THE COMPARATIVE HISTOLOGY OF THE SKIN OF HEREFORD AND ANGUS CATTLE

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by

Steve Goldsberry

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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At the time of this investigation, there were few available references concerned with the bovine skin. Most available information on skin structure dealt with the skin of the human species.

The animals for this study were secured from the Angus and Hereford herd of the Animal Husbandry Department of Michigan State University. Each breed consisted of two non-castrate males and two females from each of which twenty-four skin specimens from representative body regions were taken. The skin specimens were fixed in ten percent formalin, dehydrated in normal butyl alcohol and embedded in paraffin. The sections were stained with hematoxylin and eosin and Weigert Van Gieson connective stain. For the study of epidermal pigmentation, sections were deparaffinized in xylene and mounted directly without further processing and studied microscopically under direct light. Hair density was determined by microscopically counting the number of hair roots in an area of one square centimeter of horizontal sections. The thickness of the skin was determined by taking the average of measurements of five points selected indiscriminately on vertical sections of skin.

It was found that the skin consisted of two major divisions, the epidermis and the corium (dermis). The epidermis consisted of the stratum corneum, stratum lucidum, stratum

granulosum, stratum spongiosum and the stratum cylindricum, while the corium (dermis) consisted of a stratum papillare and a stratum reticulare. Comparatively, the stratum corneum was thicker in the Angus than in the Hereford, while the stratum germinativum was thicker in the Hereford than that of the Angus. When all of the strata of the epidermis were considered collectively, there were no prominent sex or breed differences.

In areas where the connective tissue of the stratum papillare was loosely arranged, fibrous processes extended from the basal epithelial layer into the adjacent papillary layer, but this was not found in areas where the papillary layer consisted of dense fibers.

In the stratum papillare, the fibers were found to be generally fine and loosely arranged, the papillary body was well developed in areas where there was no hair or where the hair was very thin. The stratum reticulare consisted of coarse collagenous fibers which were generally found to be parallel to the skin surface and extended in all directions in that plane. It was frequently observed that the capillary plexuses, which were very prominent in the stratum papillare, were embedded in very fine and loosely arranged networks of connective tissue which contain large numbers of cells characteristic of areolar tissue. In addition to this finding,

many eosinophilic cells were also seen. The thickness of the dermis was greater in the Hereford than in the Angus and also greater in the males than the females. The collagenous fibers of the Hereford were generally thicker and more densely arranged than those of the Angus. There were no characteristic sex or breed differences found in the glands of the skin or in hair density.

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INTRODUCTION

At the time of this study, little of the available literature was concerned with bovine skin. This is a comparative study of the microscopic characteristics and differences found in the structure of the skin of Hereford and Angus cattle. Hereford and Angus cattle are important to our economic well-being as sources of food and leather products. In the southwestern part of the United States, where many of our beef breeds are raised, fungal and other skin diseases are often difficult to diagnose and control. The author believes that if a good description of the normal histology of the skin is available, it will be of definite value to the pathologist and the veterinarian in diagnosing conditions which are abnormal. It is also believed that a similar description will be helpful to the leather industries in the selection of raw material. The author hopes that this paper will serve as a reference to pathologists, anatomists and the leather industries. It was with these points in mind that this investigation was undertaken.

REVIEW OF LITERATURE

A careful search of the literature revealed that only a small portion of the available information concerning skin structure can be applied directly to the bovine skin. Ellenberger (1906), Sisson and Grossman (1953), and Trautmann and Fiebiger (1952) gave detailed descriptions of bovine skin in their books of gross and microscopic anatomy of domestic animals. These authors agree that the skin is composed of a superficial layer, the epidermis, and a deeper layer, the dermis. They also stated that the skin of the ox is thickest of all the domestic animals, and that it varies in thickness with age, sex, breed and body location. It was stated by Sisson and Grossman (1953) that the skin of the forehead, neck, and tail root of the ox is approximately 5 to 6 mm. in thickness, while that of the brisket measures about 8 mm. Several investigators have made specific studies of the structure of bovine skin. Histological findings of cow skin were reported by Trumbower (1904). Muto (1925), in his study of the mammalian sweat glands, gave a brief description of his findings in the ox. A comparative study of the skin of oriental breeds and one western breed of cattle was made by Yamane and Ono (1936).

Yang (1952) published several papers on the histology and histochemistry of the bovine skin. A detailed description of the dermis of cow skin was made by Dempsey (1948). The myoepithelial cells of bovine sweat glands were studied by Yang and Goodall (1952).

Additional searches of the literature have revealed that many investigators have devoted their efforts to skin structure of other species. Frieboes (1920) and Odland (1950) studied the attachment mechanism between the epidermis and the dermis of man. The afferent innervation of human skin was described by Kuntz and Hamilton (1938), while Hass (1939) and Dick (1947) studied the elastic tissue of the human skin. The mitotic rhythm of the epidermis of the mouse was described by Cooper and Franklin (1940). The physiological and pathological aspects of cornification in the skin of man were described by Meirowsky and Behr (1948), while Nui and Twitty (1950) discussed the embryonic origin of melanophores in Triturus torosus. Webb and Calhoun (1954) gave a detailed description of the microscopic anatomy of the skin of mongrel dogs, while Wilcox (1950) described the histology of the skin and hair of the chinchilla. Age changes in the skin of Wistar Institute rats were observed by Warren (1951). Woolard (1936, 1937) described the intraepidermal nerve endings and also the continuity in nerve fibers. The function and structure of the dermis and epidermis were studied by Szodoray (1931).

In describing the origin of the skin, Arey (1950) stated that the skin is of dual origin, the epidermis and its appendages being derived from ectoderm, while the corium (dermis) arises from mesoderm.

Epidermis

The epidermis is composed of stratified squamous epithelium and is divided into two major segments. The outer segment is called the stratum corneum (horny layer) and the inner segment is the stratum germinativum (Malpighian layer) (Trautmann and Fiebiger, 1952). According to Yamane and Ono (1936) and Maximow and Bloom (1949) the epidermis varies greatly in thickness. The thickest portion is always found over those body surfaces which are often or persistently exposed to physical influences, while the thinnest portions occur in areas exposed comparatively little. Meirowsky and Behr (1948) described the keratohyalin of the stratum granulosum as being a prokeratin which is later converted to keratin. It was concluded by Ham (1953) that the true process by which keratohylin granules of the stratum granulosum are converted to keratin is unknown.

The stratum germinativum (Malpighian layer) is the cellular layer of the epidermis. It is divided into three layers which are determined by morphological cell types. The superficial layer is the stratum granulosum, the intermedi-

ate layer is the stratum spongiosum (prickle layer) and the deep layer is the stratum cylindricum (Trautmann and Fiebiger, 1952; Stiles, 1952; and Ham, 1953). Cooper and Franklin (1940) and Cowdry (1944), in describing the mitotic characteristics of the epidermis, stated that the basal layer is primarily regenerative in nature. Maximow and Bloom (1949) quoted Thuringer as having found 88 percent of the mitotic figures in the scalp and prepuce in layers other than the stratum cylindricum, and only 12 percent in the basal layer itself. Cooper and Franklin (1940) found that mitotic figures are more prominent during periods of rest than during periods of activity. This was based on the observations that human skin is generally active during the night, while nocturnal animals show epidermal activity during the day.

The color of the skin is modified by the presence of a yellowish-brown pigment which is usually confined to the cells of the epidermis. The quantity of the pigment varies in different parts of the body and is increased in quantity by ultra-violet light and sun rays. Both the nuclei and the mitochondria are believed to take part in the formation of melanin (Lambert, 1948). Nui and Twitty (1950) found that in addition to originating from the neural crest, chromatophores may be formed by macrophages, which engulf melanin from degenerating cells and undergo transformation. Strong (1927) found that when the pigment of the epidermis

is decreased, that of the dermis becomes increased. Meirowsky and Behr (1948) believed that melanin is formed in the intranuclear vacuoles. Dukes (1947) stated that melanin is a product of the action of tyrosine upon the melanoblast. The presence of melanin in other cells is due to phagocytic action of the individual cells. It was concluded by Maximow and Bloom (1949) that melanoblasts are positive to the "dopa" reagent and chromatophores are negative to the same reagent. Yang (1952), in a detailed study of the bovine skin, perfected a technique by which the pigment may be evaluated. It was further found that the pigmentation of the skin is more likely to be influenced by exposure to the sun, because the dorsal and lateral aspects are more heavily pigmented than the ventral areas.

It is generally accepted that the basement membrane separates the epidermis from the dermis, but its true morphology has led to extensive debate. Herxheimer (1916) stated that the basement membrane is associated with fine cytoplasmic fibers which extend toward the dermis.

Frieboes (1920) found that reticular fibers between the dermis and epidermis terminate in blunt and bulbous endings. After repeating the work of Herxheimer (1916) and Frieboes (1920), it was concluded by Odland (1950) that cytoplasmic processes of the basal epithelium fit into the spaces of the reticular fibers of the subepithelial network. No true end-

ings of the fibers were observed. Robb-Smith (1946) and Dick (1947) found that, in the human, the basement membrane is primarily a reticulum. This conclusion was confirmed by Dempsey (1948).

Dermis (corium)

The corium or dermis lies directly beneath the epidermis and consists of a superficial layer, the stratum papillare, and a deep layer, the stratum reticulare. The stratum papillare is raised into numerous elevations which penetrate the deep surface of the epidermis. The stratum reticulare is composed of dense collagenous fibers with which the finer elastic fibers are interwoven (Lambert, 1948). Dempsey (1948) found that the corium varies in thickness but the stratum papillare (grain layers) remains constant. She added that the stratum papillare contains a dense network of elastic fibers, some of which form ligaments by which the arrector pili muscles are attached. Dempsey (1948) further stated that bundles of collagenous fibers are bound by elastic and reticular rings (rings of Henle).

Dick (1947) found variations in the elasticity of the skin according to sex, age, and body regions. Females were found to have generally more elastin than males, and young specimen showed numerous fine fibers, while adults showed few-

er and coarser fibers. Dick (1947) also observed that although the elastic network lies close under the epidermis, there is no continuation of elastin across the basement membrane. Lowery et al. (1941) described a method by which elastic and collagenous fibers of the skin may be measured. Yamane and Ono (1936) observed that the papillary layer of the Holstein-Friesian is more highly developed than that of the oriental breeds. It was also found that the occurence of dermal papillae is determined by hair density. It was concluded that the papillae decrease as the hair numbers increase.

According to Trautmann and Fiebiger (1952), the subcutis consists of loose collagenous trabeculae which contain many elastic fibers and cross each other to form a meshwork. The movability of the skin is determined by the elasticity of these same fibers. Trautmann and Fiebiger (1952) added that glands were observed in the subcutis which resemble those of the external auditory meatus.

Trumbower (1904) found that the subcutaneous tissue of cattle contains large quantities of fat. It was concluded by Dempsey (1948) that fat is not readily stored in the skin of the ox, and when present it appears to be restricted to the lumbar region.

Hair

According to Lambert (1948) hair is an outgrowth of the skin which appears over the entire body surface. A typical hair consists of a shaft which is usually above the skin and a root which is inserted into an obliquely arranged epithelial tube, the hair follicle. The attached end of the hair root is enlarged to form a bulb which is invaginated by connective tissue and capillaries that form the hair papillae. Arey (1950) described the origin and embryonic development of the hair. Yamane and Ono (1936) found difficulty in establishing sex differences based on hair density evaluations. The hair of the forehead, neck and withers was usually of greatest density, when contrasted with that of the extremities which was usually of least density. The hair density of other areas was unpredictable. It was established, however, that there are marked differences in the hair counts of oriental and western breeds.

Trautmann and Fiebiger (1952) made use of a technique by which mammalian breeds may be classified by study of the hair morphology. It was observed by Wilcox (1950) that in the skin of the chinchilla, the number of hairs in a given cluster may be as high as 75, but there is always one arrector pili muscle to each hair follicle.

Skin Glands

Sebaceous glands. Most authors agree that the sebaceous glands are lobular outgrowths of the hair follicles and are usually found in groups of two or more lobules which open through small epithelial ducts into the hair follicles. Trautmann and Fiebiger (1952), Yamane and Ono (1936), and Sisson and Grossman (1953) all agreed that the sebaceous glands vary in form according to hair density. Wherever the hair is dense, the sebaceous glands are long and narrow (neck region), and when the hair is sparse, the sebaceous glands are spheroid. Sisson and Grossman (1953) found sebaceous glands to be highly developed near the margins of natural openings. It was discovered by Trumbower (1904) that the margins of the claws of cattle are rich in highly developed sebaceous glands. By use of special histo-chemical techniques, Yang (1952) demonstrated the biochemical nature of sebum.

Butcher and Parnell (1948) found that a local increase of temperature is sufficient to increase the activity of the sebaceous glands of the forehead of man. The physiology of the sebaceous glands of the hamster was studied by Montagna (1949). This study revealed that the sebaceous glands of the adult male are more active than those of the adult female. It was also found that sebaceous glands

of castrates were poorly developed, but upon sufficient injection of androgen they developed to normal size.

Sweat glands. Ellenberger (1906), Sisson and Grossman (1953) and Trautmann and Fiebiger (1952) found that two types of sweat glands exist in the skin of domestic animals. In the horse, sheep, pig and cat, the sweat glands are coiled. In the ox and dog they are generally saccular. In addition to the saccular form in the ox, Sissom and Grossman (1953) found coiled forms in the muzzle, tips of the hocks, flexures of the fetlock and in the peri-anal skin. Yamane and Ono (1936) found that sweat glands of the Oriental breeds of cattle are present in all parts of the body and are always associated with hair follicles. The secretory portions are usually deeper than the sebaceous glands. The excretory ducts are of uniform size, lined with a double layer of cuboidal epithelial cells which become stratified squamous epithelium near the opening of the duct. It was concluded that no sex differences were distinguishable. Trumbower (1904) described the sweat glands of the ox as small, red, coiled bodies in the subcutaneous fat whose ducts extended the entire distance of the skin thickness and opened on the surface of the epidermis. Dukes (1947) and Marshall and Halnan (1948) agreed that the ox sweats mainly from the nose and only with difficulty from other body areas. Sisson and Grossman (1953) found that a well developed modi-

fication of the sweat glands is present in the connective tissue of the muzzle. These are compound tubular glands arranged in lobules and associated by excretory ducts which unite to form a single duct which always opens on the surface of the muzzle. It was concluded by Yang and Goodall (1952) that the sweat glands of the ox are lined with flat epithelial cells. The nuclei of these cells are spherical and the cell outlines are indistinct. The functional epithelium is enclosed by a layer of myo-epithelial cells whose long axes are always parallel to the long axes of the gland body.

MATERIALS AND METHODS

Source of Animals

The animals available for this study came from a herd of Angus and Hereford cattle. Of each breed there were two noncastrate males and two females, whose ages ranged from 14 to 21 months, except for one female Hereford of 36 months. They were made available by the Animal Husbandry Department of Michigan State University. These animals were raised under ideal nutritional and environmental conditions and appeared to be in excellent condition.

Techniques

Selection and processing of tissues. Skin specimens of about 5 centimeters square were taken from 24 body areas (Plate I) of freshly slaughtered animals and fixed in 10 percent formalin for 2 to 5 days, after which pieces of skin 2 x 6 mm. for vertical sections and 10 x 10 mm. for horizontal sections were dehydrated in four changes of normal butyl alcohol. The first three changes were for 6 hours each and the fourth change was from 18 to 24 hours. They were subsequently cleared in xylene for approximately 3 hours prior to infiltration with 3 changes of equal parts of 54° C. and 56° C. paraffin for 36 hours, and embedded in

Tissuemat.* Vertical sections were cut at 10 to 12 microns and horizontal sections were cut at 8 to 10 microns.

Stains. Harris' hematoxylin and eosin was used as a routine stain on all sections. Weigert and Van Gieson's stain for elastic and collagenous tissues was used on all vertical sections.

Pigment determination. Pigment values were determined by a slight modification of Yang's (1952) method. Sections were deparaffinized in 2 changes of xylene for approximately 2 minutes each and mounted without staining. Pigment was classified by the following standards:

0 = absence of pigment
1+ = small patches (minimal amounts)
2+ = continuous bands with heavier patches
3+ = moderately heavy and involving several layers of epithelium
4+ = very dense, obstruction of cell outline (maximal amounts)

Color of the pigment granules was not used as an evaluating factor because of specific breed differences.

