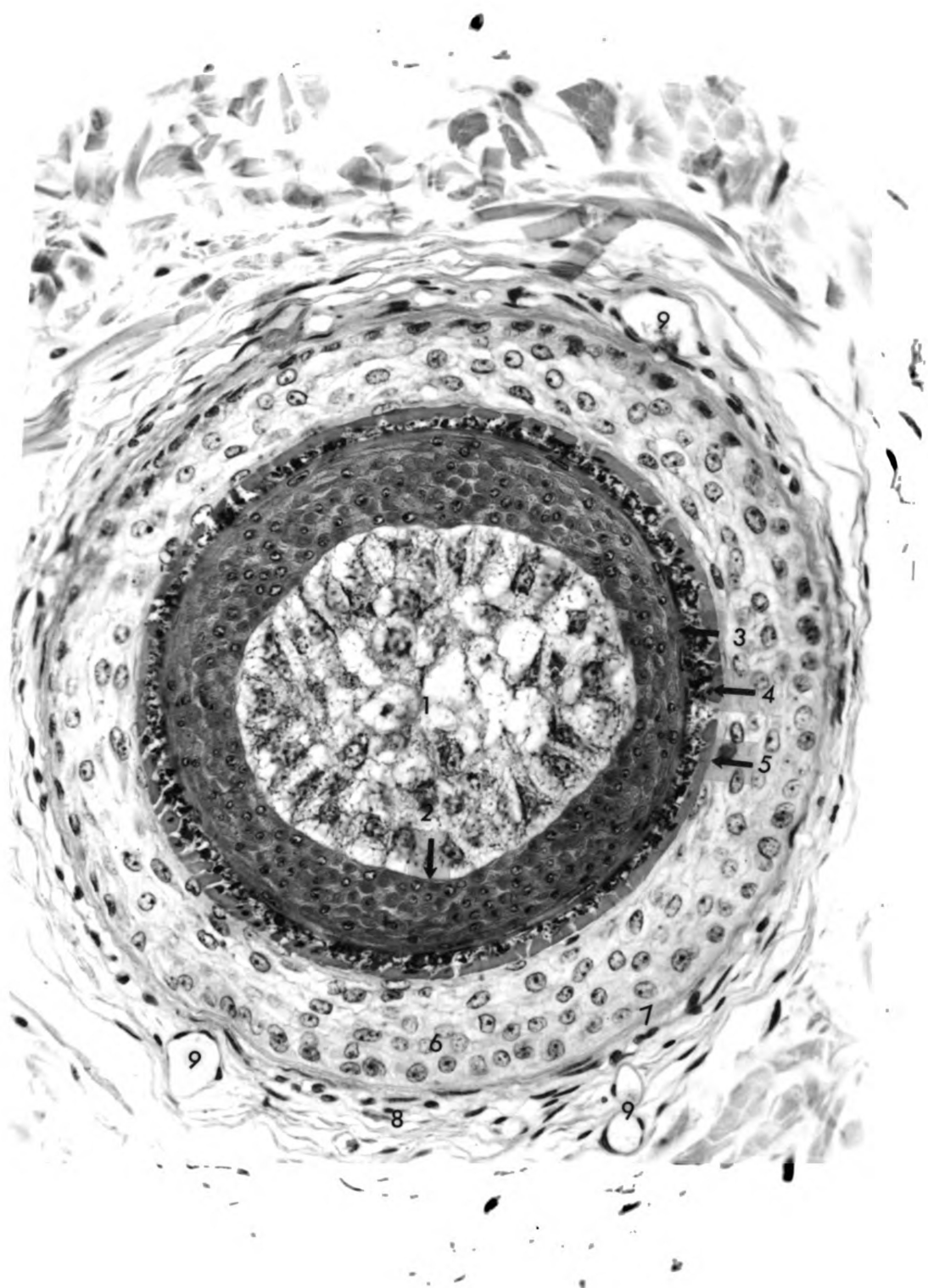


Plate XIV

Vertical section through the muzzle showing the replacement of hair.

Mallory's triple stain. 142X

1. Hair about to be shed
2. New hair
3. Sebaceous gland
4. Blood vessels
5. Tactile corpuscles
6. Skeletal muscle

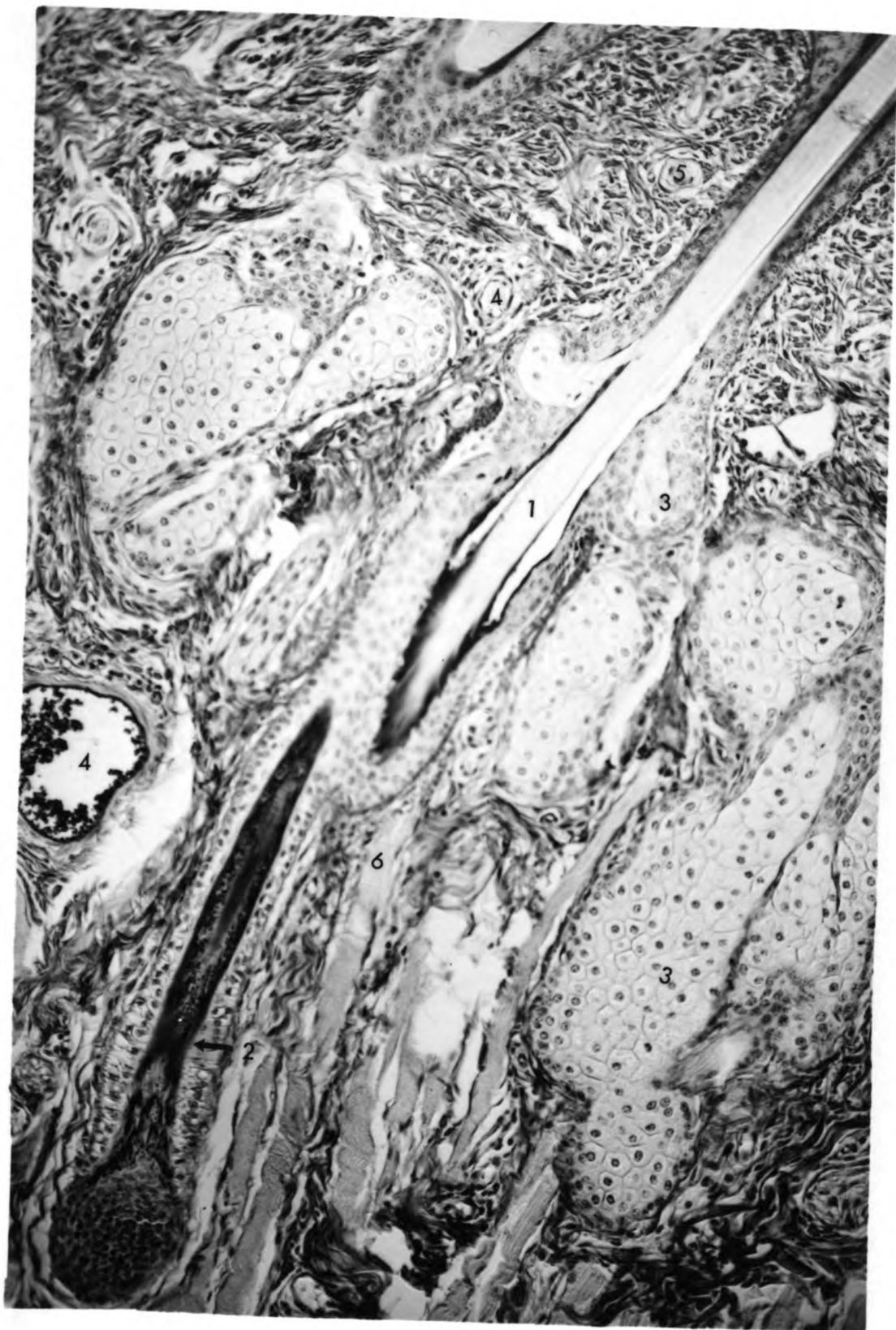


Plate XV

Vertical section through the dorsal abdominal skin
showing follicular folds on the primary hair follicle.

H. and E. stain. 355X

1. Follicular folds
2. Sebaceous gland
3. Follicular lumen



Plate XVI

Vertical section through the muzzle showing the tactile hair in longitudinal section.

