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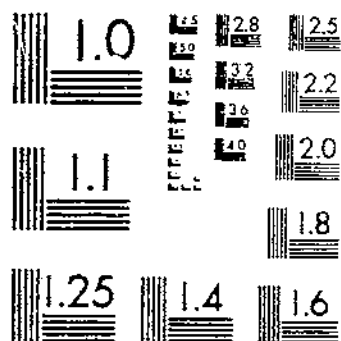
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MOHAIR HISTOGENESIS, NATURATION, AND SHEDDING IN THE ANGORA GOAT

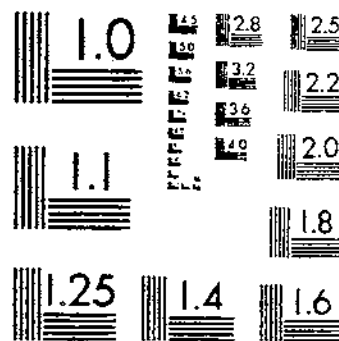
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MOHAIR HISTOGENESIS, MATURATION, AND SHEDDING IN THE ANGORA GOAT

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ABSTRACT

Maturation of the primary follicles in the angora begins at about 110 days of fetal life. Maturation of the secondary follicles, however, is not complete until after birth. The sebaceous glands of the angora are also present in a portion of the secondary follicles and are of considerable size. No branching follicles were seen. It appears that one can depend on follicular counts for evaluation of the potential density of angora fleece.

Relations between body growth, skin differentiation, and the appearance of follicular anlagen, follicular growth, and maturation have been compared with other

animals directly related to the angora by descent or belonging to the same family.

In the skin of purebred angoras, medullated fibers constitute 1.5 to 3.5 percent of the total. The ratio of secondary to primary follicles is about 8 to 1. Shedding, resting, and reorganizing follicles in summer skins constitute from 3 to 9 percent of the total, depending on the goat's age (1 to 10 years); nongrowing follicles are relatively fewer in young animals. In the winter skins of angoras, nongrowing follicles are more abundant, about 10 percent in yearlings and over 60 percent in 9-year-old animals.

MOHAIR HISTOGENESIS, MATURATION, AND SHEDDING IN THE ANGORA GOAT

By Lubow A. Margolena¹

The angora goat, *Capra hircus angoriensis* (pls. 1 and 2), once believed to have originated in Turkey, may have had its original home in Turkestan, according to Spiridonov (as cited by Levy) (9)². In Spiridonov's view, the "sil" wool goats were first brought to Asia Minor during the 13th century by people who were then migrating from Turkestan. The goats thrived particularly well in the province of Ankara (Angora); hence, their name.

Lydekker (10) stated "... that the long silky hair of the breed—the mohair of commerce represents an excessive development of the Pashm of the Kashmir and wild goats, the so-called 'kemp' of the angora being the remnant of the original hair of the outer coat of the former." Mackenzie (11) writes that the angora originated from a cross between *Capra aegagrus* and *C. falconeri*. The common goat of Europe and Asia derived from *C. aegagrus*. The angora is smaller than the common dairy goat and, irrespective of sex, bears horns. Mohair differs from sheep's wool by having epidermal scales about twice as long as sheep's wool. Mohair also lacks crimp. The scales of cashmere wool are intermediate in length; those of mohair are 50 percent longer.

According to von Bergen (1), mohair fiber has about 5 scales per 100 μ length; cashmere and sheep's wool have 6 to 7 and 10 to 11 per 100 μ , respectively. The

scales of mohair adhere neatly to the cortex, practically without overlapping. This arrangement provides a fairly smooth surface, which is typical of the angora, and which is not found in any other animal fiber used by the industry. Mohair fiber is nearly circular in cross section, having a proportion in width to length of 1 to 1.2.