Hair density. In order to determine hair density, several improvisations were made. On a thin glass slide an area of 1 centimeter square was marked with a glass marking pencil, and divided into four equal segments. The four divisions were counted separately and totaled. The average was taken as the number of hairs per square centimeter of

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*Fisher Scientific Company, Pittsburgh, Pennsylvania.

skin surface. In order to make counting easier the field of vision was reduced to the desired size by inserting a small plastic window into the eyepiece.

Skin thickness. The thickness of the skin was determined by measuring vertical sections of skin from the outermost to the deepest border. By use of an ocular micrometer, measurements were taken at five points which were selected indiscriminately. The average was taken as the skin thickness. For measuring thick objects, the 16 mm. objective was used and for small structures, the 4 mm. objective was used.

RESULTS AND DISCUSSION

Skin Thickness

The thickness of the skin varies greatly with breed, sex and body region. This study of skin thickness revealed that breed differences were very pronounced in the stratum corneum, stratum germinativum, dermis and total skin. The stratum corneum was thickest in the Angus, with measurements ranging from 8 to 80 microns with an average of 23 microns, while the same layer in the Hereford varied from 8 to 71 microns with an average of 16 microns. The stratum germinativum was thickest in the Hereford; these values ranged from 26 to 900 microns with an average of 86 microns, while the comparative values in the Angus varied between 19 and 1,000 microns and averaged 81 microns. A few minor differences were found in total epidermis, but they were not significant in comparing breeds and sexes (Tables 1 and 2).

The dermal thickness varied extensively with sex, breed and body location. A comparison of sexes revealed that the Angus male had a dermal measurement of 5,151 microns, while the female dermis measured only 4,605 microns. In the Hereford, the male and female averages were 6,059 microns and 5,758 microns respectively. The total breed

thickness of the dermis in the Hereford was 5,908 and that of the Angus was 4,605 microns (Tables 3 and 4).

The total skin thickness of the Hereford males and females was practically equal in all areas included in this study, with respective measurements of 6,081 and 5,944 microns. The Angus males showed a slight but persistent thickness advantage in sixteen of the twenty body areas included in this study; they were of greater thickness in the male than the female and showed a comparative average of 5,115 and 4,660 microns, respectively. A comparison of the total skin showed that a pronounced breed difference was evident. Of the twenty body areas studied, the Hereford skin thickness was greatest in all except the tail root and the forehead (Tables 5 and 6). The total skin average for the Hereford was 6,012 microns, while that of the Angus was 4,887 microns. According to the findings in this study, it may be generally stated that the thickest epidermis is found in the muzzle. The stratum corneum was thickest in the Angus breed and also was usually of increased thickness where the stratum germinativum was thinnest. Skin from the head, neck, brisket and tail root was usually thickest in both breeds and sexes, while the thinnest skin was generally found in the axillary and ventral abdominal regions.

Epidermis

In both the Angus and the Hereford breeds, the epidermis consisted generally of stratified squamous epithelium, of which two layers were easily recognized. The superficial layer was the stratum corneum and the deeper layer the stratum germinativum (Plate II).

Stratum corneum. The stratum corneum usually consisted of a layer of cornified cells, but occasionally in thick layers some cells were still undergoing parakeratosis. The stratum corneum was comparatively thicker in the Angus than in the Hereford, but no sex differences were noticeable.

Stratum spongiosum. The stratum spongiosum consisted of several layers of polygonal cells which lay between the stratum corneum and the stratum cylindricum (Plate II). The cytoplasmic processes and the inter-cellular bridges which are usually described in the prickle layer were prominent only in those areas where there were five or more rows of cells in this layer. In the Angus the stratum spongiosum was poorly developed and in most areas it consisted of from three to six layers of cells (Plate VI). The same layer in the Hereford was more pronounced than that of the Angus and generally consisted of from six to twelve layers in which the inter-cellular bridges and the cytoplasmic fibrils were easily demonstrated.

Stratum cylindricum. The stratum cylindricum of both breeds consisted of a single layer of columnar epithelial cells that varied in height with epidermal thickness. These cells were tallest in thick epidermis and when the epidermis consisted of only two or three rows of cells, the cylindrical cells were low columnar. The Hereford was usually found to have taller cells in the basal layer than the Angus, but this is believed to be a characteristic of epidermal thickness and not a breed difference. This conclusion is supported by the fact that similar cell types were found in all areas of similar epidermal thickness without regard to sex or breed. The basal cells of both breeds were found to have numerous cytoplasmic processes which extended into the adjacent tissues of the dermis in areas where the dermal fibers were fine and loosely arranged, but this was not generally true in areas where the subepithelial fibers were dense and coarse.

Stratum granulosum. The stratum granulosum was poorly developed in almost all areas studied in both sexes and breeds. In most areas, the stratum granulosum was represented by an occasional cell, whose nucleus was undergoing karolysis while the cytoplasm contained dark staining granules. These cells were usually found at the border between the stratum corneum and the stratum spongiosum. In the fetlock, where the epidermis was fairly thick, there were two

rows of granular cells, but in the muzzle where the epidermis was extremely thick, there were only a few of these cells found.

Stratum lucidum. The stratum lucidum was occasionally present in areas where the epidermis was moderately thick. It was absent in the muzzle, the margins of the hoof and horns, and perianal skin (Plate II). This layer was found in the tips of the hocks and the upper legs. There was little suggestion of the stratum lucidum in other body areas. The stratum lucidum, when present, was located on the lower border of the stratum corneum, which was adjacent to the superficial cellular layer of the epidermis. These findings were fairly constant in both sexes and breeds.

Although there were sex and breed differences in separate layers of the epidermis, the total averages were approximately the same without regard to sex or breed differences (Tables 1 and 2). The epidermis was thickest in the muzzle of all animals studied and measured approximately 900 microns (Plate II). It was uniform in thickness over the entire surface, except for the papillary pegs, and became thin abruptly at the margin of the hairy skin. In addition to the epidermis of the muzzle, the thickest epidermis was found to lie over areas where the total skin was thinnest, such as the lumbar and the ventral abdominal regions.

Mitotic figures were seldom encountered in either the Hereford or the Angus breeds.

Epidermal pigmentation. This study revealed a distinct breed difference between the Hereford and the Angus, but there were no sex differences found. In the Angus, the epidermal pigment was found without exception as fine black granules without regard to pigment density, while that of the Hereford was always found to be a variety of brown, even in the areas of greatest density. Because of the color differences of the pigment, it was necessary to modify the method of Yang, S. H.. (1952) who used color, density, and number of infiltrated epidermal layers as determining factors. In this comparative study of epidermal pigmentation in the Hereford and Angus, color of pigment granules was not conisdered. Areas which contained no pigment were designated "0", while those which contained pigment were evaluated from 1+ to 4+ with the maximum being 4+ and lesser quantities the corresponding numbers. In the Angus, the hair coat is grossly black over the entire surface of the body, but microscopically the epidermal pigment varied with general body location. By taking an average of pigment values according to body regions, it was found that the dorsal aspects, and the muzzle and hoof margin, contained pigment values of 3+, and the lateral aspects and extremities 2+, while the ventral areas contained average values of 1+. A similar study of the

Hereford showed that the epidermal pigment was influenced by body region and gross color of the hair coat. In areas where the hair coat was white, the underlying skin was generally free of pigment, without regard to body location, but in areas where the hair coat was red, pigment was generally present, but varied with body region. The dorsal and lateral areas and the extremities contained quantities which varied from 1+ to 3+, while those of the ventral surfaces were generally free from pigment (Table 7). According to findings in this study, it may be generally stated that epidermal pigmentation was primarily influenced by the gross color of the hair coat, and secondarily by exposure to sunlight. Pigmentation of the skin which underlay the borders of red and white hair in the Hereford was found to be unpredictable.

Dermis (Corium)

The dermis (corium) is the thickest portion of the total skin and lies directly beneath and adjacent to the epidermis (Plate VI). This part of the skin is divided into two layers; the superficial is the stratum papillare and the deep layer is the stratum reticulare. In many of the body areas of the animals investigated, these layers fused in such manner that their exact borders were indistinct. For this reason comparative measurements were not taken.

Stratum papillare. In the stratum papillare, the connective tissue fibers were usually fine and loosely arranged and the collagenous fibers were coarser than other fiber types. They were arranged between and at vertical angles with the hair follicles, but generally parallel to the epidermis (Plate IX). One of the prominent and characteristic structures of the stratum papillare was the papillary body which, when present, lay adjacent to and invaginated the basal layer of the epidermis. In both breeds and sexes, it was most highly developed in the muzzle (Plate II), the hoof and horn margins, and the perianal skin. It was usually more prominent where the hair was thin and decreased in frequency of occurrence and in size as the hair density was increased. In this study, the stratum papillare usually extended from the basal layer of the epidermis to the deepest portion of the sweat gland, which was slightly deeper than the papillae of the hair bulb.

Stratum reticulare. The stratum reticulare, which was the thicker of the two layers, consisted of collagenous fibers which were densely arranged with diameters about three times the diameters of those in the stratum papillare. These fibers were usually arranged in large bundles which were generally parallel to the skin surface, extending in all directions in that plane. On a few occasions smaller fibers were found to extend toward the skin surface; however,

this was not a characteristic finding. On several occasions the stratum reticulare was found to be composed of large bundles which were loosely arranged without any definite pattern. This observation was not specific for any sex, breed, or body area. In the perianal skin, the collagenous bundles were arranged so that they extended in one general direction and were parallel to the epidermis.

Elastic tissue. The elastic fibers of the corium were very prominent in the stratum papillare, where they were very fine and extended in all directions, forming a loosely arranged network (Plate III). These fibers were observed to be very dense in areas of the hair follicle where the arrectores pilorum muscles were attached, but no definite attachments between the elastic tissue and the muscles were found. In the dermis the elastic fibers were in most cases associated with blood vessels and nerve trunks. Capillary and nerve plexuses were embedded in very fine fibrous networks, in which large numbers of cell types which are characteristic of areolar tissue were found (Plate III). These cells were found in this connection without exception, and were very prominent in the stratum papillare. In addition to the above-mentioned cell types, eosinophils were also very prominent. Large, dense elastic fibers similar to those observed in the dog by Webb and Calhoun (1954) were found in the deepest portion of the dermis and were often associated

with the large nerve trunks and blood vessels (Plate X). The collagenous fibers of the Hereford appeared to be slightly coarser than those of the Angus. According to the results obtained from this study, the major comparative breed and sex difference in the dermis was the dermal thickness. Fat was seldom observed in the areas studied, but when present it was usually found in sections taken from the dewlap and brisket.

Hair

The hair and hair follicle were morphologically similar to the descriptions given by Trautmann and Fiebiger (1952). In addition to their description of the hair follicle, the author found a series of folds to exist in the middle third of the hair follicle and slightly beneath the opening of the sebaceous duct into the lumen of the hair follicle (Plates V, VI, XI). These folds were usually found in numbers which varied from 10 to 25. They were not of uniform size and shape, and extended horizontally into the lumen of the hair follicle. The lengths of the folds ranged from 10 to 40 microns. They were present without exception. The true nature and function of this structure were not determined.

The angles at which the hair penetrated the epidermis varied with body area. In anal skin, the angle was approximately 90°, while in the upper foreleg the angle of pene-

tration was less than 45°. The hair density determination did not reveal characteristic sex or breed differences. The average number of hairs per square centimeter was 1,336 for the Angus males and 1,308 for the Angus females, while the similar values for the Hereford were 1,194 and 1,010.

In areas of the body where the hair coat was grossly colored, pigment was prominent throughout the entire length of the hair root. The deep end of the hair follicle was often found to serve as an anchorage for the arrectores pilorum muscle which was usually attached to the side of the hair follicle which formed the greatest angle with the basal layer of the epidermis. In no case were the hair follicles found to contain more than a single hair (Plate IX).

Skin Glands

Sweat glands. The sweat glands of the Hereford and the Angus breeds were similar to those described by Ellenberger (1906), Sisson and Grossman (1953) and Yang, S. H. (1952) for the ox. In this investigation, they were found in all parts of the body of both sexes and breeds. Two general types were recognized, a saccular and a loosely coiled type. The coiled glands were found in the perianal skin, the fetlock and tips of the hock. Occasionally the glands at the margin of the hooves and horns were coiled. The epithelium of the coiled glands was low columnar, in contrast to the

flat cells of the saccular types (Plate VIII). Both types of glands were usually located at a depth which approximated that of the hair bulb. They became narrow at the lower level of the hair follicle to form the excretory duct which consists of two layers of low epithelial cells. The sweat duct extends toward the surface in a course which is parallel to the hair follicle and usually passes between the lobules of the sebaceous gland (Plate VII) to open into the hair follicle near the surface of the skin.

The observation of the glands of the muzzle agrees favorably with those described by Sisson and Grossman (1953) and Zimmerman (1934).

They were compound tubular glands which were found in large, closely coiled masses or lobules which were located deep in the subepidermal (dermal) tissue. The epithelium of the secretory tubules varied from cuboidal to pyramidal forms (Plate IV). The nuclei of these cells were located near the basal end of the cell, and in those cells which contain numerous granules, the nuclei appeared flattened. Granules were usually not found in the cells of the excretory ducts. These ducts, which were found among the tubules, were easily distinguished by their columnar epithelium which stained pink with hematoxylin and eosin. The numerous small ducts of each individual mass of lobules extended toward the surface and united to form larger ducts.

The uniting of the smaller ducts to form larger ones was easily demonstrated by horizontal sections between the gland masses and the epidermis (Plate IV). By similar sections the ducts were found to extend toward the surface through the connective tissue between the papillary pegs of the epidermis. A short distance from the periphery of the gland masses the epithelium of the ducts was transformed to stratified squamous epithelium, which contained a 4+ pigment value (Plate IV) in all of the Angus cattle investigated. The openings of the ducts on the surface of the muzzle were seen grossly with the unaided eye and were found to number from 5 to 12 per square centimeter.

The sweat glands showed no sex or breed differences, but there was a noticeable breed characteristic in the large excretory ducts of the muzzle. In all Angus cattle studied, the ducts were heavily pigmented from the periphery of the lobule to the basal layer of the epidermis, while pigment was always absent in the same ducts of the Herefords. In neither breed was pigment found within the periphery of the gland masses themselves.

Sebaceous glands. The sebaceous glands observed in this study were primarily lobulated and were found to vary from two to approximately twenty lobules. They were usually attached to the middle third of the hair follicle and lay in the angle formed by the arrector pili muscle and the

hair follicle. In areas where the glands were highly developed, occasional branching of the excretory ducts was frequently observed.

The cells, which were polygonal in type, showed early degenerative changes in both the cytoplasm and nuclei. The nuclei appeared shrunken and faded, while the cytoplasm contained many granules of various sizes. These glands were rarely found to have a lumen; however, when the lumen was seen, it was usually near the area of the excretory duct and contained a fine granular substance which showed no special affinity for hematoxylin and eosin.

The sebaceous glands of both breeds were found to be arranged in a specific manner. Highly developed glands frequently encircled the hair follicle, while those less developed were attached to the follicle so that all of the gland bodies extended in a common direction (Plate IX).

The excretory ducts were usually short and were lined with stratified squamous epithelium which extended from the hair follicle. They were found to open into the hair follicle at a point which was always deeper than the opening of the sweat ducts. These findings were common to both breeds and sexes studied in this experiment.