H. and E. stain. 80X

1. Epidermis
2. Outer connective tissue sheath
3. Inner connective tissue sheath
4. Blood sinus
5. Fibroelastic trabeculae
6. Sebaceous glands
7. Nerve trunk
8. Skeletal muscle

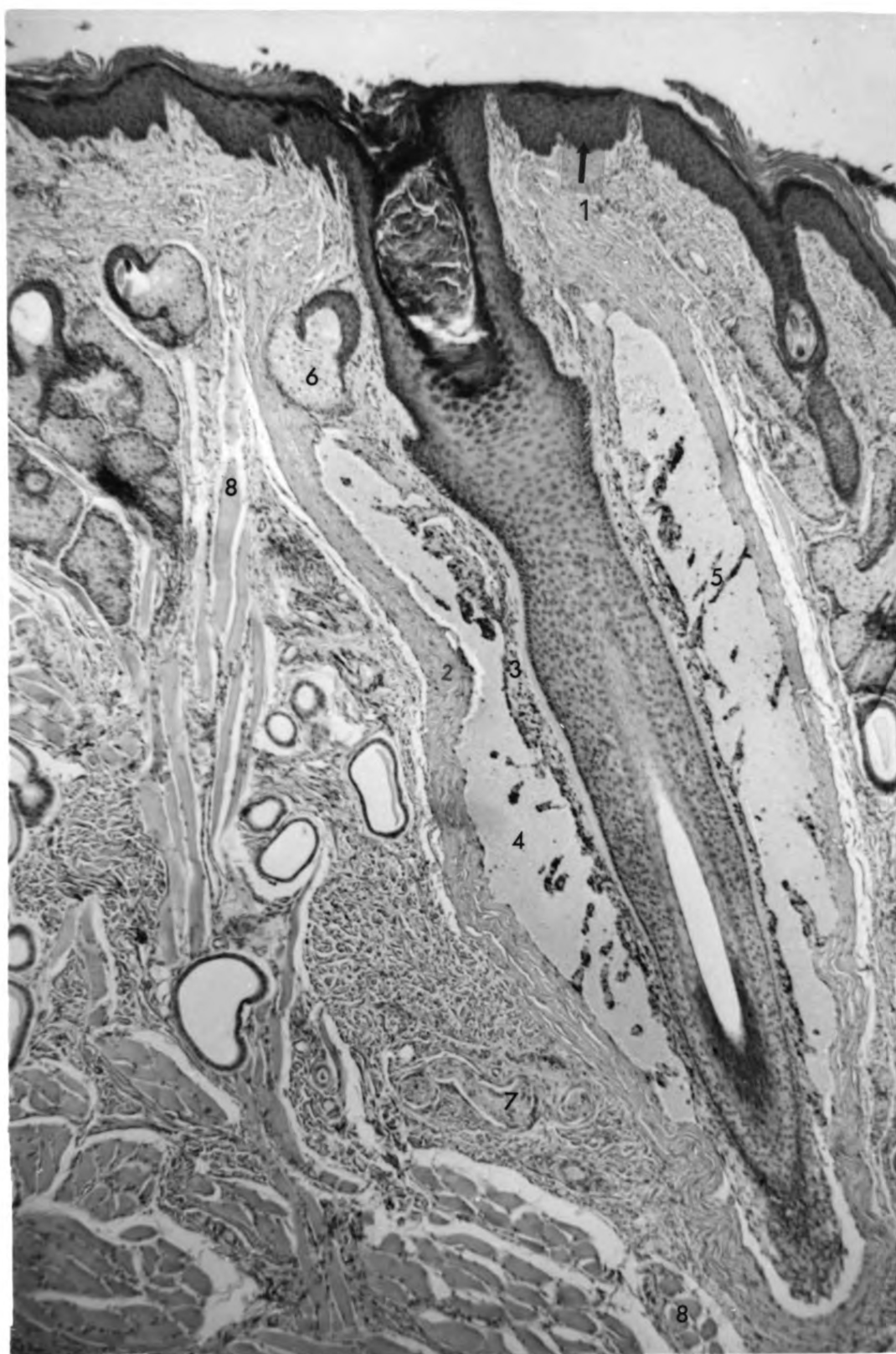


Plate XVII

Frontal section through the muzzle showing the tactile hair in cross section.

Mallory's triple stain. 200X

1. Outer connective tissue sheath
2. Blood sinus
3. Fibroelastic trabeculae
4. Sebaceous glands
5. Hair
6. Skeletal muscle



Plate XVIII

A cross section of the sinus hair of the upper eyelid showing the attachment of the skeletal muscle to the outer connective tissue sheath.

H. and E. stain. 189X

1. Outer connective tissue sheath
2. Skeletal muscle
3. Blood sinus
4. Fibroelastic trabeculae
5. Hair
6. Duct of the sweat gland

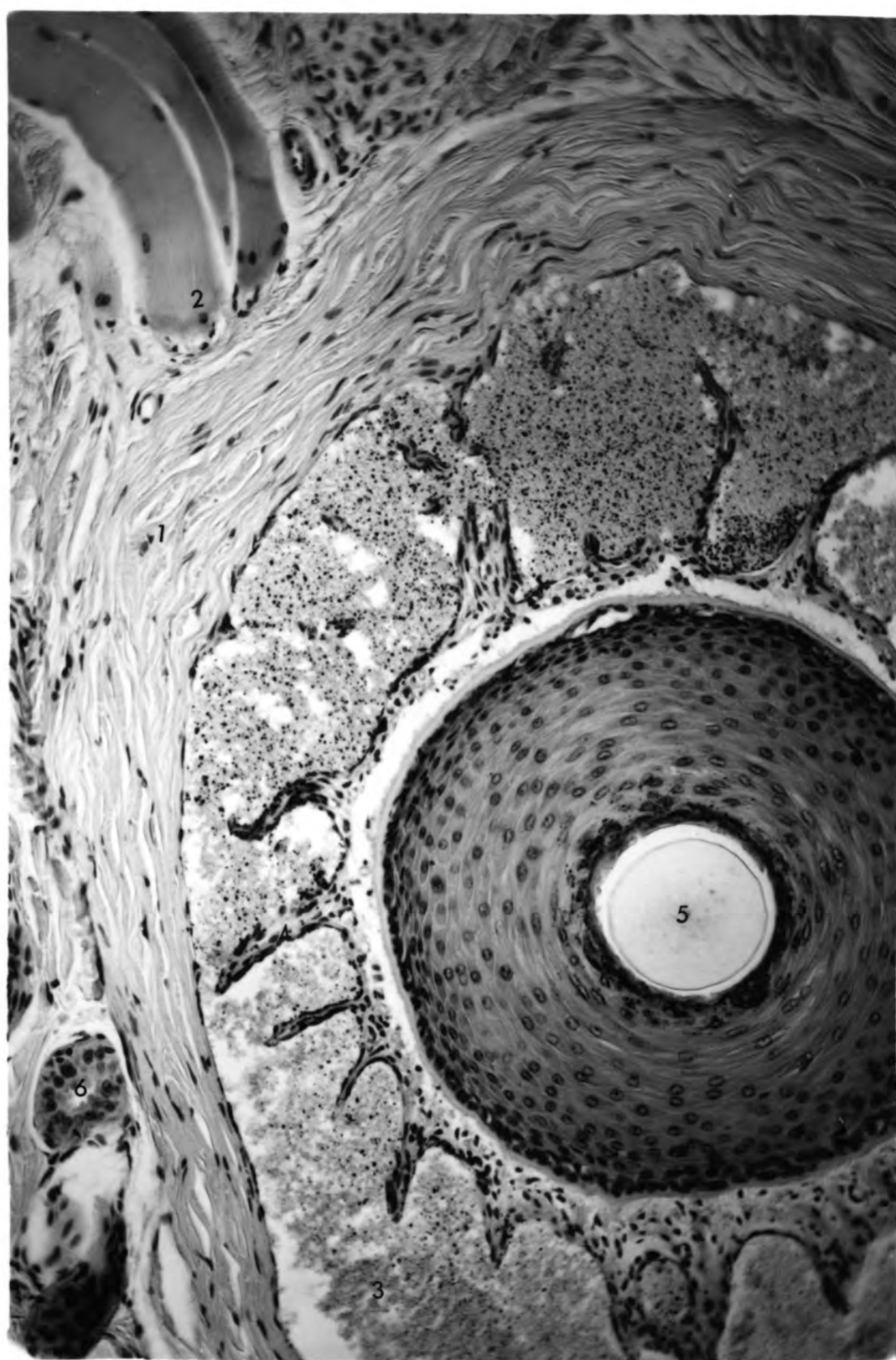


Plate XIX

Oblique section through the skin at the base of the
horn showing large sebaceous glands (horn glands).

Mallory's triple stain. 55X

1. Epidermis
2. Hair follicle
3. Sebaceous glands
4. Sweat glands



Plate XX

Frontal section through the skin at the base of the horn showing the large sebaceous glands (horn glands) in cross section.