The millions of angora goats kept and bred in fairly dry parts of the world, as for example in the Republic of South Africa, the United States, and Turkey, are raised for their remarkable white fleece (pls. 1, 2, 3). Under favorable conditions, these goats can grow mohair locks close to 30 cm in length yearly. Angoras produce three main types of locks: Ringlets, flat, and straight (pl. 3, A). Depending on country, circumstances, and climate, annual and biannual shearing are practiced.

The original studies of von Nathusius (1866) (20) were followed by a considerable number of publications on skin and wool follicles. Comparable reports on goats are not abundant. They include Duerden and Spencer's observations (1930) (2) on postnatal angora goats, Marincowitz's (1959) (18) on the fleece of angora goats, and Margolena's studies (1959) (13) of histogenesis. Postnatal skins and follicles of dairy goats (*Capra hircus*) (13) suggest that these animals could be regarded as belonging to the same species (*hircus*).

OBJECT OF RESEARCH

This project was undertaken to determine the following:

- The differentiation of the skin and the determinants for initiation of the mohair follicles within the framework of the general development of the fetus.

- The establishment of follicular populations and sequential maturation of the follicles.
- The postnatal shedding and regeneration of mohair fiber.
- The initiation of hair follicles after birth.
- An estimate of the percentage of medullated hair.
- A study of the effects of season and age on proportions of growing, nongrowing, or shedding hairs.

¹Retired; formerly associate biologist of the former Sheep and Fur Animal Research Branch, Animal Science Division, now Northeastern Region, Agricultural Research Service.

²Italic numbers in parentheses refer to Literature Cited, p. 8.

MATERIALS

Biopsies of the middorsum of the fetus, supplemented by some specimens of the midventrum, crown of head, and jaw, were obtained from animals from the flock of the Texas Agricultural Experiment Station, McGregor, Tex.³ Prenatal biopsies included those of angora fetuses 49, 50, 60, 70, 80, 90, 100, 110, 120, 130, and 140 days old. Postnatal biopsies of newborn female kids up to 1 year old were taken from the same source (7 for 1959, 6 for 1960, and 4 for 1961).

Biopsies of does 1 to 10 years old were taken during different seasons.

Nine postnatal biopsies of angora does from the flock of the Agricultural College of Grootfontein, Middleburg, C.P., Republic of South Africa, were also used.⁴ With the exception of one specimen 6 months old, all the South African material was collected during spring (October 21) 1960. These biopsies included 1-day and 30-day samples, and specimens from does 1/2, 1, 2, 3, 4, 5, and 6 years old.

METHODS

Naked or clipped, freshly excised skin biopsies were sandwiched, dermis side down, between squares of blotting paper (23). Thus, they were held flat, fixed in 10-percent formalin, formalin-saline, or Bouin's fluid.

The mounted sections were stained with (1) hematoxylin, phloxine orange G (12); (2) orcein-Giemsa (22); or (3) orcein, Mallory II, orange G (17). Some sections were tested for desoxyribonucleic acid (DNA) in the Feulgen procedure and counterstained with picric

acid and fast green. For nonspecific fats, oil red O was used. For counterstaining, Harris' hematoxylin followed by (1) Farrant's gum arabic or by (2) Amann's syrup (7) with cotton blue were applied. Amann's syrup simultaneously counterstains, mounts, and preserves. It also clearly identified blood capillaries in fetal skin.

Lecithin, or a related lipine, was tested by Gurr's technique (5). Cholesterol and its esters were tested by Schultz's and Feigin's procedures, as cited in Pearse (21).

THE PRENATAL ANGORA GOAT

Development and Maturation

Fetal development and differentiation of the skin follicles.—An embryo becomes a fetus in about 17 to 24 days. This is 34 to 40 days after conception (4). This transformation takes place shortly before the appearance of the earliest follicular anlagen.