TABLE 1

MEASUREMENTS OF EPIDERMAL THICKNESS OF HEREFORD CATTLE IN MICRONS

Location	Male			Female		
	C	F	Av.	C	E	Av.
Forehead	54	66	60.0	61	54	57.5
Dorsal neck	64	42	53.0	70	48	59.0
Dorsal thorax	49	72	60.5	58	48	53.0
Dorsal lumbar	32	84	58.0	56	120	88.0
Tail root	47	36	41.5	68	60	64.0
Ventral dewlap	50	54	52.0	48	48	44.0
Ventral brisket	55	78	66.5	74	72	73.0
Ventral abdomen	75	96	85.5	98	54	76.0
Ventral udder	40	48	44.0	70	48	59.0
Ventral axilla	32	48	40.0	42	38	40.0
Ventral groin	73	36	54.5	71	72	71.5
Lateral neck	37	30	33.5	37	36	36.5
Lateral thorax	27	60	43.5	53	48	50.5
Lateral abdomen	33	48	40.5	53	72	62.5
Gluteus	43	30	36.5	50	30	40.5
Upper foreleg	77	42	59.5	26	66	46.0
Fetlock	51	66	58.5	100	42	71.0
Upper hindleg	65	36	50.5	60	60	60.0
Lower hindleg	45	120	82.5	127	36	81.5
Achilles insertion	46	24	35.0	220	36	128.0
Perianum	48	64	56.0	91	90	90.5
Muzzle	763	1,350	1,056.5	339	90	889.5

TABLE 2

MEASUREMENTS OF EPIDERMAL THICKNESS OF ANGUS CATTLE IN MICRONS

Location	Male			Female		
	A	D	Av.	G	H	Av.
Forehead	72	43	57.5	100	95	97.5
Dorsal neck	24	45	34.5	50	57	53.5
Dorsal thorax	16	49	32.5	84	80	82
Dorsal lumbar	57	48	52.5	30	30	30
Tail root	115	59	87	66	52	59
Ventral dewlap	35	37	36	84	85	84.5
Ventral brisket	43	41	42	58	58	58
Ventral abdomen	48	31	39.5	144	103	123.5
Ventral udder	22	32	27	42	52	47
Ventral axilla	50	30	40	126	145	135.5
Ventral groin	47	40	43.5	36	33	34.5
Lateral neck	29	33	31	138	77	107.5
Lateral thorax	42	38	40	60	70	65.0
Lateral abdomen	49	45	47	36	33	34.5
Gluteus	42	40	41	36	40	38
Upper foreleg	36	24	30	48	35	41.5
Fetlock	38	46	42	30	41	35.5
Upper hindleg	30	34	32	42	42	42
Lower hindleg	49	30	39.5	42	42	42
Achilles insertion	76	52	64	108	92	100
Perianum	280	65	172.5	72	76	74
Muzzle	1,650	973	1,311.5	1,100	1,107	1,103.5

TABLE 3

MEASUREMENTS OF DERMAL THICKNESS OF HEREFORD CATTLE IN MICRONS

Location	Male			Female		
	B	F	Av.	C	E	Av.
Forehead	7,660	5,430	6,545	4,910	5,580	5,245
Dorsal neck	7,440	6,960	7,200	6,190	8,040	7,115
Dorsal thorax	6,420	4,930	5,675	5,570	6,950	6,260
Dorsal lumbar	6,170	7,170	6,670	3,560	5,880	4,720
Tail root	7,280	7,960	7,620	5,730	5,440	5,585
Ventral dewlap	14,930	5,450	10,190	6,000	9,450	7,725
Ventral brisket	6,020	7,920	6,940	6,000	7,430	6,715
Ventral abdomen	7,890	5,660	6,775	5,500	5,950	5,775
Ventral udder	6,190	4,450	5,320	4,190	5,450	4,820
Ventral axilla	7,000	4,700	5,850	7,270	5,460	6,365
Ventral groin	5,930	6,710	6,320	5,710	5,930	5,820
Lateral neck	7,770	5,940	6,855	5,150	5,460	5,305
Lateral thorax	5,250	4,440	4,845	6,260	6,950	6,605
Lateral abdomen	4,540	3,950	4,255	6,040	5,430	5,735
Gluteus	7,330	4,220	5,775	5,450	5,970	5,710
Upper foreleg	5,120	4,210	4,665	3,650	4,930	4,290
Fetlock	5,980	4,680	5,330	3,950	4,960	4,455
Upper hindleg	3,820	6,210	5,015	4,520	6,440	5,480
Lower hindleg	4,350	4,880	4,615	5,980	4,460	5,220
Achilles insertion	5,920	3,480	4,700	5,540	6,960	6,250

TABLE 4

MEASUREMENTS OF DERMAL THICKNESS OF ANGUS CATTLE IN MICRONS

Location	Male			Female		
	A	D	Av.	G	H	Av.
Forehead	6,430	8,080	7,255	6,900	6,100	6,500
Dorsal neck	6,750	5,850	6,300	4,950	6,330	5,640
Dorsal thorax	3,710	5,510	4,610	5,670	5,990	5,830
Dorsal lumbar	6,320	7,090	6,705	4,470	5,070	4,770
Tail root	4,380	6,070	5,225	4,930	6,550	5,740
Ventral dewlap	8,920	6,290	7,605	7,410	6,000	6,705
Ventral brisket	4,950	5,020	4,985	2,440	4,007	3,223
Ventral abdomen	4,370	4,620	4,495	3,610	4,400	4,005
Ventral udder	3,990	3,570	3,780	4,960	5,000	4,980
Ventral axilla	3,380	3,730	3,555	2,370	2,570	2,470
Ventral groin	5,250	4,030	4,640	5,210	4,360	4,785
Lateral neck	9,090	7,160	8.125	3,460	5,580	4,520
Lateral thorax	4,470	5,520	4,995	5,190	2,930	4,060
Lateral abdomen	5,830	5,310	5,570	2,960	4,970	3,965
Gluteus	4,170	5,630	4,900	5,460	6,000	5,730
Upper foreleg	3,980	4,330	4,155	4,950	3,170	4,060
Fetlock	3,020	3,990	3,505	2,970	3,270	3,120
Upper hindleg	4,380	4,370	4,375	3,210	5,350	4,280
Lower hindleg	2,270	4,280	4,275	2,960	5,180	4,070
Achilles insertion	4,240	3,900	4,070	2,890	4,440	3,665

TABLE 5

MEASUREMENTS OF TOTAL SKIN THICKNESS OF HEREFORD CATTLE IN MICRONS

Location	Male			Female		
	B	F	Av.	C	E	Av.
Forehead	7,713	5,500	6,606	4,967	5,635	5,301
Dorsal neck	7,497	7,000	7,248	6,355	8,085	7,220
Dorsal thorax	6,723	5,000	5,816	5,625	7,000	6,312
Dorsal lumbar	6,203	7,250	6,726	3,616	6,000	4,808
Tail root	7,330	8,000	7,665	5,796	5,500	5,648
Ventral dewlap	14,979	5,500	10,239	6,036	9,500	7,768
Ventral brisket	6,076	8,000	7,038	6,733	7,500	7,116
Ventral abdomen	7,962	5,750	6,856	5,601	6,000	5,800
Ventral udder	6,228	4,500	5,364	4,985	5,500	5,241
Ventral axilla	7,027	4,750	5,888	7,311	4,500	5,905
Ventral groin	6,007	6,750	6,378	5,782	6,000	5,891
Lateral neck	7,811	6,000	6,905	5,189	9,500	7,344
Lateral thorax	5,272	4,500	4,886	6,312	7,000	6,656
Lateral abdomen	4,577	4,000	4,288	6,091	5,500	5,795
Gluteus	7,375	4,250	5,812	6,000	6,000	6,000
Upper foreleg	5,194	4,250	4,722	3,680	5,000	4,340
Fetlock	6,031	4,750	5,390	4,050	5,000	4,525
Upper hindleg	4,586	6,250	5,418	4,591	6,500	5,545
Lower hindleg	3,881	5,900	4,890	6,105	4,500	5,302
Achilles insertion	4,390	3,500	3,445	5,756	7,000	6,378

TABLE 6

MEASUREMENTS OF TOTAL SKIN THICKNESS OF ANGUS CATTLE IN MICRONS

Location	Male			Female		
	A	D	Av.	G	H	Av.
Forehead	6,497	8.118	7,308	7,000	7,003	7,001
Dorsal neck	6,777	5,890	6,333	5,000	6,385	5,692
Dorsal thorax	3,724	5,562	4,643	5,750	6,071	5,910
Dorsal lumbar	6,370	7,140	6,755	4,500	5,098	4,799
Tail root	4,508	6,128	5,318	5,000	6,500	5,750
Ventral dewlap	8,954	6,331	7,644	7,500	6,081	6,760
Ventral brisket	4,998	5,061	5,030	2,500	4,071	3,285
Ventral abdomen	4,410	4,655	4,533	3,750	4,500	4,125
Ventral udder	4,018	3,604	3,811	4,000	5,050	4,525
Ventral axilla	3,430	3,759	3,595	2,500	2,710	2,605
Ventral groin	5,292	4,381	4,836	5,250	4,389	4,819
Lateral neck	9,114	7,189	8,151	3,500	5,655	4,577
Lateral thorax	4,508	5,562	5,035	5,250	3,000	4,125
Lateral abdomen	5,880	5,351	5,615	3,000	4,999	3,999
Gluteus	4,214	5,669	4,942	5,500	6,035	5,767
Upper foreleg	4,018	4,572	4,295	5,000	3,200	4,100
Fetlock	3,234	4,033	3,633	3,000	3,310	3,155
Upper hindleg	4,410	4,405	4,408	3,250	5,387	4,318
Lower hindleg	4,320	4,312	4,316	3,000	5,221	4,110
Achilles insertion	4,320	3,954	4,137	3,000	4,533	3,766

TABLE 7

PIGMENT EVALUATION

Location	Angus				Hereford			
	Male		Female		Male		Female	
	A	D	G	H	B	F	C	E
Forehead	1-B	4-B	2-B	2-B	0-W	0-W	0-W	0-W
Dorsal neck	3-B	2-B	3-B	3-B	0-W	1-R	3-R	1-RW
Dorsal thorax	2-B	3-B	2-B	3-B	0-W	0-W	3-R	3-R
Dorsal lumbar	3-B	3-B	4-B	3-B	2-R	2-R	3-R	3-R
Tail root	2-B	3-B	4-B	4-B	1-R	1-R	3-R	3-R
Ventral dewlap	2-B	1-B	2-B	3-B	0-W	0-W	0-R	0-W
Ventral brisket	1-B	1-B	0-B	1-B	0-W	0-W	0-R	0-W
Ventral abdomen	1-B	1-B	1-B	1-B	0-W	0-W	0-R	0-W
Ventral udder	3-B	2-B	0-B	0-B	0-W	3-W	0-R	0-W
Ventral axilla	1-B	1-B	1-B	1-B	0-W	0-W	0-W	1-R
Ventral groin	2-B	1-B	1-B	1-B	0-W	0-W	0-W	0-W
Lateral neck	2-B	2-B	1-B	1-B	0-W	1-R	3-R	1-R
Lateral thorax	2-B	3-B	4-B	2-B	1-R	1-R	3-R	1-R
Lateral abdomen	3-B	3-B	2-B	2-B	1-R	1-R	2-R	2-R
Gluteus	3-B	2-B	2-B	3-B	1-R	3-R	1-R	1-R
Upper foreleg	1-B	1-B	1-B	1-B	1-R	0-RW	1-R	1-R
Fetlock	1-B	1-B	1-B	1-B	0-W	0-RW	1-R	1-R
Upper hindleg	2-B	1-B	1-B	1-B	0-R	0-R	0-W	1-R
Lower hindleg	2-B	2-B	1-B	1-B	1-W	0-W	2-R	0-W
Achilles insertion	3-B	4-B	2-B	1-B	0-W	0-RW	4-R	1-R
Perianum	4-B	2-B	3-B	2-B	2-W	2-R	2-W	3-W
Hoof margin	4-B	4-B	3-B	2-B	0-W	0-W	0-W	1-W
Horn margin	*	*		*	*	*	0-W	*
Muzzle	4-B	4-B	4-B	4-B	2-W	0-W	0-W	0-W

Key:
0 = absence of pigment
Numbers = quantitive pigment values (1+ = minimal, 4+ = maximal)
Alphabets = Gross color of hair coat
B = Black
R = Red
W = White
RW = Red and white borders

*Animals without horns.

Plate I. Designation of areas from which tissues were taken

1. Forehead
2. Dorsal Neck
3. Dorsal Thorax
4. Dorsal Lumbar
5. Tail Root
6. Ventral Dewlap
7. Brisket (Sternum)
8. Ventral Abdomen
9. Udder or Scrotum
10. Axilla
11. Groin
12. Lateral Neck
13. Lateral Thorax
14. Lateral Abdomen
15. Gluteus
16. Upper Foreleg
17. Fetlock
18. Upper Hindleg
19. Lower Hindleg
20. Achilles insertion (Hock)
21. Perianal Skin
22. Hoof-Skin Margin
23. Horn-Skin Margin
24. Muzzle

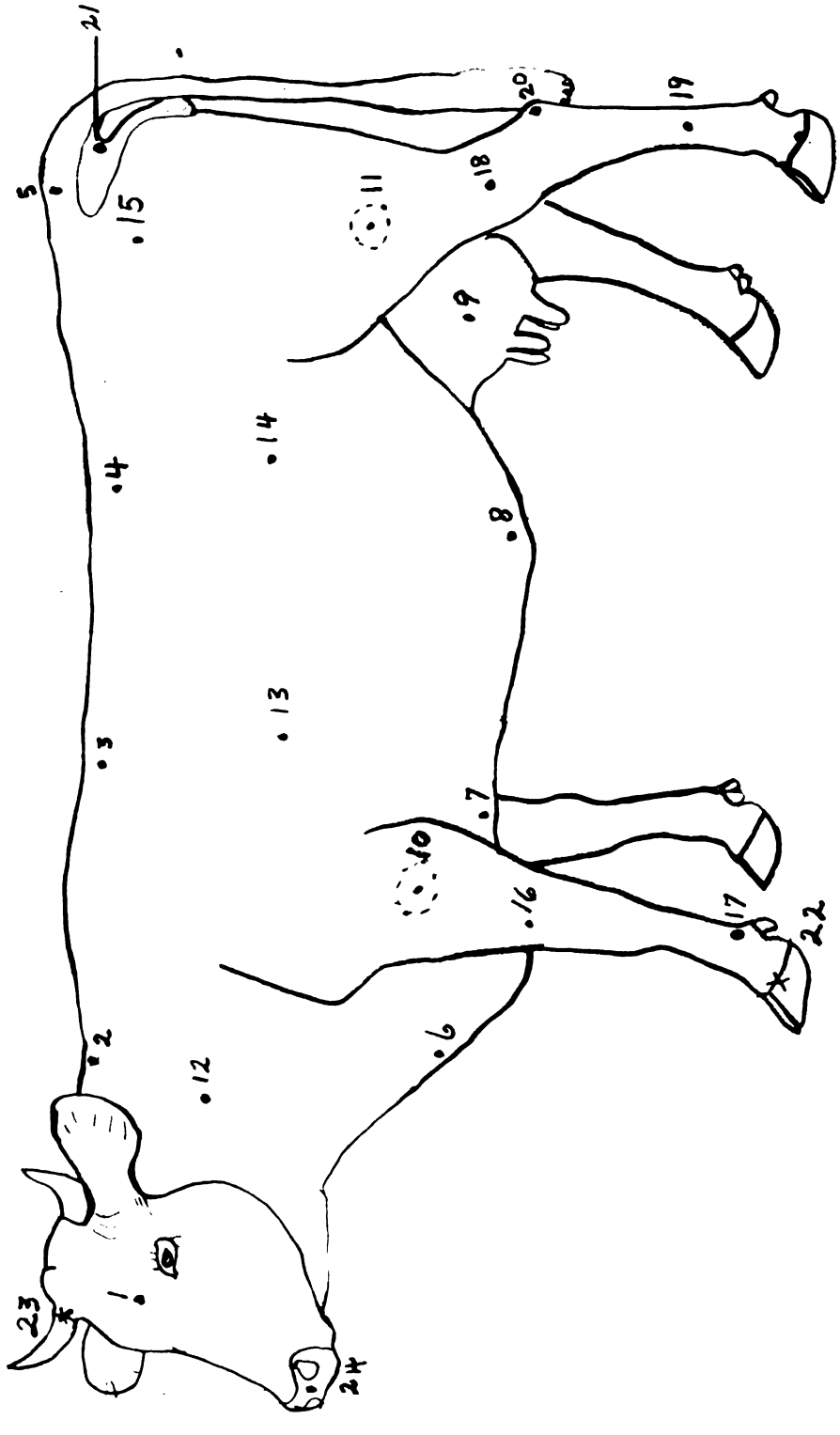
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Plate II. Vertical section through the epidermis of the muzzle of Hereford male. H. and E. stain. 170X.