Mallory's triple stain. 154X

1. Primary hair follicle
2. Secondary hair follicle
3. Sebaceous glands

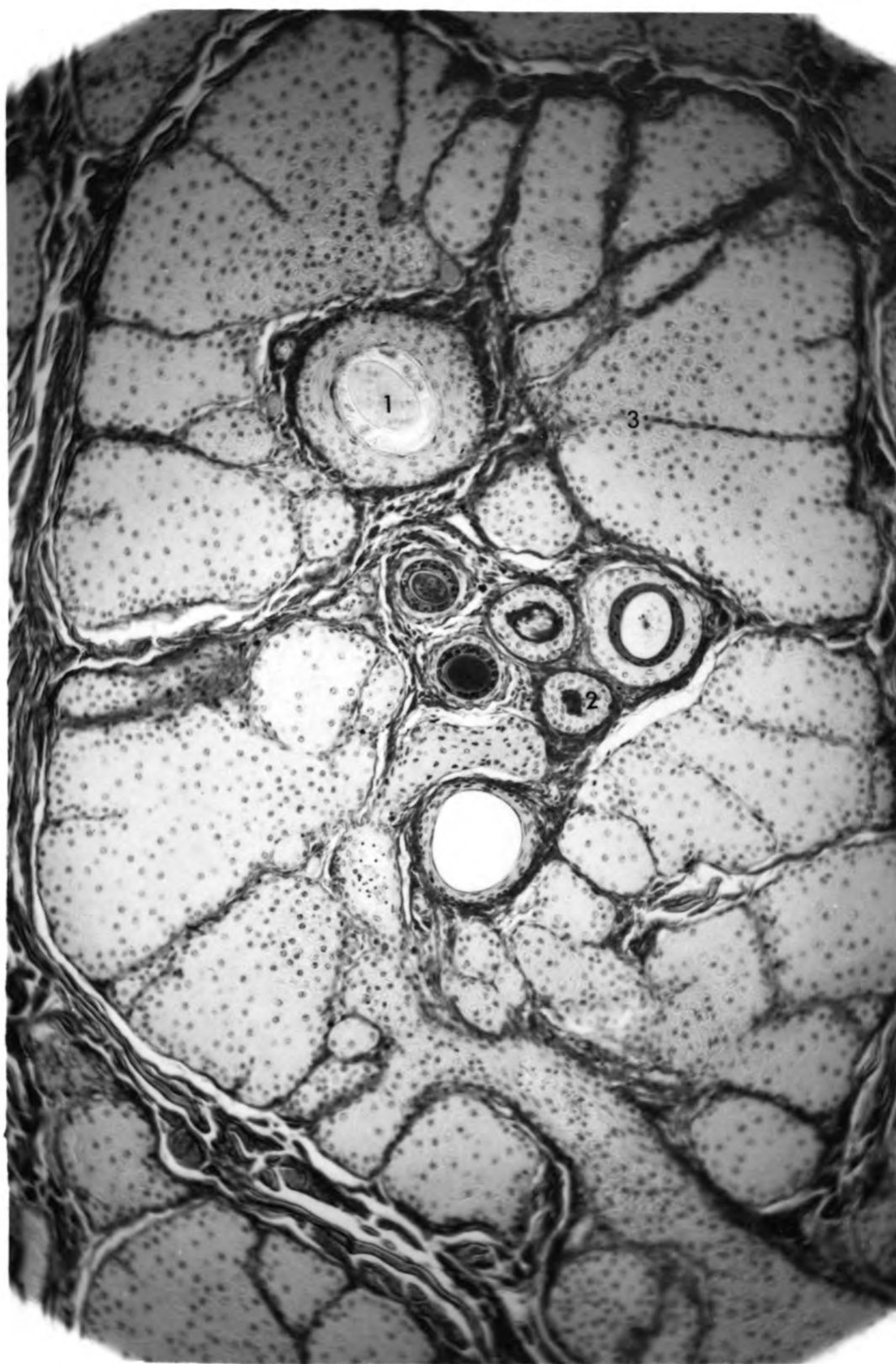


Plate XXI

A vertical section through the skin of the perianal region showing the large branching sebaceous glands.

H. and E. stain. 152X

1. Sebaceous gland

2. Duct of the sebaceous gland

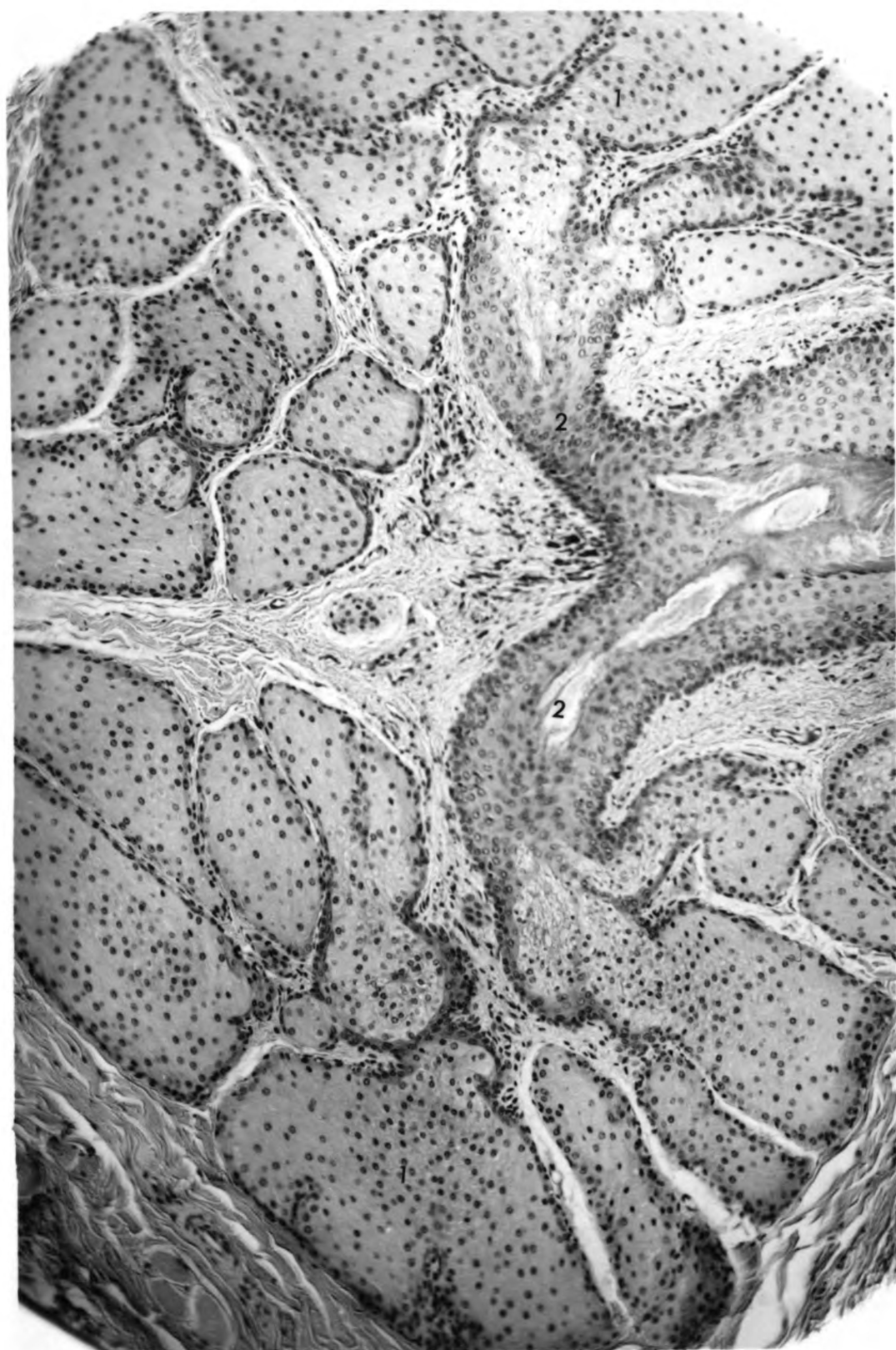


Plate XXII

Sagittal section through the upper eyelid showing the tarsal gland.

Mallory's triple stain. 66X

1. Tarsal gland
2. The excretory duct of the tarsal gland
3. Tubular skin glands
4. Skeletal muscle (m. orbicularis palpebrae)
5. Epidermis