Developmental relationship in body growth.—Fetal measurements of the lengths of vertebral columns of sheep and goats are more dependable than weight at comparable ages as a developmental indicator (3). Also, measurements of the crown-rump length are almost as dependable as measurements of the vertebral column (3). Choice of the crown-rump length in this comparative study was motivated further by possible shrinkage or swelling of the softer parts because of changes that may be caused by fixation (8). Inasmuch as the fetuses of angora goats were received fixed, while fetuses of

dairy goats and sheep were taken fresh in Beltsville, Md., for measurements and then fixed, the data reported here are indications of trends. The data show a resemblance between fetal sheep and fetal goats in general rate of growth, as expressed by their crown-rump lengths (pls. 4 and 5; table 1).

Fetal skin.—Chronological sequence of follicular development is remarkably alike in different breeds of sheep and goats.

Between the 50th and the 60th day, a stiffening develops in the skin, generally together with a gradual reorientation of the epithelial cells. Prior to that stage, the epidermal cells were merely stretched over the dermis without character or polarity of their own. In the Feulgen reaction, their chromatin appears unresolved and weakly stained. The same lack of differentiation persists in the underlying mesodermal cells.

³Grateful appreciation is expressed to Dr. Maurice Shelton of the Texas Agricultural Experiment Station, formerly located at McGregor, Tex., for his interest and cooperation in the procurement of biopsies over a 7-year period.

⁴Sincerest thanks are also due the Director of the Agricultural Experiment Station, Grootfontein, Middleburg, C.P., Republic of South Africa, in obtaining biopsies of the station's angora flock.

The distribution of blood vessels in the skin bears a relationship to the initiation of the follicular anlagen, as well as to the development of the follicular population. In the skin of angora fetuses 40 to 50 days old, there is a branching of vessels upward from the subcutaneous layer. These vessels may again branch into smaller horizontal vessels in the dermis or may continue upward towards the epidermis. The horizontal blood vessels are replaced by slanting and vertical ones at a later stage. These, in turn, may branch. Their capillaries flank the sebaceous and sudoriferous glands as well as the lower part of the follicles without directly touching any cells of epidermal origin.

Melanocytes and pigment.—Almost no cells resembling "immature melanocytes," as described by Zimmer-

Table 1.—Crown-rump measurements of goat and sheep fetuses, McGregor, Tex., and Beltsville, Md.

No.	Sex	Birth	Days (number)	Lengths (cm)
Angora Goats, McGregor, Tex.				
X-1	(1)	² Tw 1	35	2.25
X-2	(1)	Tw 2	35	2.20
X-4	(1)	Tw 1	49	3.50
X-6	(1)	³ S	51	6.75
X-14	M	S	60	11.50
X-7	M	S	80	16.75
11-A	M	S	90	18.00
X-9A	F	S	100	20.00
X-8A	F	S	110	25.00
X-10A	M	S	125	25.00
Dairy Goats, Beltsville, Md.				
58 CA 1 ⁴	(1)	⁵ Tr 1	50	7.25
58 CA 2	(1)	Tr 2	50	8.05
58 CA 3	(1)	Tr 3	50	6.95
42 Tg A ⁶	M	Tr 1	70	14.50
42 Tg B	M	Tr 2	70	14.75
42 Tg B	F	Tr 3	70	14.00
673 Tg (50%)	M	S	81	18.80
13 CA	M	S	88	19.90
15 CA	F	S	88	20.00
- CA	F	S	⁷ 100	30.00
244 CA	M	Tw 1	⁷ 103	19.50
244 CA	M	Tw 2	⁷ 103	20.00
-	F	Tw 2	⁷ 112	27.50
156 Tg (75%)	M	Tw A	118	34.20
156 Tg (75%)	M	Tw B	118	38.40
154 CA	M	S	120	34.70
183 CA	F	S	128	31.70
172 Tg (50%)	M	S	129	34.90
123 CA	M	S	130	28.80
- Tg	(1)	Tw	140	39.50

Table 1.—Crown-rump measurements of goat and sheep fetuses, McGregor, Tex., and Beltsville, Md.—Con.