A. Stratum corneum
B. Stratum germinativum
C. Papillary body of dermis

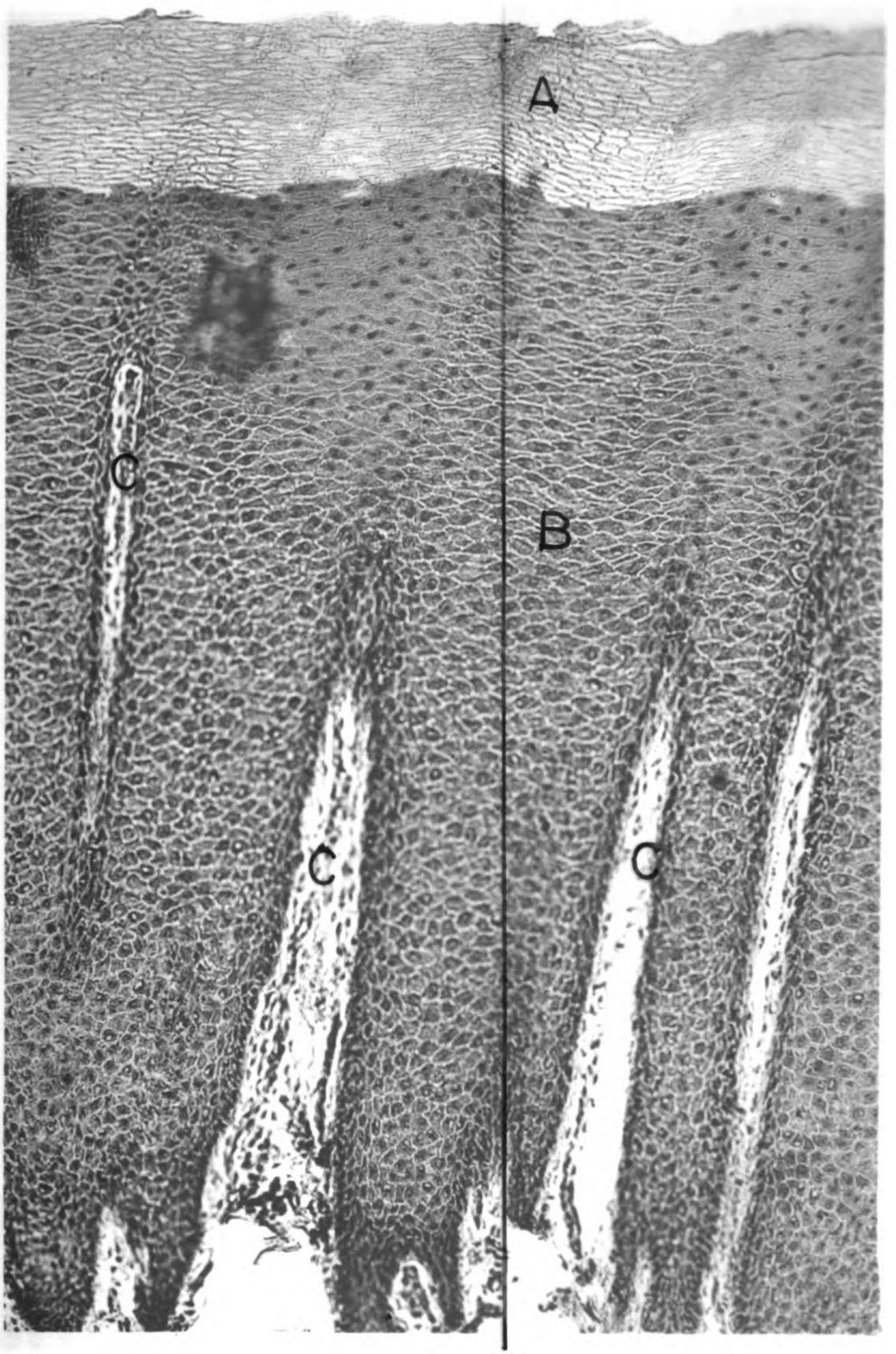
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Plate II. Vertical section through the epidermis of the muzzle of Hereford male. H. and E. stain. 170X.

A. Stratum corneum
B. Stratum germinativum
C. Papillary body of dermis

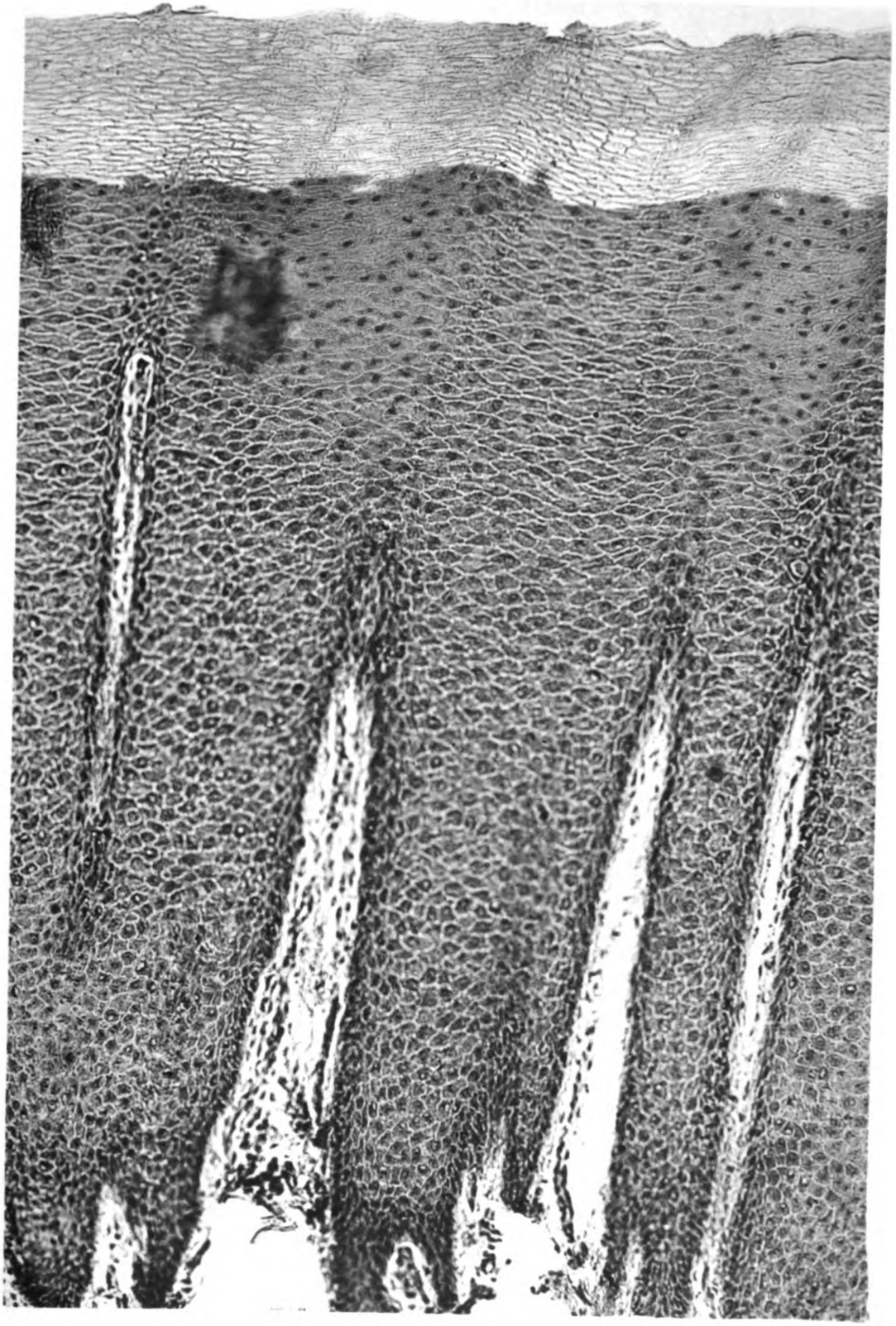
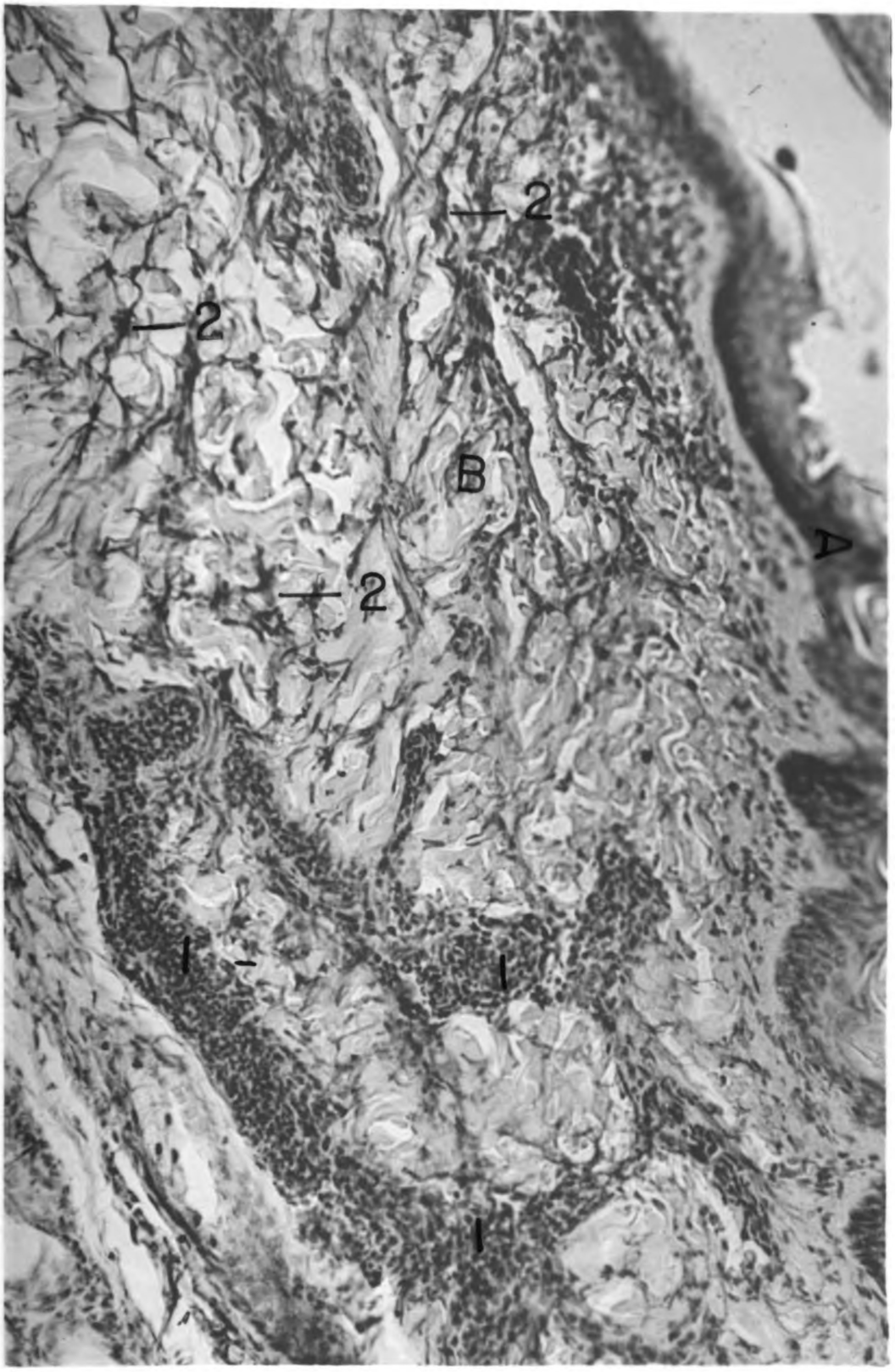


Plate III. Section from ventral abdomen showing fine elastic fibers in stratum papillare. Weigert's elastic stain without counterstain. 250X.

A. Epidermis
B. Stratum papillare
   1. Areolar type cells and eosinophiles around blood vessels and nerve trunks
   2. Elastic fibers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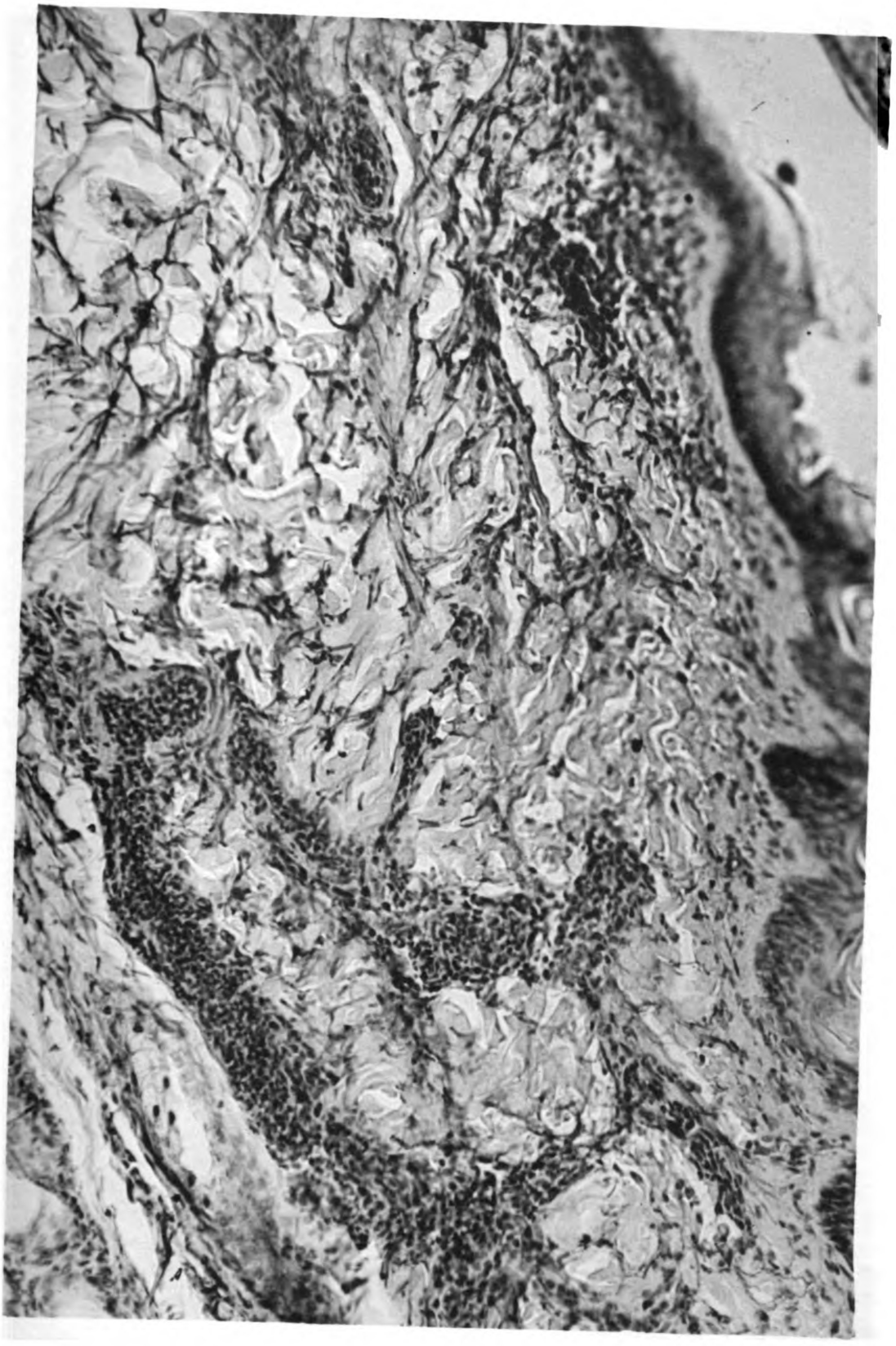

Plate IV. Cross section through the coiled glands and large excretory ducts of muzzle. H. and E. stain. 210X.