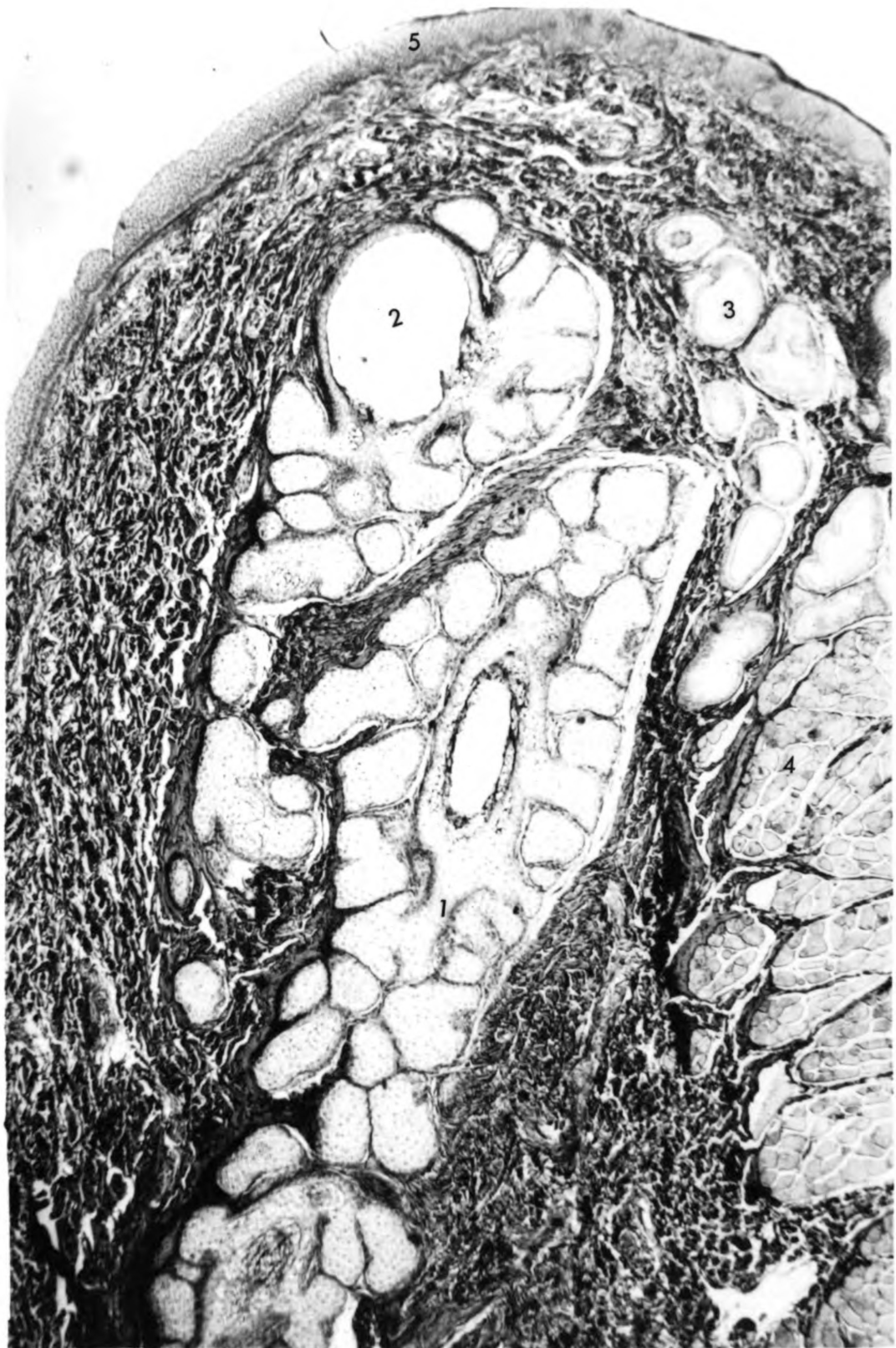


Plate XXIII

Cross section of the apocrine tubular glands from the skin of the udder.

H. and E. stain. 180X

1. Star-shaped secretory tubules
2. Secretory tubules with flattened or cuboidal cells.
3. Columnar cells with lobed processes
4. Myoepithelial cells
5. Periglandular tissue
6. Capillaries
7. Smooth muscle cells
8. Tubules filled with secretory material

Plate XXIV

Vertical section through the skin of the ventral neck region showing coiled tubular skin glands around the bulb of the hair follicle.

H. and E. stain. 175X

1. Hair bulb
2. Hair
3. Tubular skin glands
4. Duct of the tubular skin glands



Plate XXV

Vertical section through the muzzle showing the longitudinal section of the sweat gland with its duct.

Mallory's triple stain. 330X

1. Sweat gland
2. Sweat duct
3. Secretory columnar epithelial cells with apical projection
4. Skeletal muscle
5. Sebaceous glands

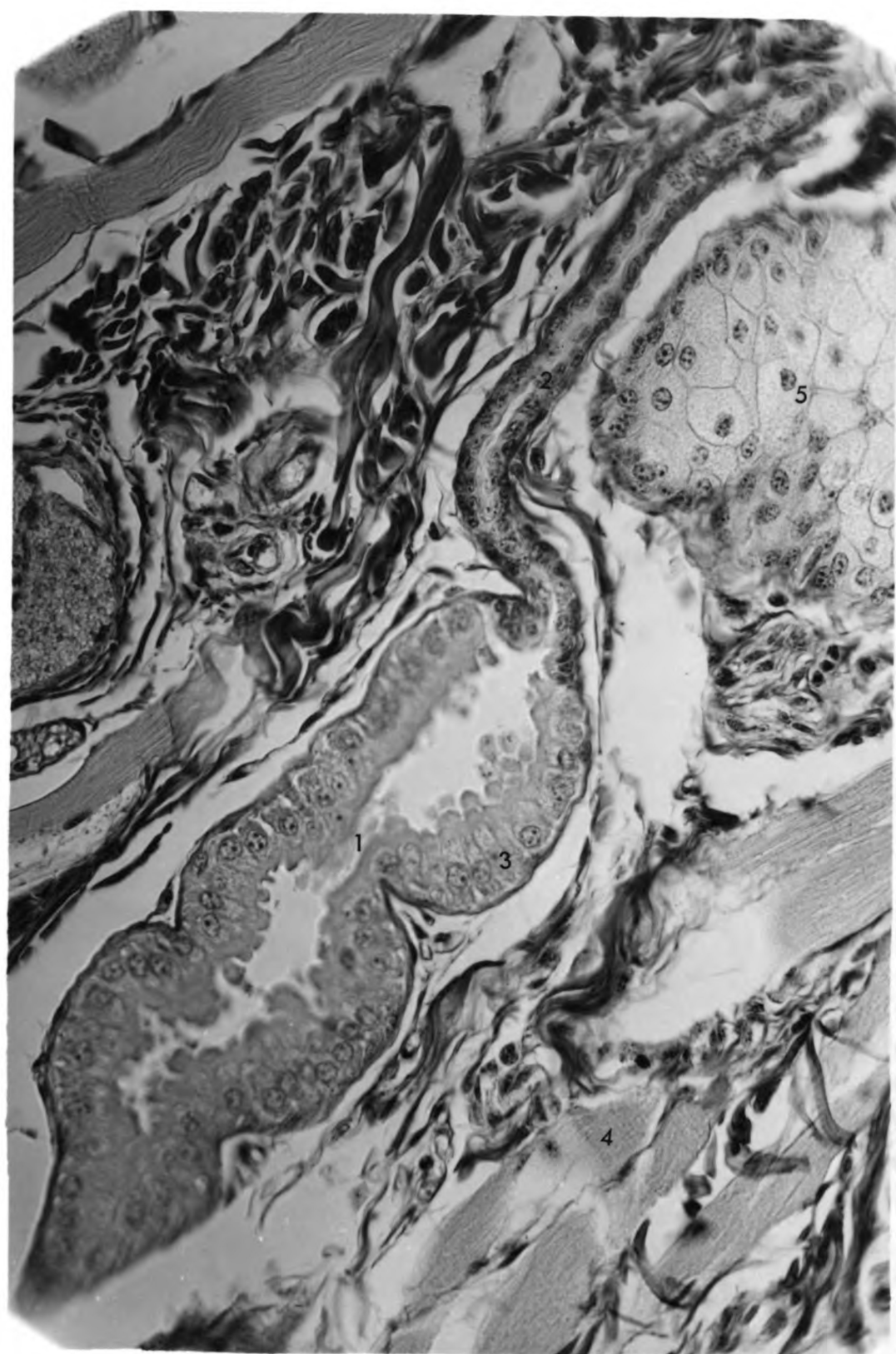


Plate XXVI

**Frontal section of the skin of the perianal region
showing tubular coiled skin glands in cross section (female).**

Mallory's triple stain. 200X

- 1. Tubules of the apocrine glands**
- 2. Columnar cells with apical projections**
- 3. Cuboidal cells**
- 4. Secretory material in the lumen**
- 5. Myoepithelial cells**
- 6. Capillaries**

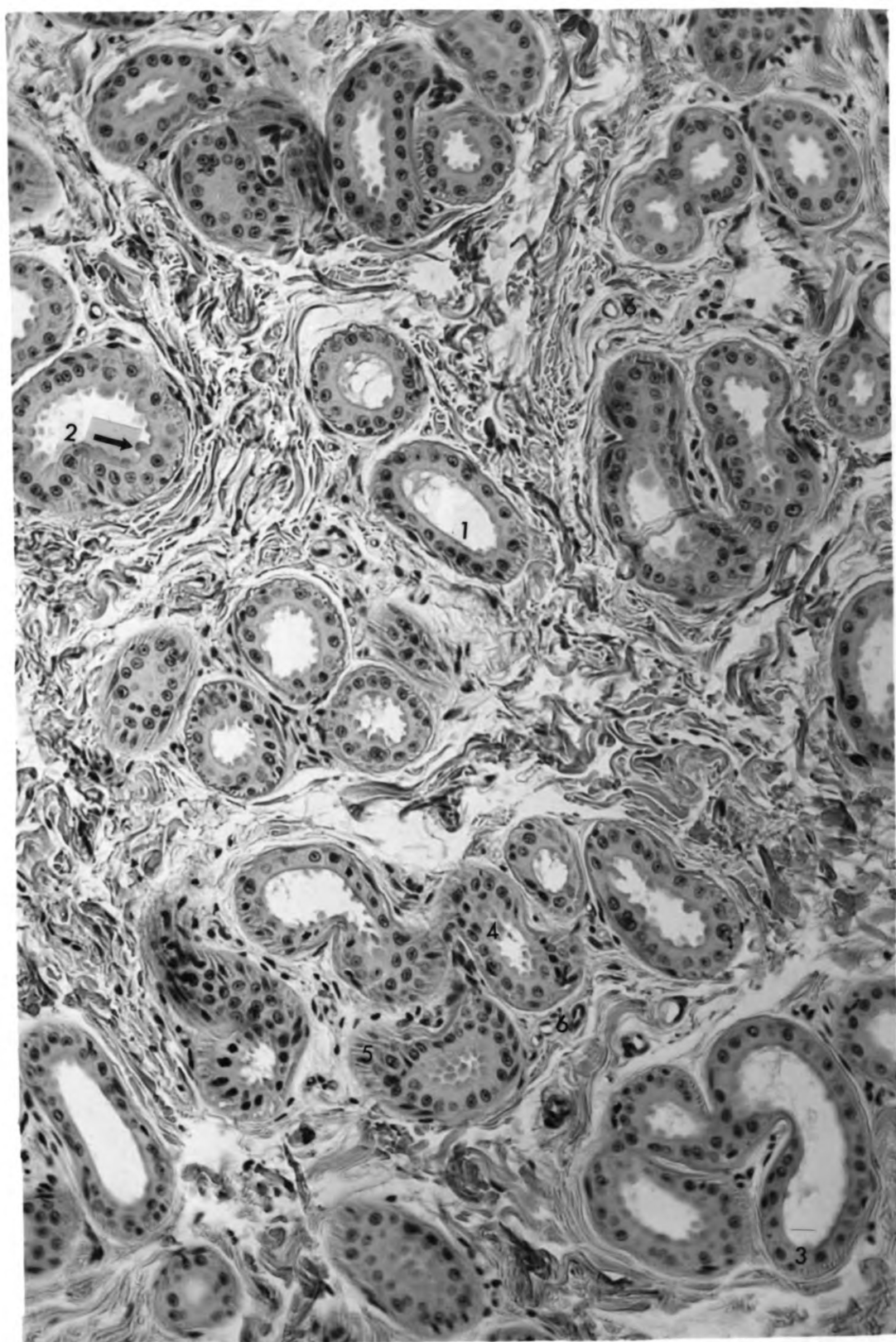


Plate XXVII

Vertical section through the skin of the planum nasale
showing the compound tubulo-acinar serous glands.

Alcian Blue and Nuclear Fast Red. 220X

1. Acinus containing acid
mucopolysaccharides
2. Serous acini
3. Intralobular duct
4. Interlobular duct
5. Interlobular connective
tissue septa
6. Skeletal muscle

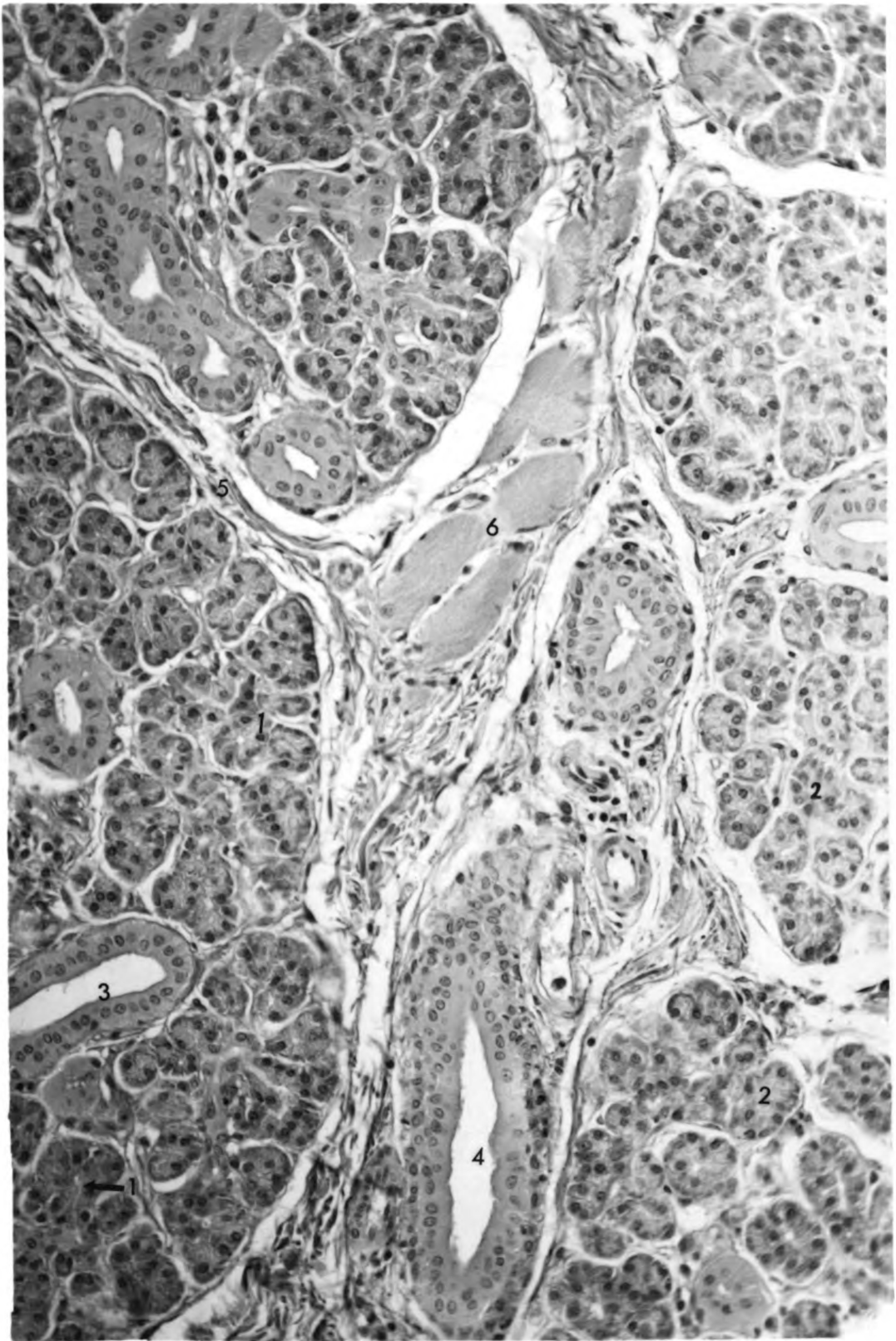


Plate XXVIII

Cross section of the teat showing the large sebaceous glands and the tubular apocrine glands.

Mallory's triple stain. 210X

- 1. Hair follicle**
- 2. Sebaceous glands**
- 3. Tubular apocrine glands**
- 4. Myoepithelial cells**