1. Large pigmented excretory ducts (4+ pigment value)
2. Coiled glands of muzzle (serial sections show that the ducts anastomose to form a common excretory duct)
3. Small non-pigmented intra-lobular duct
4. Nerve trunk

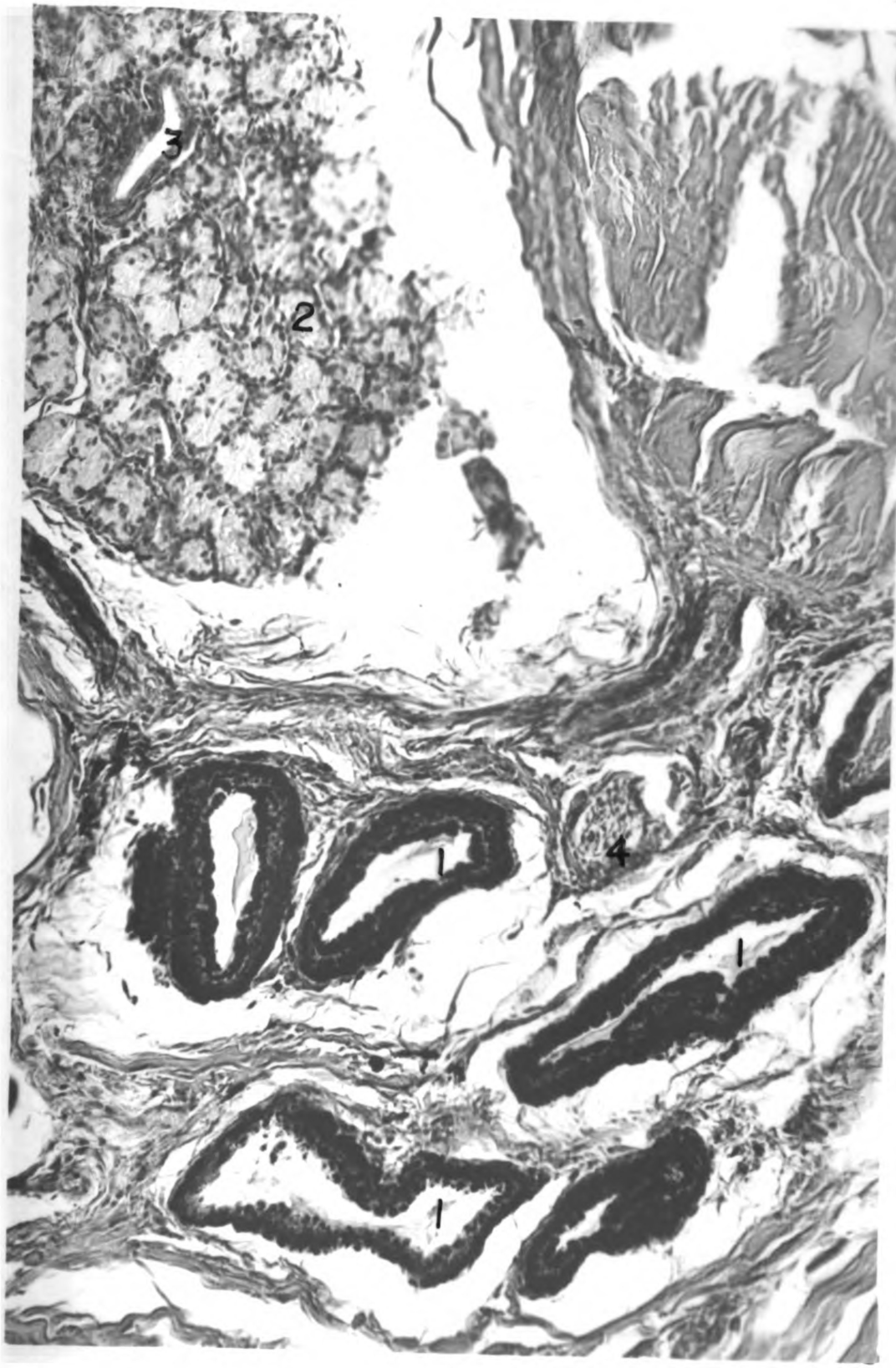
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Plate IV. Cross section through the coiled glands and large excretory ducts of muzzle. H. and E. stain. 210X.

1. Large pigmented excretory ducts (4+ pigment value)
2. Coiled glands of muzzle (serial sections show that the ducts anastomose to form a common excretory duct)
3. Small non-pigmented intra-lobular duct
4. Nerve trunk

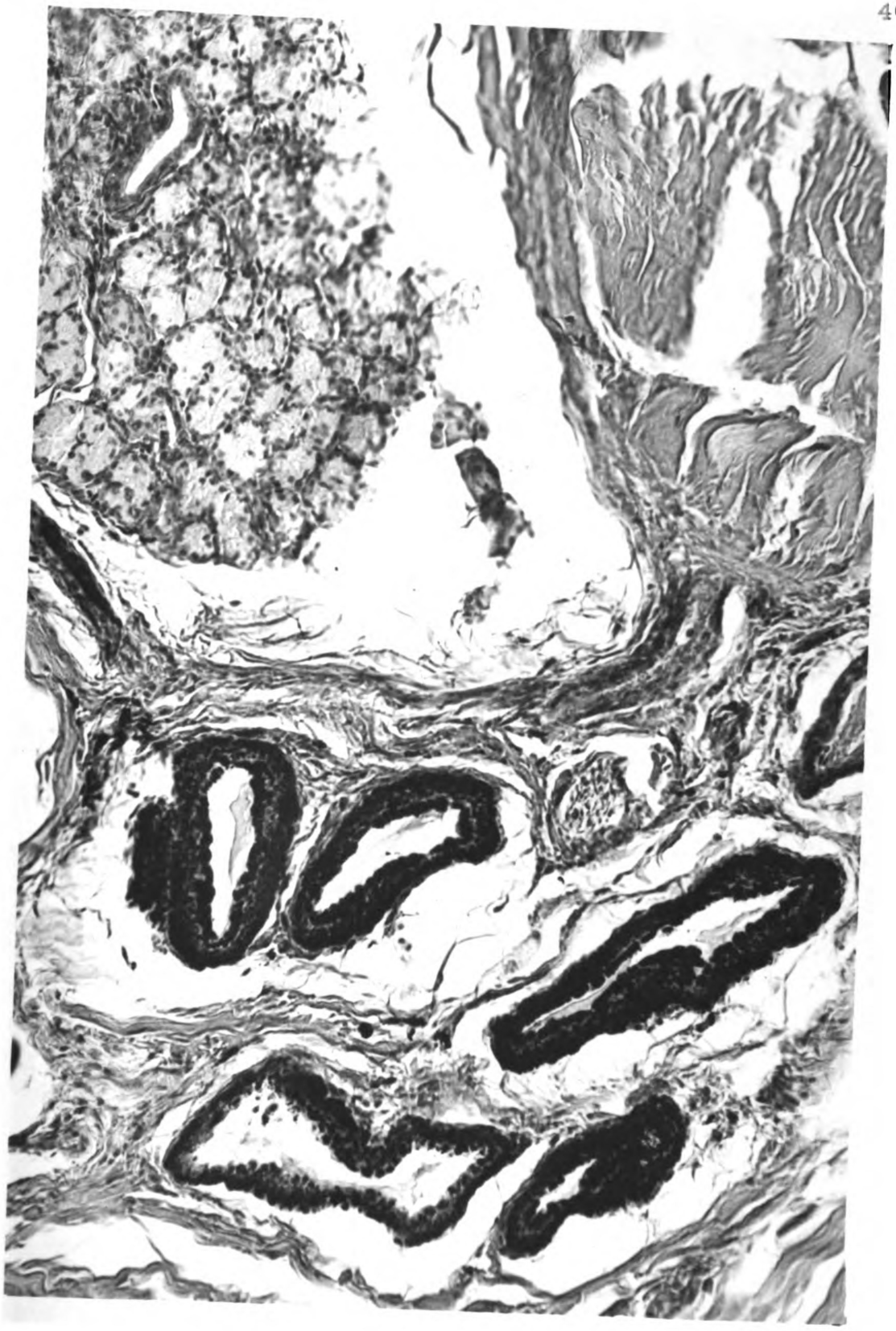

Plate V. Vertical section through the stratum papillare showing follicular folds. H. and E. 290X.

1. Hair shaft
2. Hair follicle
3. Opening of sebaceous duct
4. Follicular folds

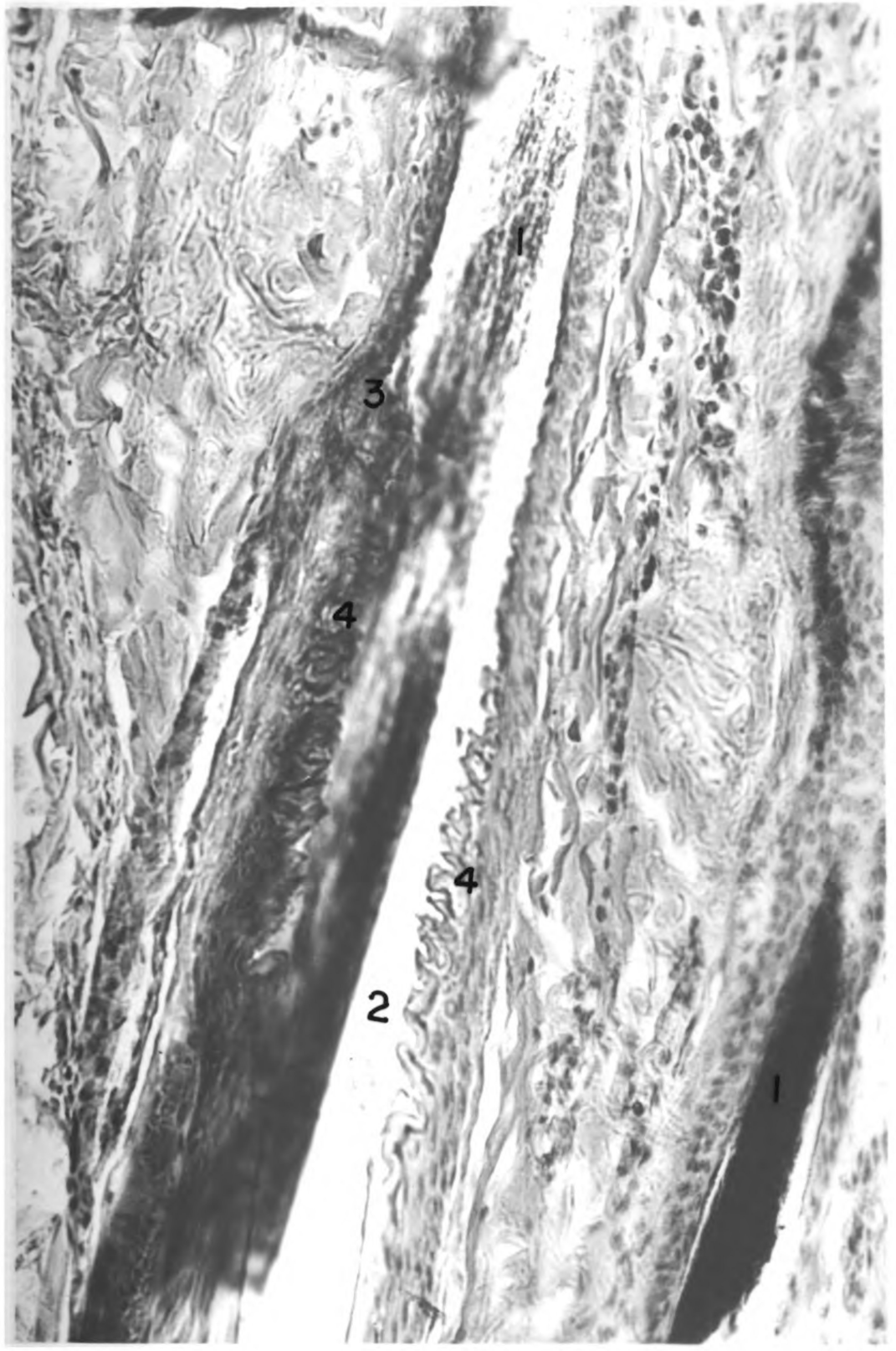
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Plate V. Vertical section through the stratum papillare showing follicular folds. H. and E. 290X.

1. Hair shaft
2. Hair follicle
3. Opening of sebaceous duct
4. Follicular folds

1

3

4

4

5

1

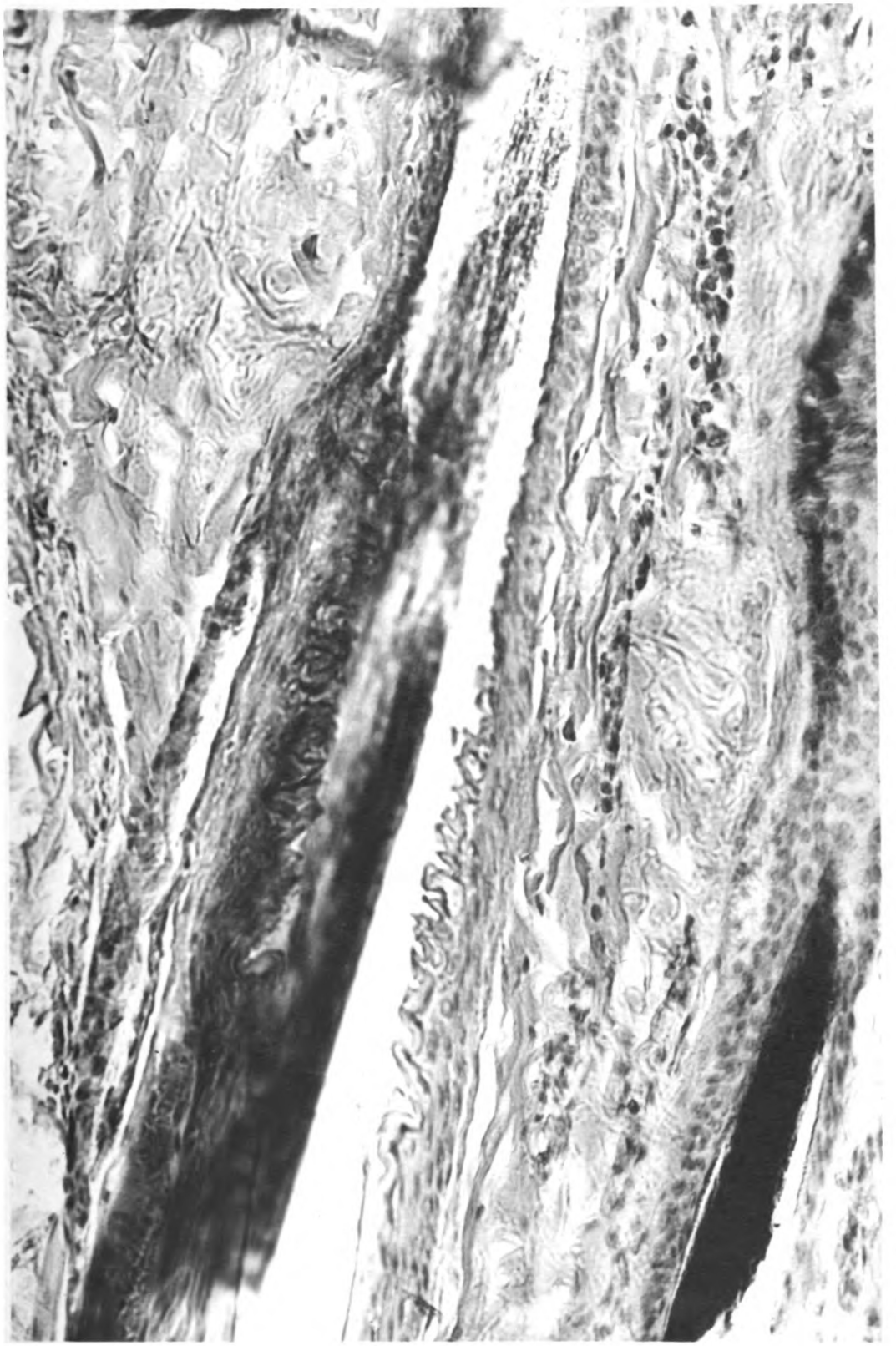

Plate VI. Vertical section of skin from the achilles insertion showing moderately thick epidermis with an occasional granular cell and poorly developed papillae. H. and E. stain. 260X.