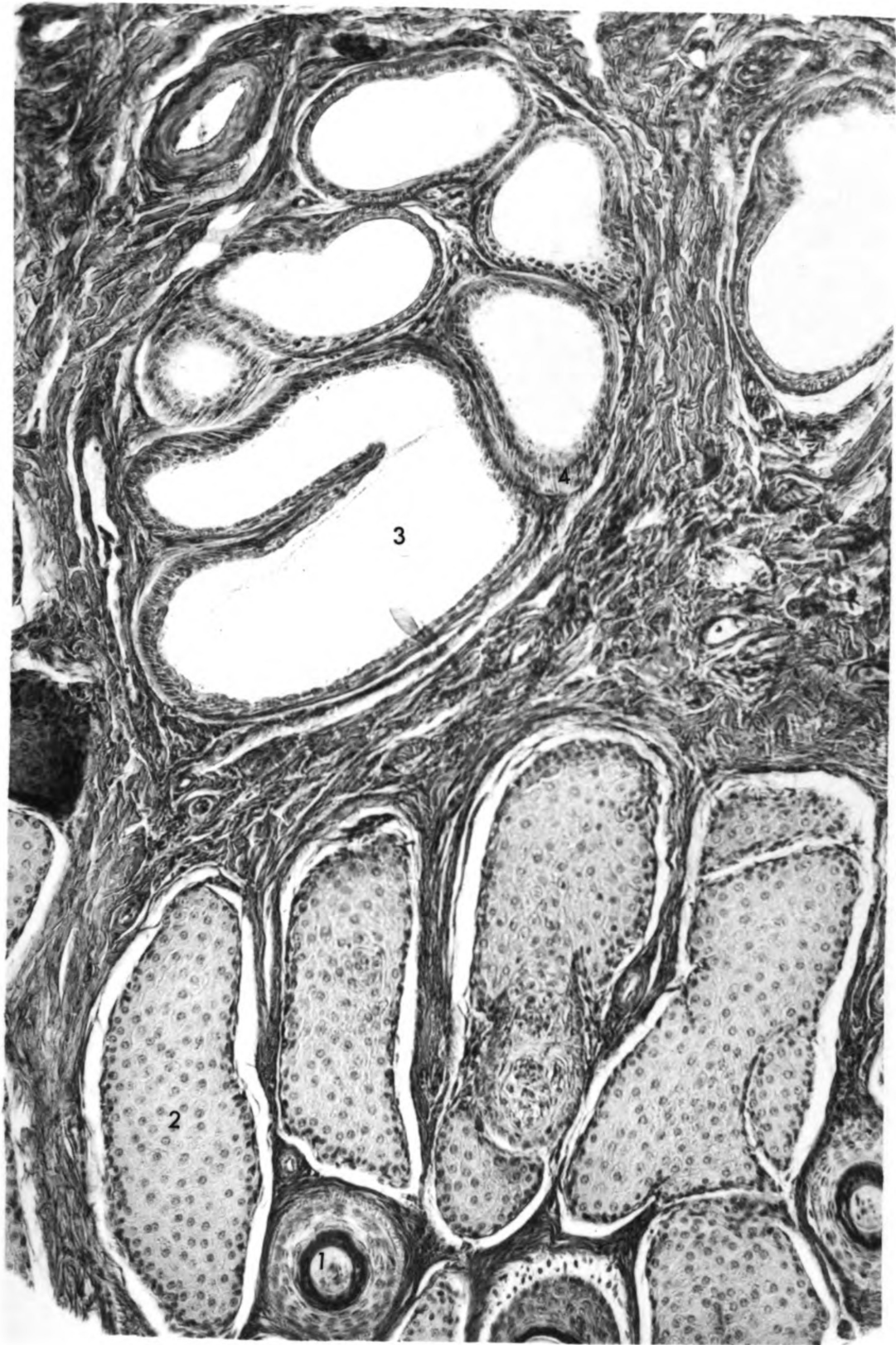


Plate XXIX

Oblique section through the muzzle showing the relationship of the ducts of sweat glands and sebaceous glands.

H. and E. stain. 180X

1. Hair follicle
2. Duct of the sweat gland
3. Sebaceous glands
4. Opening of the sebaceous duct
into the hair follicle
5. Capillaries

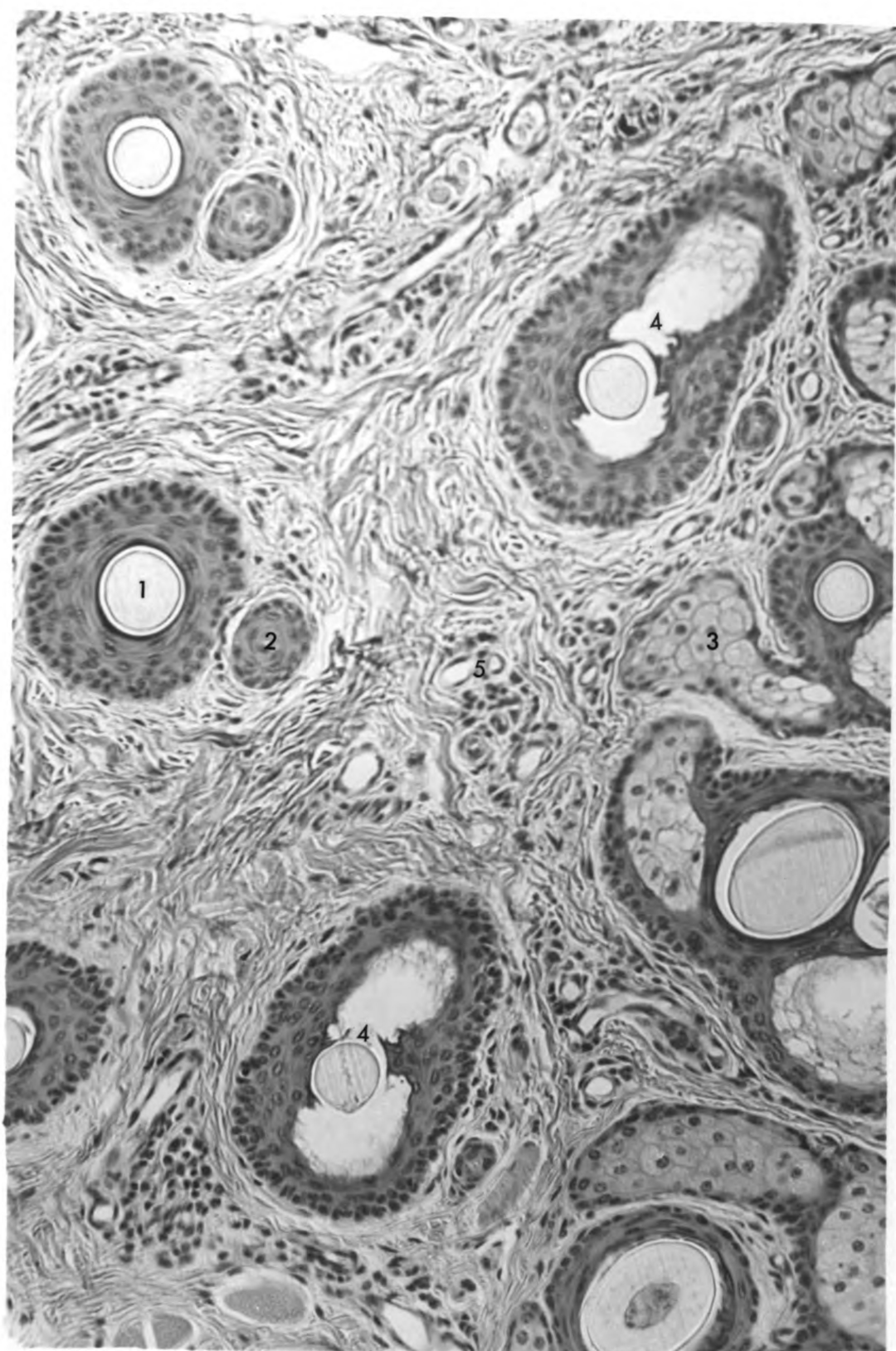


Plate XXX

Cross section of the sweat glands of the skin of the udder showing longitudinally oriented myoepithelial cells.

Mallory's triple stain. 592X

1. Columnar epithelial cells
with processes
2. Myoepithelial cells
3. Periglandular tissue

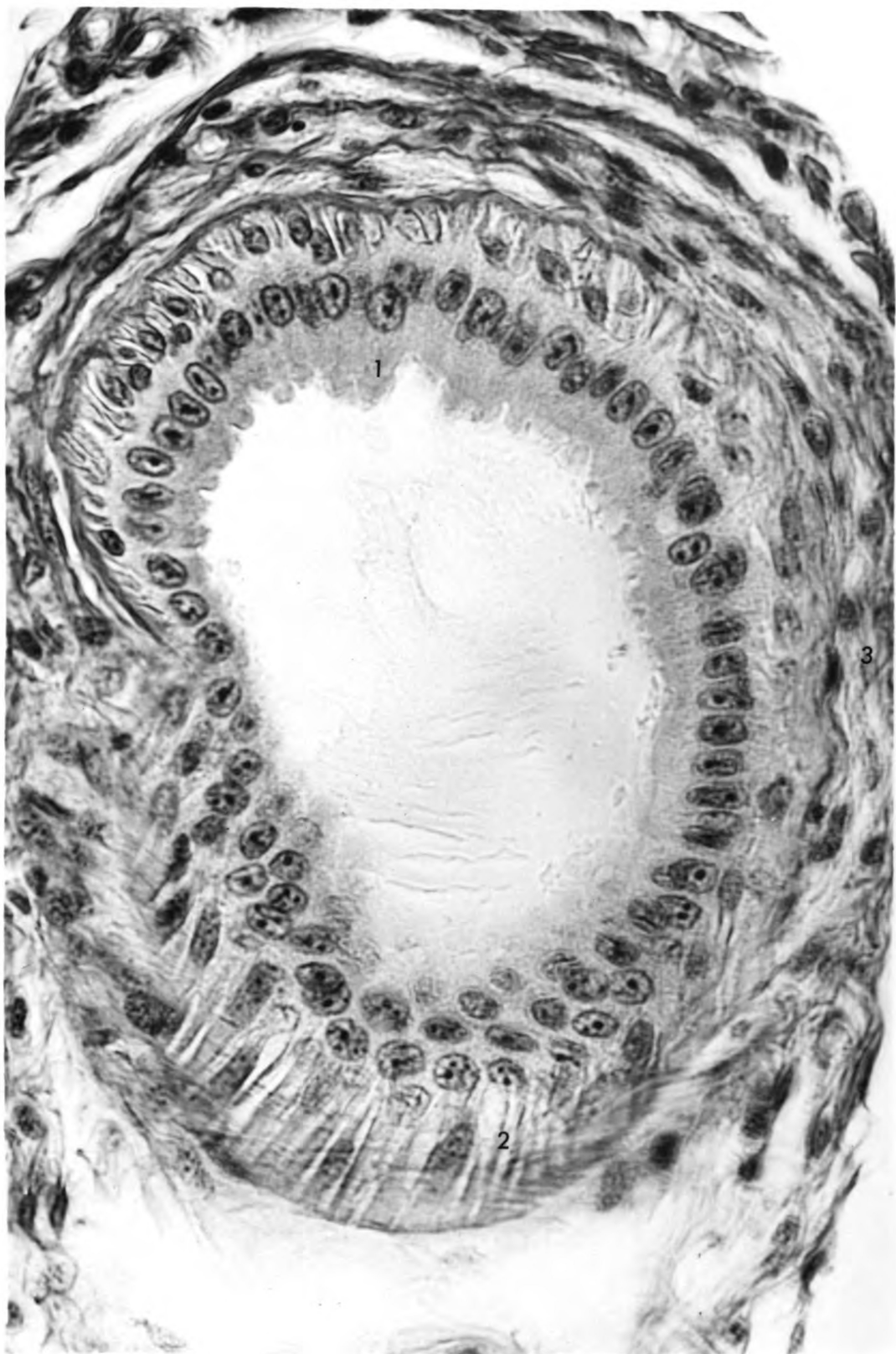


Plate XXXI

Vertical section through the planum nasale showing the lamellar structures in the dermis with oval elongated inner bulbs containing nerve endings.

Beilschowsky modified stain. 1500X

1. Oval inner bulb
2. Elongated inner bulb

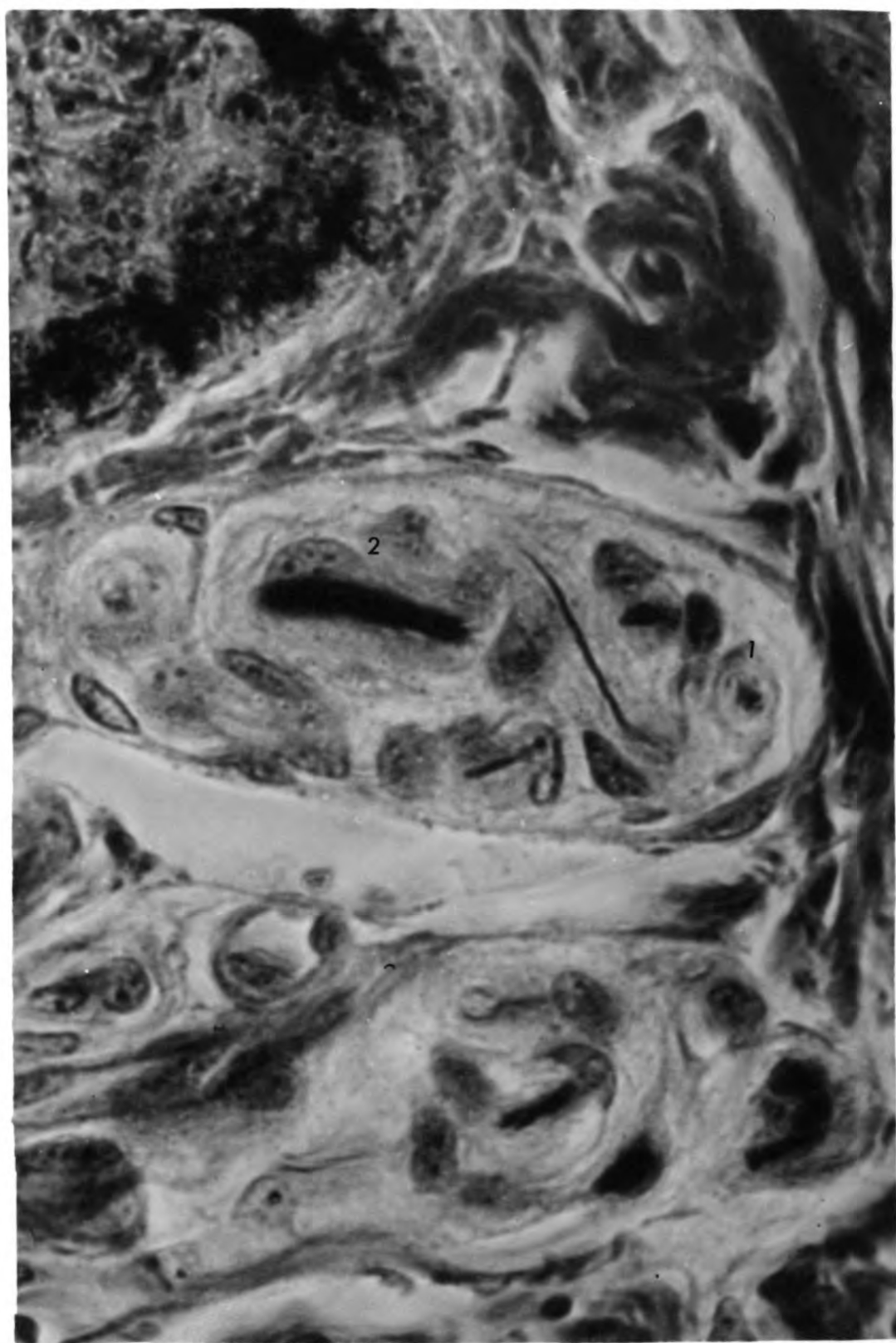


Plate XXXII

Vertical section through the planum nasale showing
capsulated and free sensory nerve endings in the
superficial layer of the dermis.

Beilschowsky modified stain. 1080X

1. Free nerve endings
2. Lamellar corpuscles with brush-
like tapered nerve endings

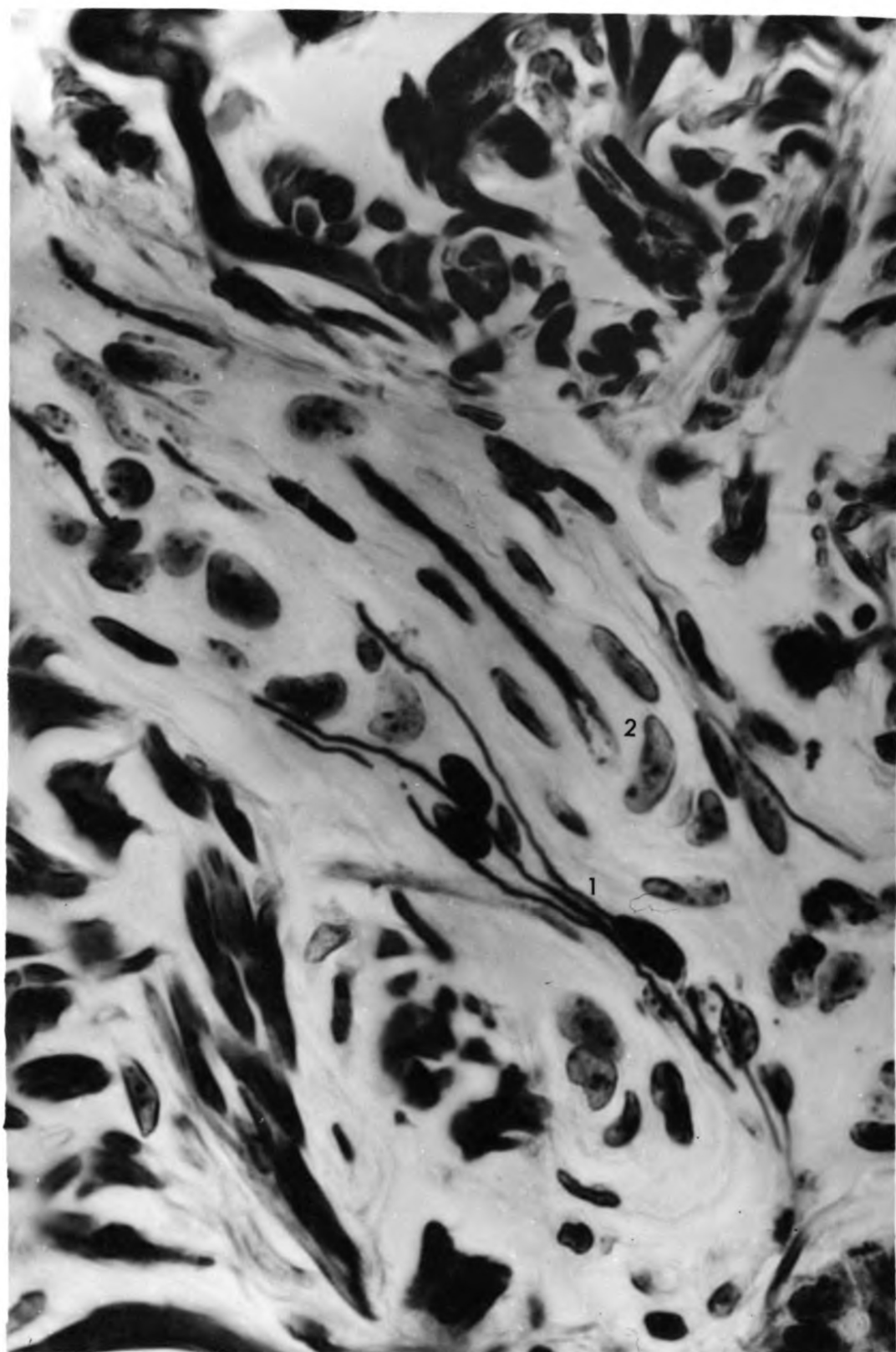


Plate XXXIII

Vertical section through the skin of the planum nasale showing oval-shaped corpuscles containing nerve endings within a connective tissue capsule.