A. Epidermis
B. Dermis
1. Granular cell
2. Stratum corneum
3. Stratum germinativum
4. Hair follicle
5. Sebaceous gland
6. Oblique section of the follicular folds

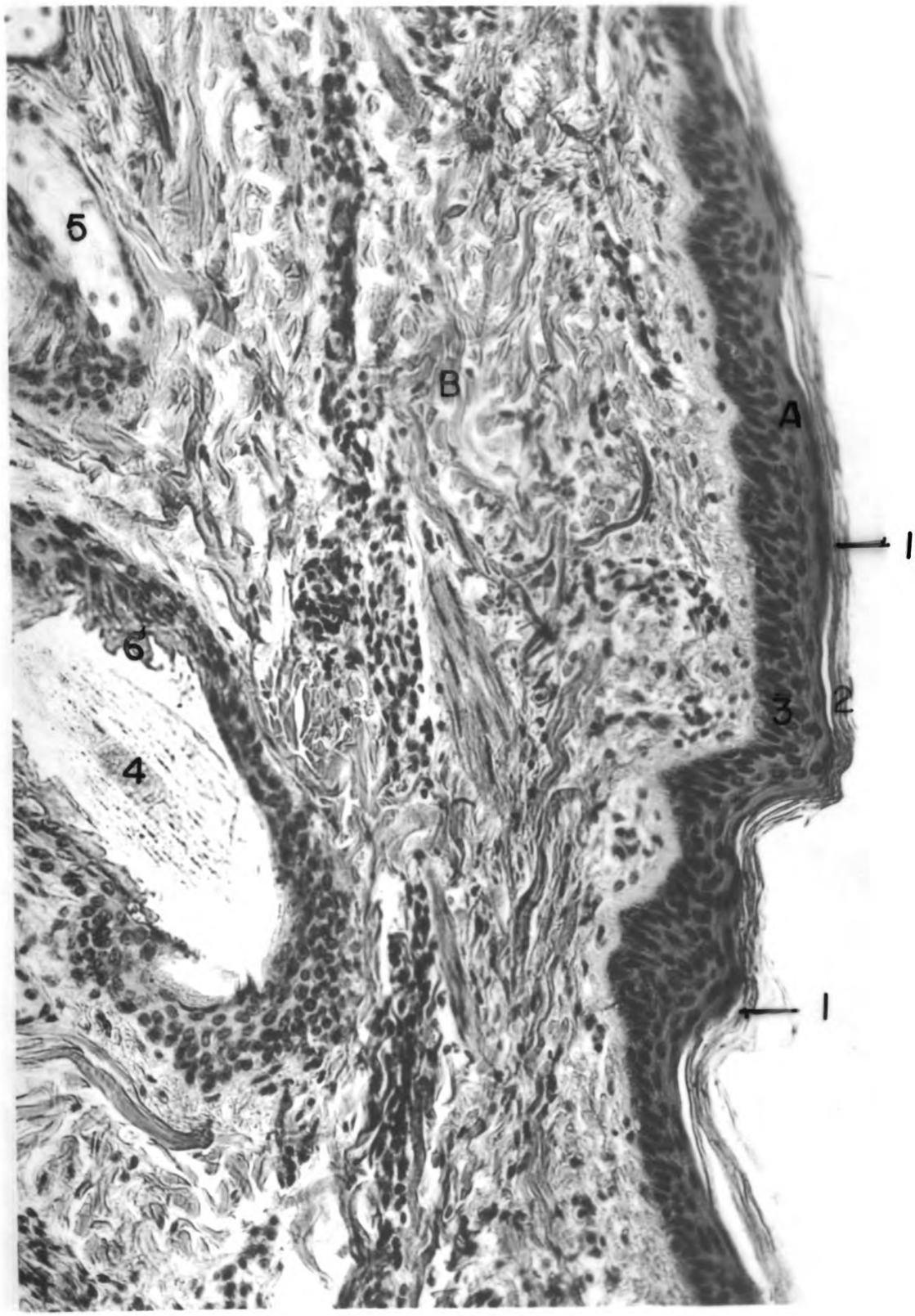
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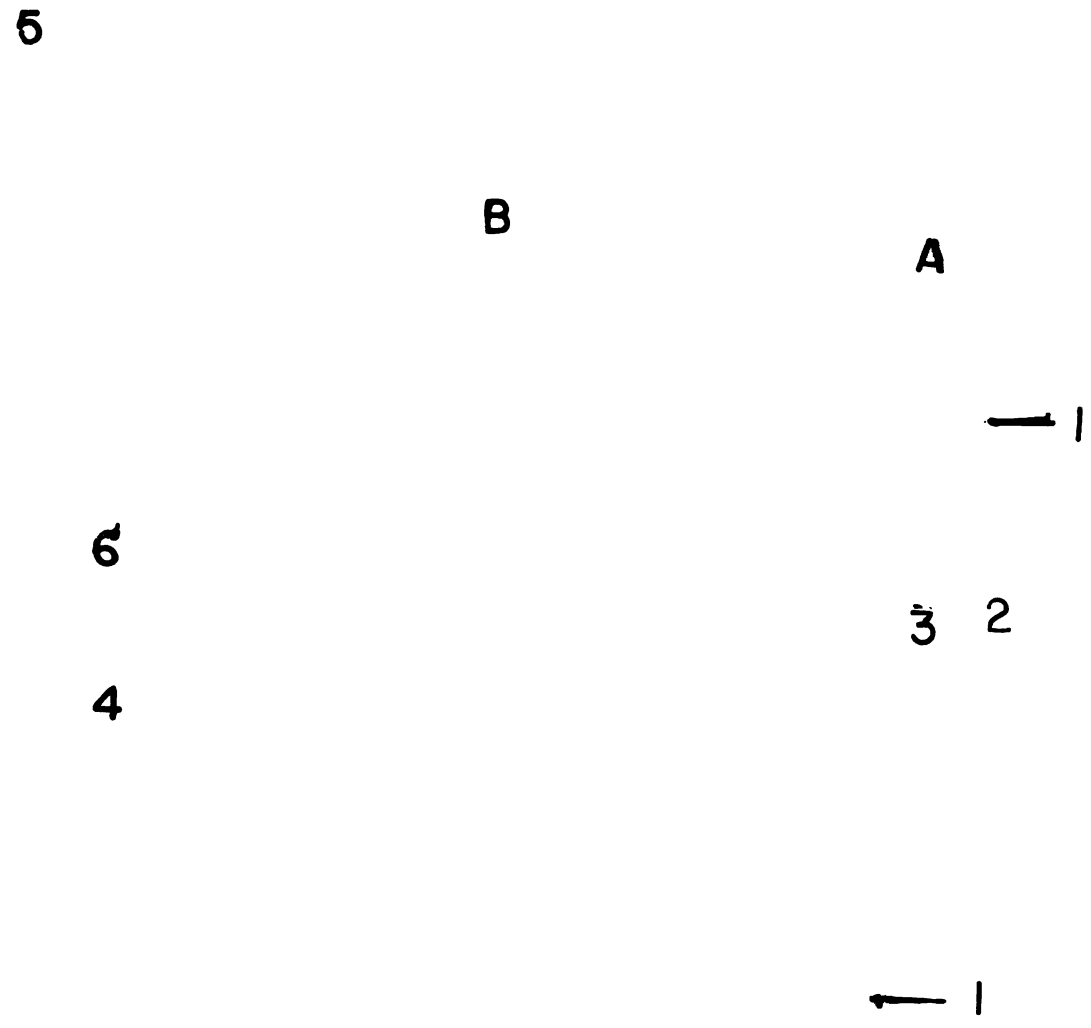
Plate VI. Vertical section of skin from the achilles insertion showing moderately thick epidermis with an occasional granular cell and poorly developed papillae. H. and E. stain. 260X.

A. Epidermis
B. Dermis
1. Granular cell
2. Stratum corneum
3. Stratum germinativum
4. Hair follicle
5. Sebaceous gland
6. Oblique section of the follicular folds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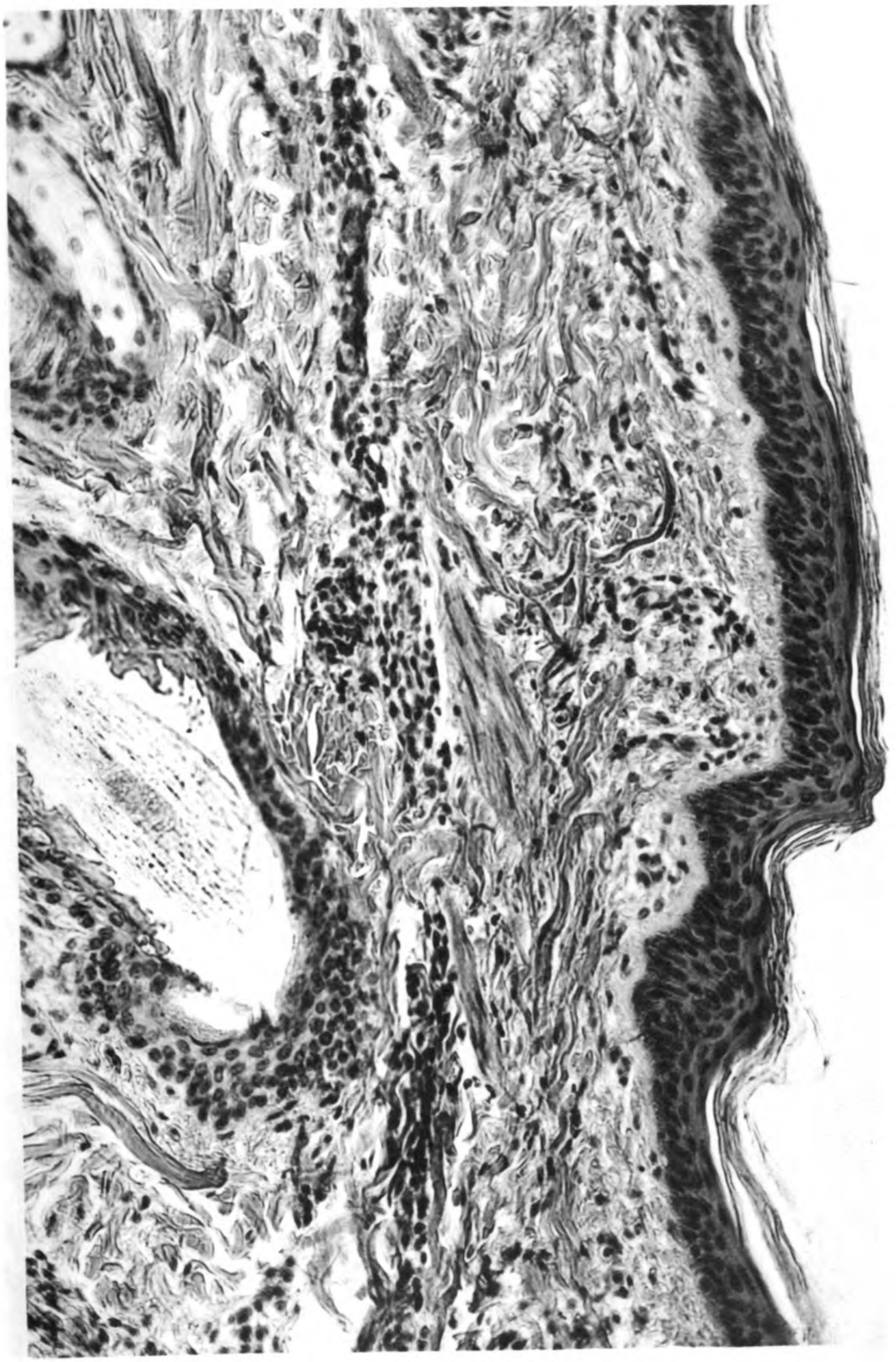

Plate VII. Cross section of hair and large sebaceous glands of perianal skin. H. and E. stain. 270X.

1. Sebaceous gland
2. Hair follicle
3. Sweat ducts passing between the lobules of the sebaceous glands

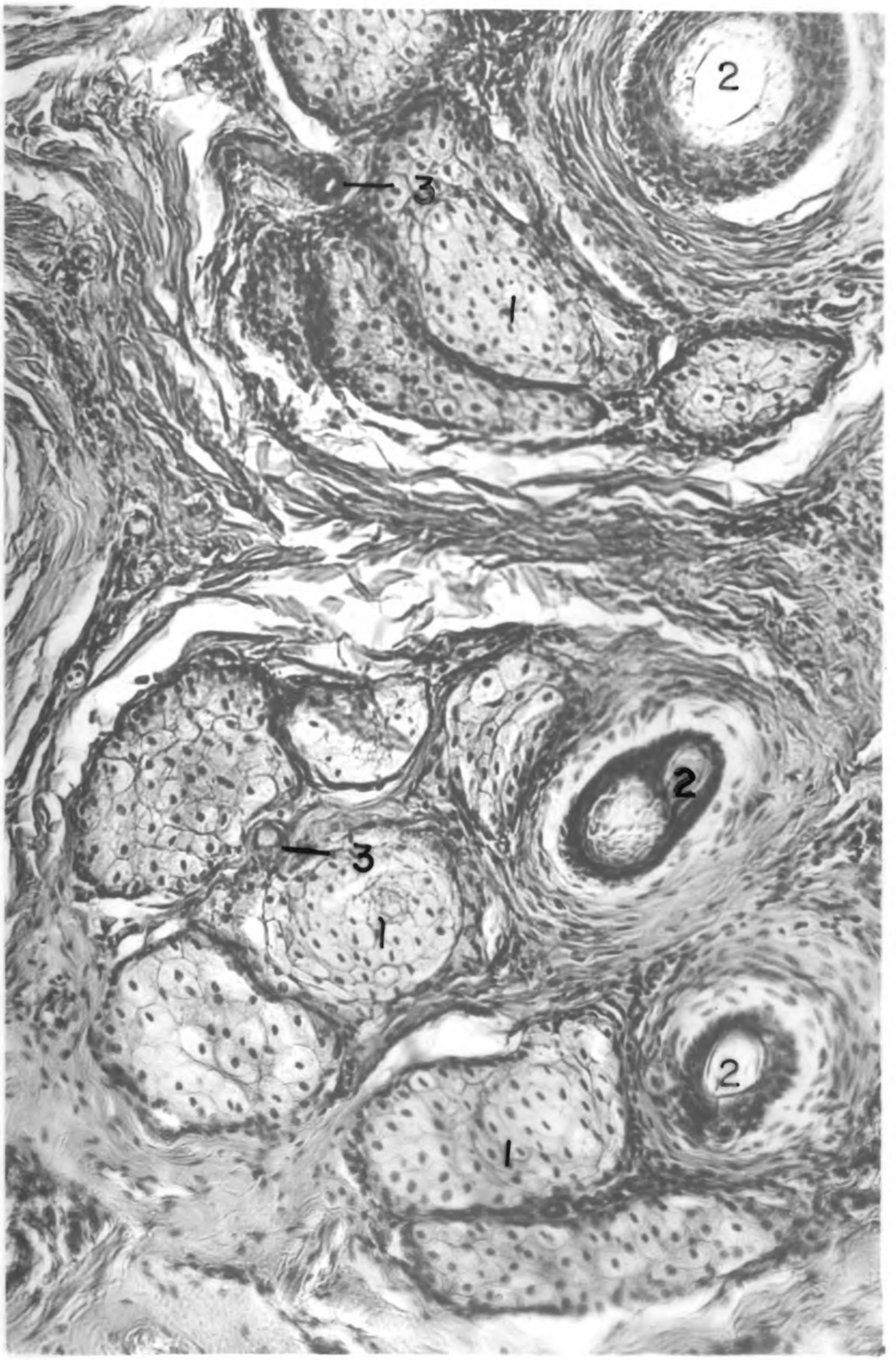
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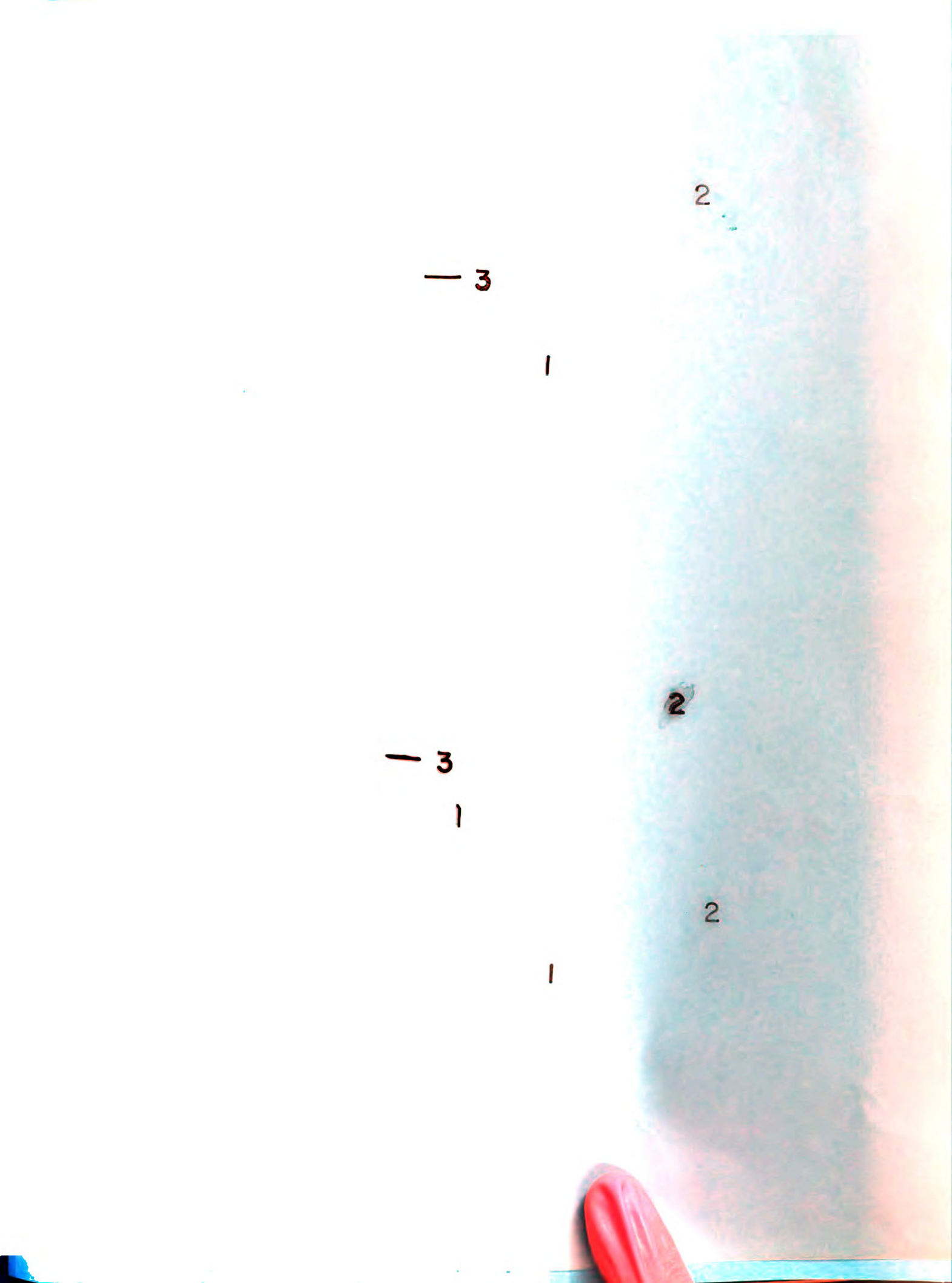
Plate VII. Cross section of hair and large sebaceous glands of perianal skin. H. and E. stain. 270X.