Beilschowsky modified stain. 1200X

1. Oval corpuscles
2. Nerve endings
3. Connective tissue capsule

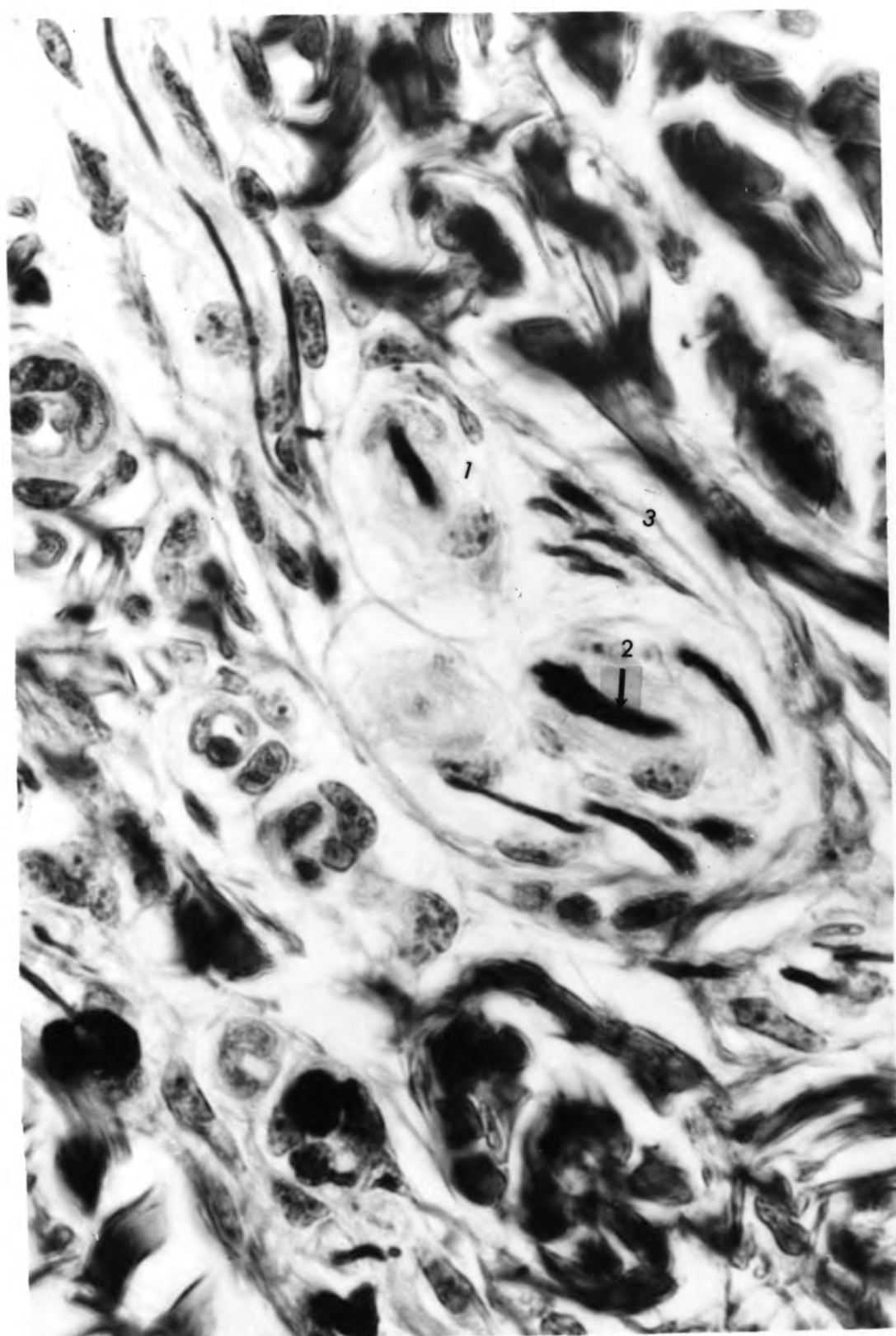


Plate XXXIV

Cross section through the wattle showing the central core of elastic cartilage, large blood vessels and nerve trunks.

H. and E. stain. 19X

1. Elastic cartilage
2. Blood vessels
3. Nerve trunks
4. Hair follicles
5. Sweat glands
6. Sebaceous glands
7. Epidermis
8. Dermis

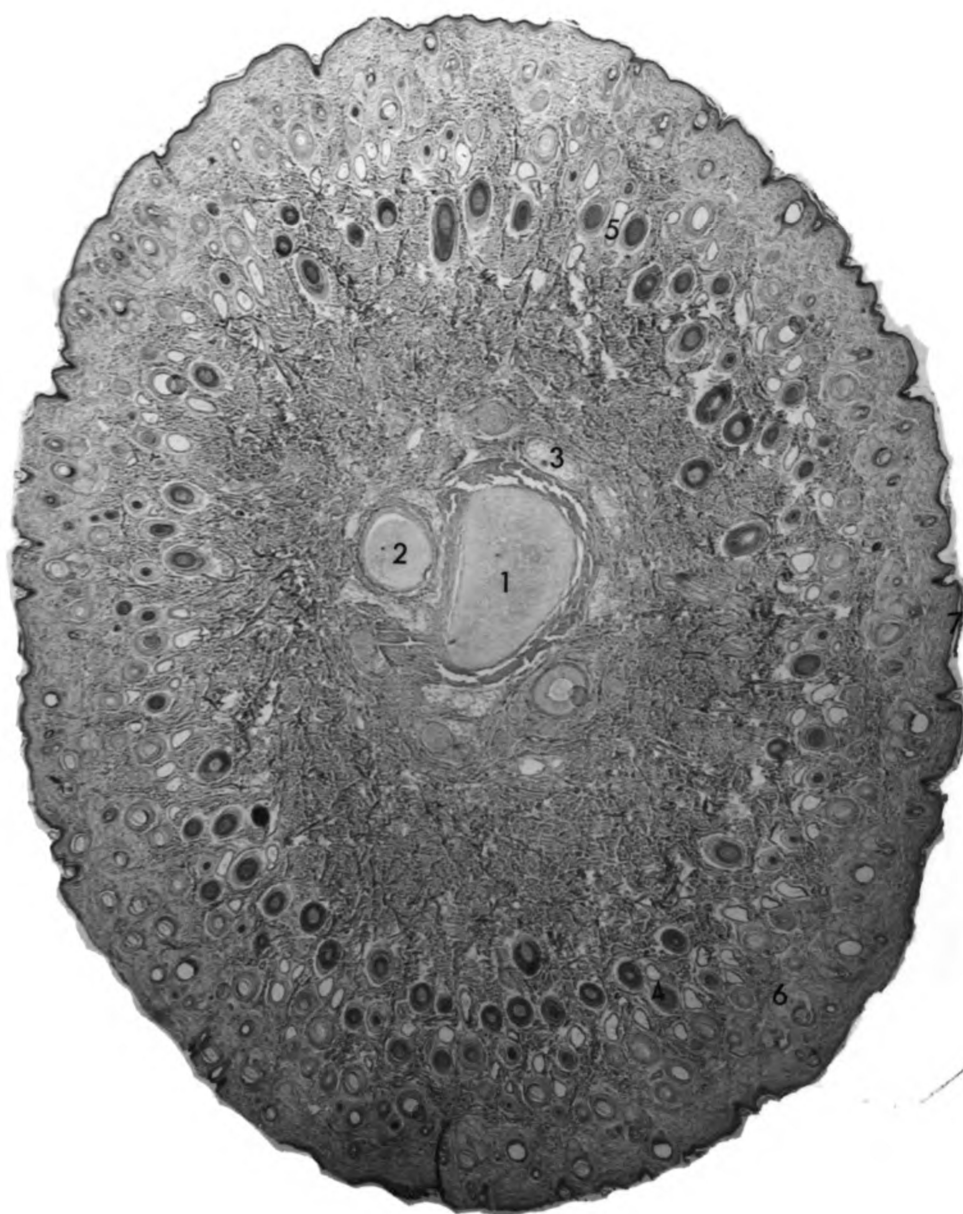


Plate XXXV

Cross section through the teat showing the large sebaceous glands and tubular skin glands.

H. and E. stain. 18X

1. Epidermis
2. Hair follicles
3. Sebaceous glands
4. Sweat glands
5. Blood vessels
6. Teat canal



[REDACTED]

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