1. Sebaceous gland
2. Hair follicle
3. Sweat ducts passing between the lobules of the sebaceous glands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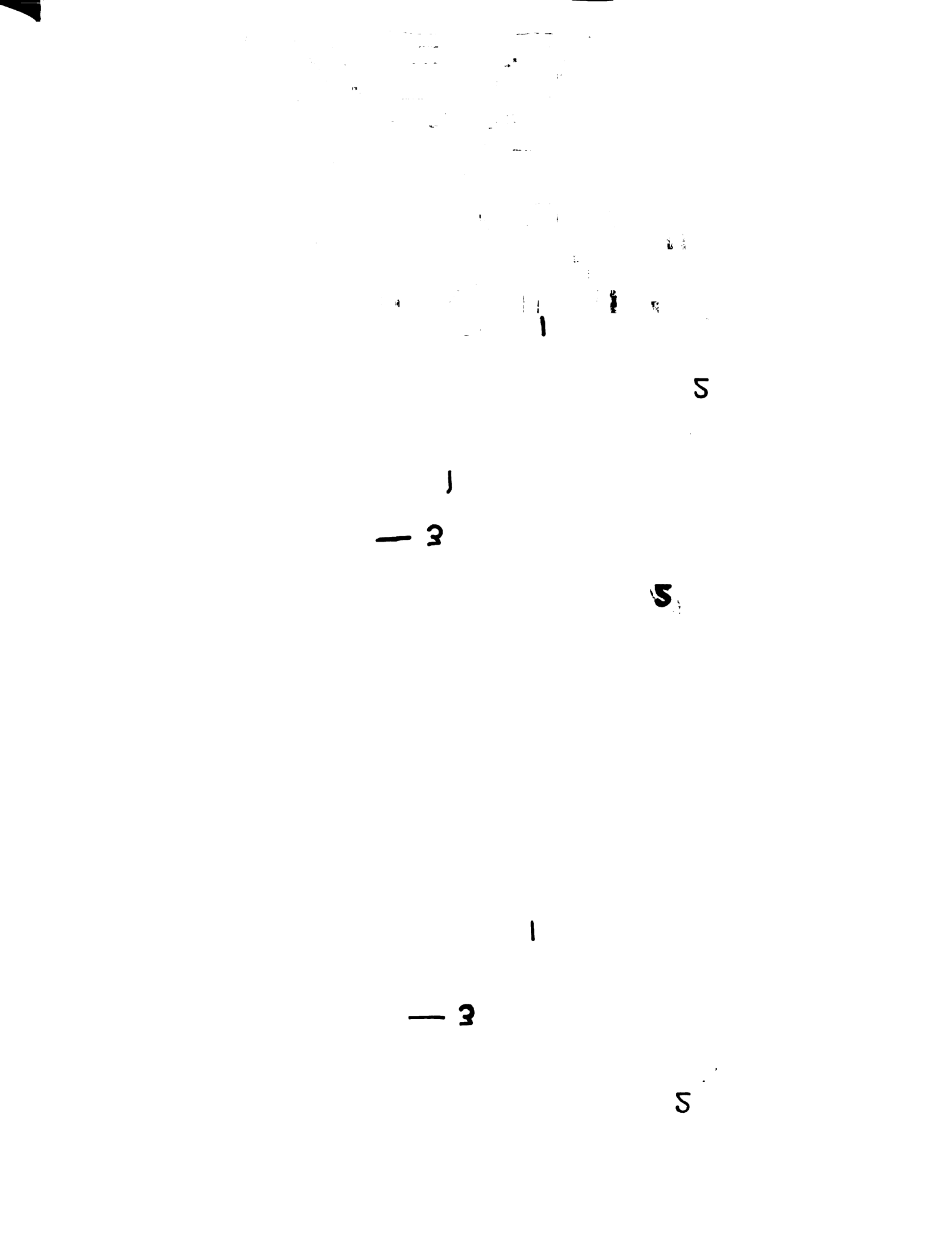

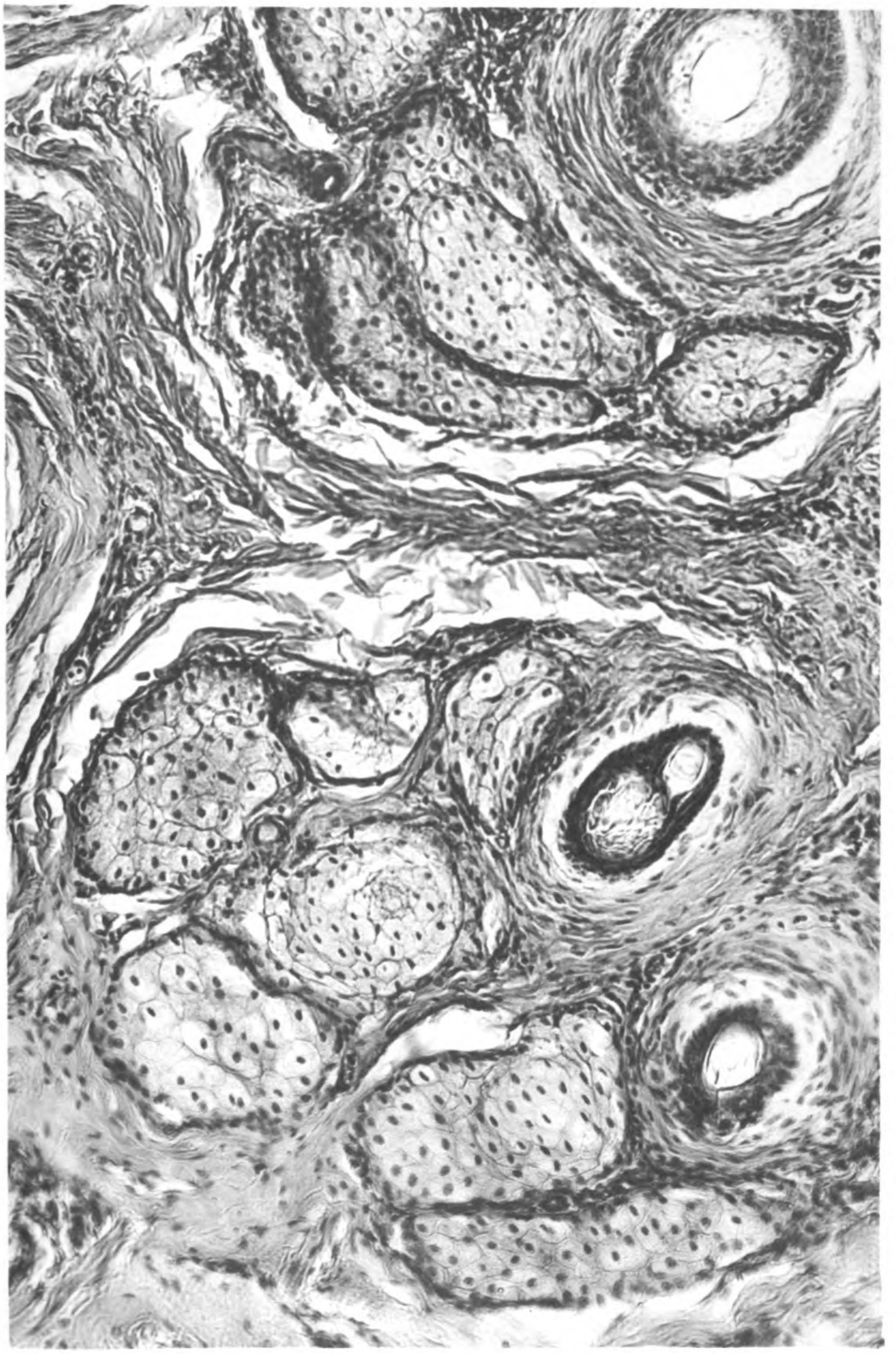

Plate VIII. Vertical section of hair follicle showing hair shaft and saccular sweat glands of dorsal thorax containing granular materials which were commonly found in sweat glands. H. and E. stain. 250X.

1. Hair shaft
2. Sweat glands
3. Flat cells of sweat gland
4. Hair bulb

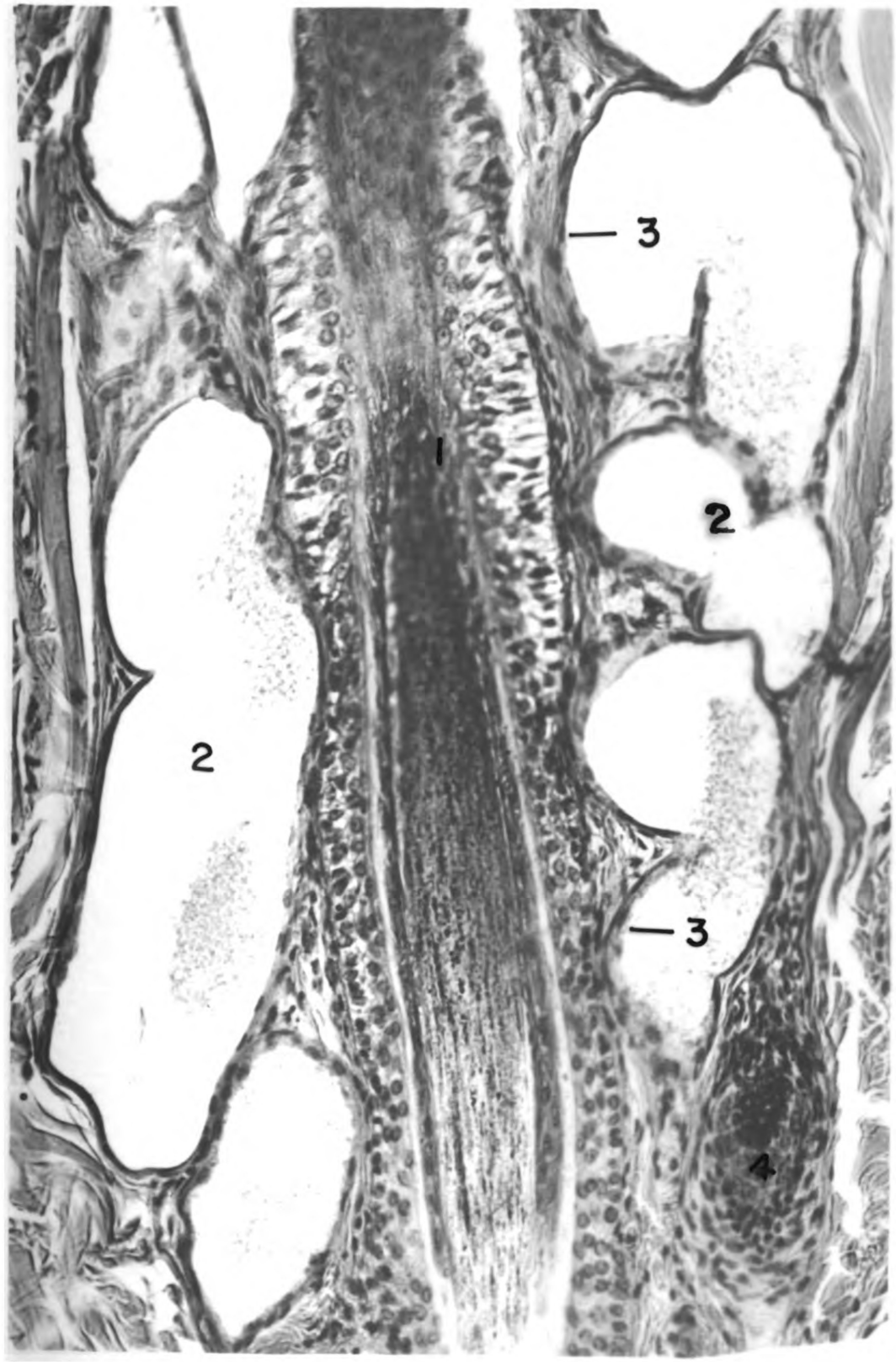
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Plate VIII. Vertical section of hair follicle showing hair shaft and saccular sweat glands of dorsal thorax containing granular materials which were commonly found in sweat glands. H. and E. stain. 250X.

1. Hair shaft
2. Sweat glands
3. Flat cells of sweat gland
4. Hair bulb


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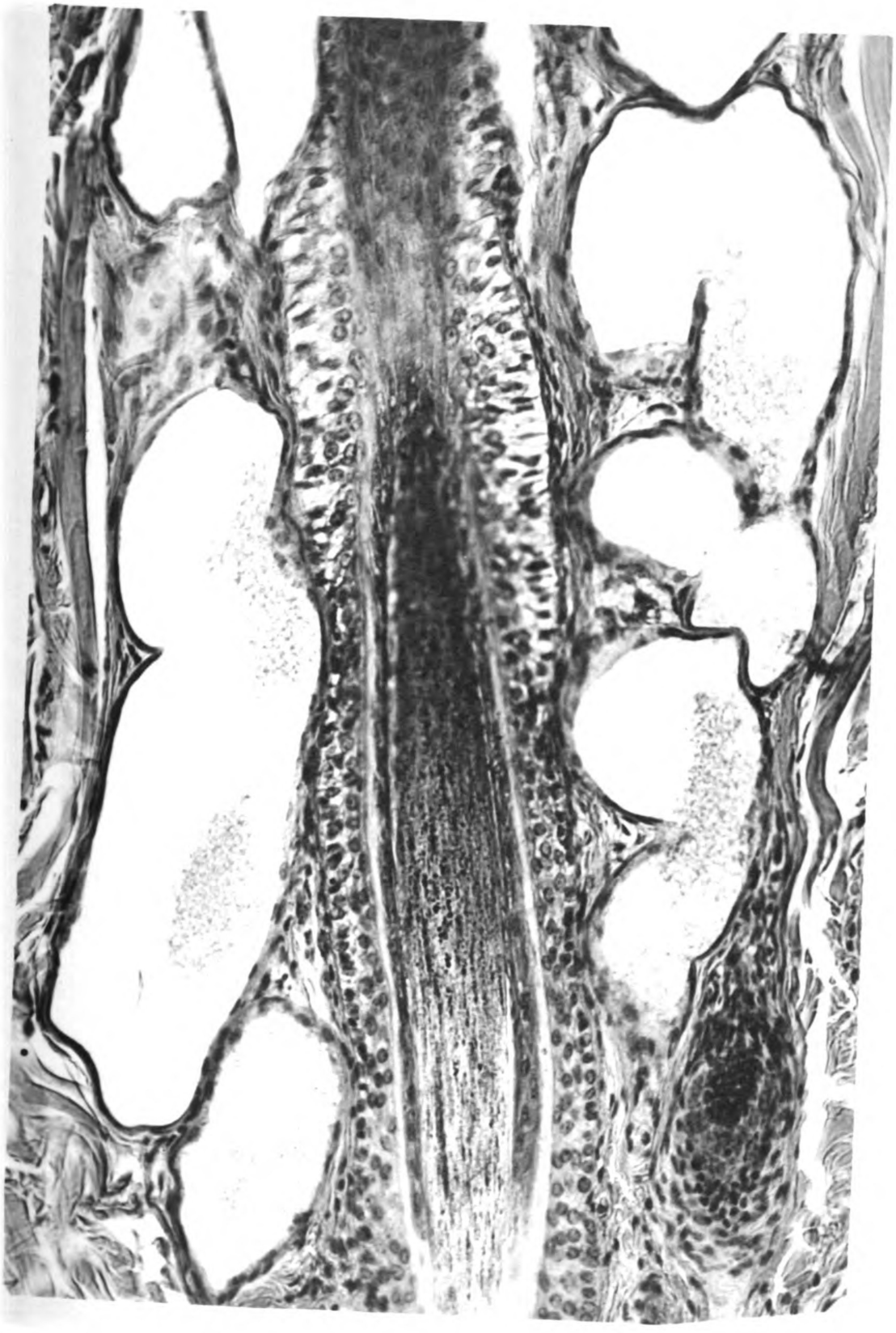

Plate IX. Cross section of hair and small sebaceous glands showing the directional arrangement of lobules. H. and E. stain. 250X.

1. Sebaceous glands (Note that these glands are situated similarly with respect to each hair follicle)
2. Hair follicle
3. Sebaceous ducts near the hair follicle
4. Stratum papillare

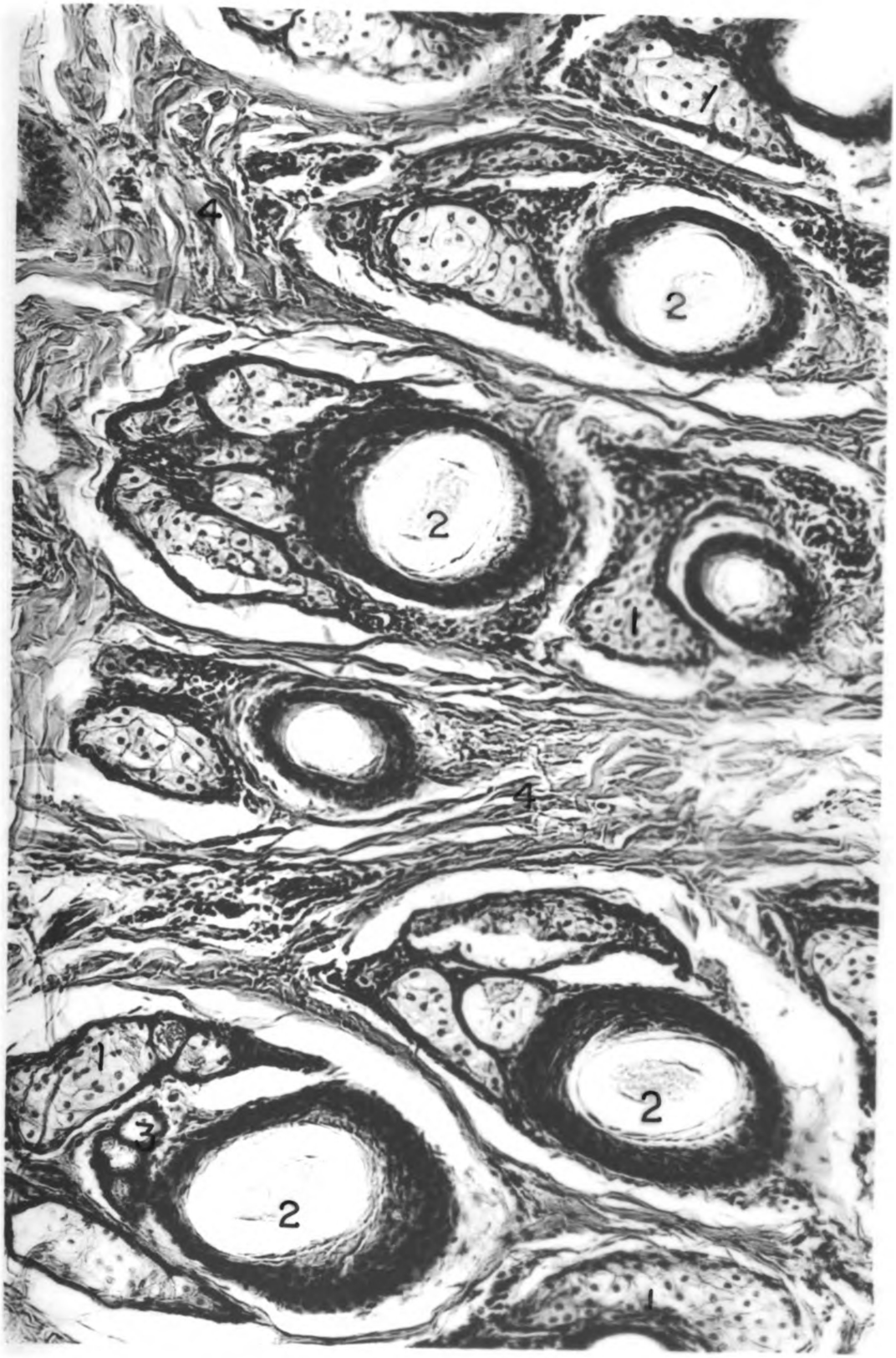
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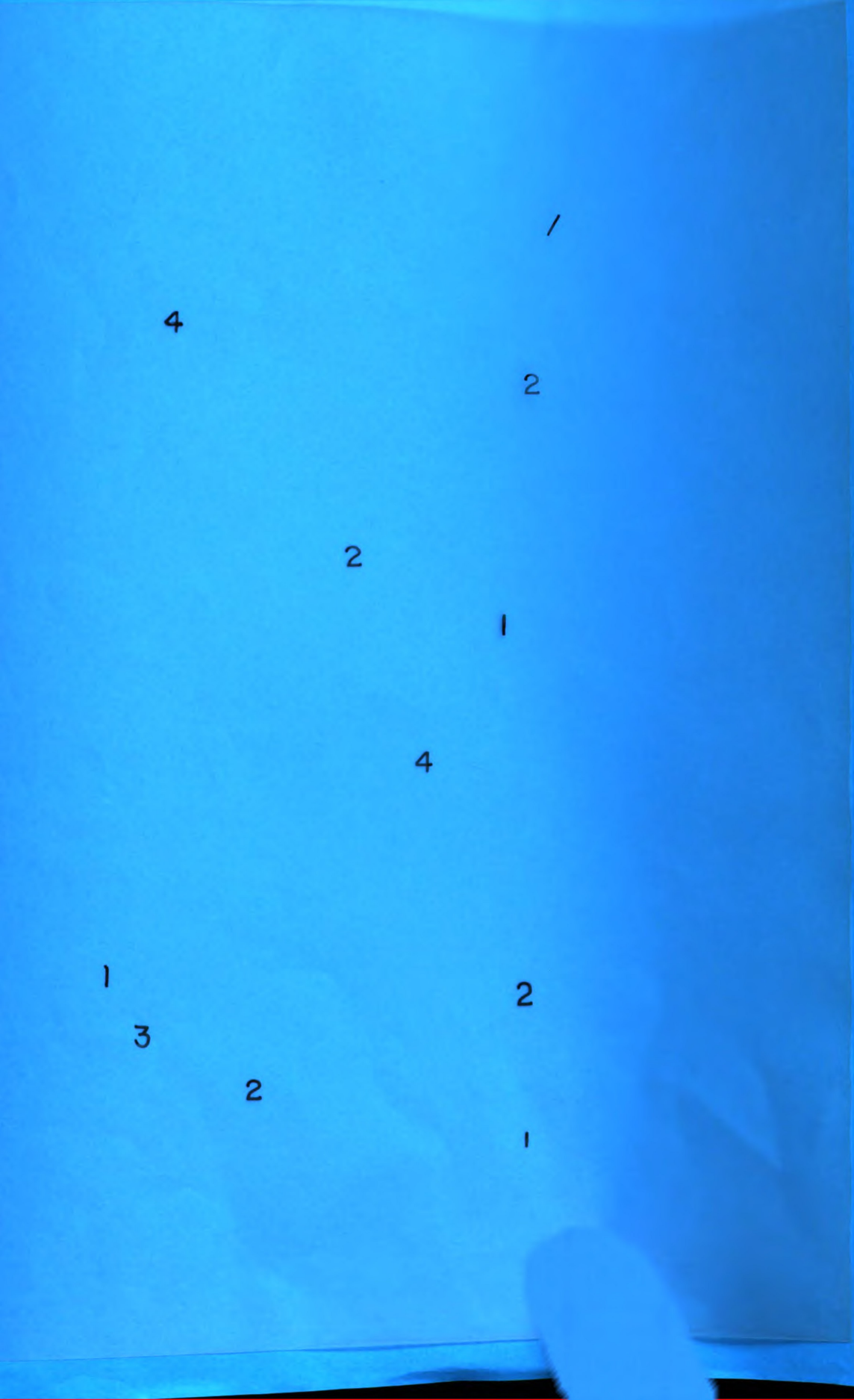
Plate IX. Cross section of hair and small sebaceous glands showing the directional arrangement of lobules. H. and E. stain. 250X.

1. Sebaceous glands (Note that these glands are situated similarly with respect to each hair follicle)
2. Hair follicle
3. Sebaceous ducts near the hair follicle
4. Stratum papillare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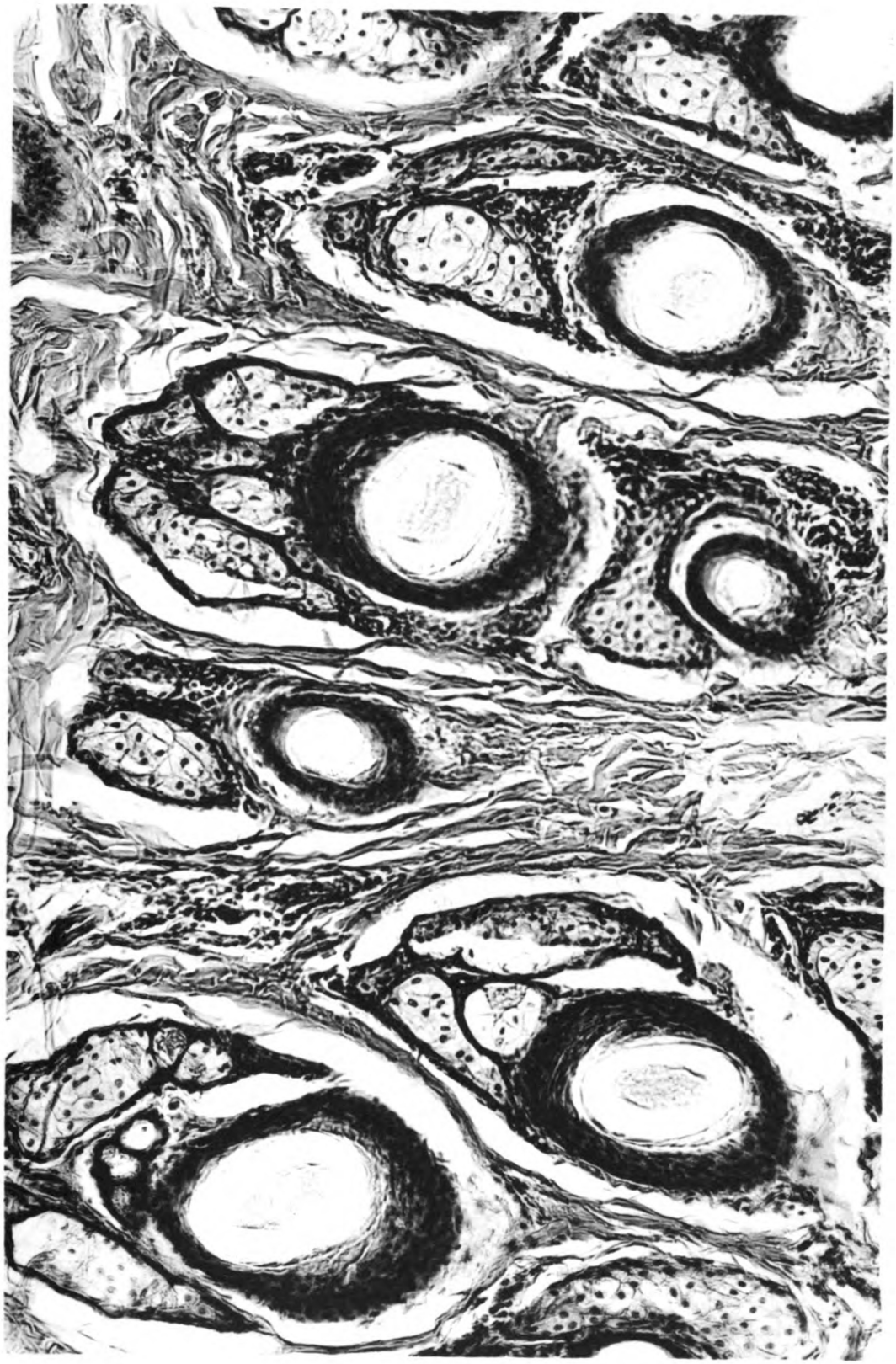

Plate X. Vertical section of lateral neck region showing coarse elastic fibers in the deep dermis. Weigert's elastic stain without a counter stain. 260X.

Plate XI. A diagrammatic sketch of a typical vertical section through the hair follicle and glands of the skin of the ox.

1. Epidermis
2. Sweat duct
3. Sebaceous duct
4. Sebaceous gland
5. Sweat gland
6. Papilla of hair bulb
7. Follicular folds

SUMMARY AND CONCLUSIONS

Specimens were secured from the Angus and Hereford herds of the Animal Husbandry Department of Michigan State University for this experiment. Of each breed studied, there were two noncastrate males and two females, from which skin specimens representing twenty-four areas of the body were taken (Plate I).

This investigation was primarily comparative and included a study of all layers of the skin, the hair density, epidermal pigmentation and the glands of the skin.

The stratum corneum was thickest in the Angus, and the stratum germinativum was thickest in the Hereford, but the total epidermal thickness of both breeds was practically equal. The stratum granulosum and stratum lucidum were not prominent in most areas of the body, but were found in the Skin of the extremities.

The dermis consisted of the stratum papillare and the stratum reticulare. The papillary layer was composed of fine fibrous networks while the fibers of the reticular layer were coarser and more densely arranged. The elastic fibers of the stratum papillare were usually fine and formed a very loose network. Those of the stratum reticulare were usually restricted to capillary plexuses and in the deep

portion of this layer, they were very coarse and were frequently parallel to the larger blood vessels. There were no prominent sex or breed differences found. This finding is in disagreement with Dick (1947), who found that females have more elastin than males.

The results of this investigation agreed with Dempsey (1948) in her finding that fat is not readily stored in the Skin of the ox but disagreed with her observation that fat is restricted to the lumbar region. This study showed fat to be stored in the skin of the dewlap and brisket and usually absent from other body regions.

Epidermal pigmentation was found to have specific breed characteristics which were easily demonstrated. The pigment of the Angus was always black, while that of the Hereford was always brown. Colors did not change with increase or decrease in density.

The hair was morphologically similar to that described for the ox by other authors, with one exception. A series of folds which was always present in the upper one-third of the hair follicle and slightly deeper than the opening of the sebaceous ducts into the lumen of the hair follicle, were observed as horizontal projections into the follicle. These projections were not described in the available literature. Hair density showed no sex or breed difference, and at no time were the hair follicles found to contain more than one

hair. The hair count of the four animals obtained in early winter was compared with that of the four amimals procured in the spring but no apparent differences existed.

The sebaceous glands varied in size and form with hair density. In areas where the hair was thin, at the margins of the hooves and around the natural openings, they were highly developed. The lobules were generally oval and tended to encircle the hair follicles. On several occasions they were found to range from fifteen to twenty lobules per hair follicle. In areas where the hair was dense (neck regions), the sebaceous glands were comparatively small and narrow. There were usually two or three lobules per hair follicle. These findings agreed with the observations of Sisson and Grossman (1953). In addition to the above observations, the small sebaceous glands were found to be attached to the hair follicle so that the lobules of a given area extended in the same direction. This directional arrangment of sebaceous glands was not described in the available literature. They were always associated with the hair and opened into the hair follicle through a short epithelial duct.

The sweat glands were found to be of three types, a loosely coiled form found in the fetlock, prianal skin and the achilles insertion, a closely coiled modification of the latter peculiar to the muzzle, and a saccular form present in all other body areas. The sweat glands of the hairy skin

opened into the hair follicle through sweat ducts, while the ducts of the muzzle opened directly on the surface of the epidermis. These findings agreed with Sisson and Grossman (1953). They disagree with the observations of Trumbower (1904) who found that the sweat glands of the ox are small and red coiled bodies in the subcutaneous tissue with the ducts opening directly on the skin surface. Trautmann and Fiebiger (1952) found additional glands in the subcutaneous tissue which are similar to those of the external auditory meatus. The author found no such gland types to be present in this investigation.

From the results of this study it was concluded that although breed and sex differences were frequently found upon critical analysis of the skin, the color of the epidermal pigmentation is the most dependable factor when differentiating between Angus and Hereford cattle microscopically.

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