No.	Sex	Birth	Days (number)	Lengths (cm)
Karakul Sheep, Beltsville, Md.				
232 KC ⁸	F	Tw 1	45	5.15
332 KB ⁹	M	Tw 2	45	5.20
272 KC	(1)	S	60	12.50
249 KC	(1)	S	65	14.60
115 KN ¹⁰	F	S	⁷ 71	14.90
344 K ¹¹	M	S	80	19.90
- K	F	Tw 1	90	24.15
- K	F	Tw 2	90	26.03
- K	M	S	90	27.00
- K	M	Tw 1	100	29.57
- K	M	S	120	37.00
- K	M	S	120	36.20
- K	F	S	126	41.50
- K	F	S	135	44.20

¹ Not determined.

² Tw - twin.

³ S - single.

⁴ CA - Common American.

⁵ Tr - triple.

⁶ Tg - Toggenburg.

⁷ Approximate age.

⁸ KC - Karakul X Corriedale.

⁹ KB - Karakul X Blackface.

¹⁰ KN - Karakul X Navajo.

¹¹ K - Purebred Karakul.

mann and Becker (24), were seen in the 40- to 60-day-old angora fetal skins. Pigmented cells are abundantly present about the epidermis of fetal Karakul sheep after 45 days. They are considerably sparser in the 60-day-old fetuses of dairy goats, and totally absent in the angora of similar age. Photomicrographs of melanocytes and pigment are represented in plate 6. No histochemical methods were used to test the presence of melanoblasts in fetal angora skins; thus, their incidence remains uncertain.

The basement membrane.—The basement membrane of the angora becomes organized somewhere between the 50th and 60th day of fetal life, preparing for the sharp delineation of the dermis from the epidermis, and prior to the appearance of mohair follicular anlagen. From that period on, the basal membrane intercedes wherever cells of epidermal origin find themselves in juxtaposition with dermal cells or their derivations (pl. 7, A and C). Hardy (6) has described a similar phenomenon occurring during corresponding stages of fetal development in mice.

Sixty days' gestation.—Except for the head, the 60-day-old epidermis has only occasional follicular anlagen. These precursors of the earliest follicles (central primary) are present in the 70-day-old skin of the fetus.

At this stage, the ventral skin anlagen may be more advanced than those of the dorsal skin (pl. 8, A). Note the heavy accumulation and the orientation of the dermal cells flanking the anlage.

A similar difference in follicle development at about midterm of gestation was also found in Beltsville, Md., Karakul fetuses. In both instances and within a few days only, the dorsal and ventral follicles appear to have reached the same stage of development. More advanced follicles, including the laterals of the trio group, are present in the 70-day-old fetal jaw (pl. 8, B) and crown of head specimens of the angora. The oldest of these mohair follicles (central primary) may have reached the prebulbar stage by now (pl. 8, B, extreme right). Besides mohair follicles, larger follicles that produce vibrissae are also well advanced at this period (pl. 8, B, extreme left).

Eighty days' gestation.—About 80 days, for a brief time the epidermis becomes a wide, multilayered covering composed of the usual three layers (basal, intermediate, and the corneum) and, in addition, several layers of spinous cells in the intermediate layer. The numerous mitoses in the Malpighian (mostly, but not exclusively, basal) layer furnish the cells necessary for the development of the primary follicles and provide for the beginning of the secondary follicles, in addition to supplying cells for the appropriate covering of the rapidly growing body. During this period of accelerated epidermal proliferation, the periderm is discarded as an unnecessary, limiting blanket (pl. 8, C).

Between the 80th and the 90th day, islets of fat cells become differentiated in elongated, disconnected groups in the areolar part of the dermis close to blood vessels and more or less parallel to the underlying skin muscle fibers. Anatomically developed, but seemingly unfunctional, sudoriferous glands accompany the primary follicles (14) (pl. 7, B; pl. 8, C).

Ninety days' gestation.—The 3-month-old fetal skin shows the typical disposition of the trio follicular group (pl. 9, A). Having attained a certain size, the follicles change from a baglike structure to one ready to receive and accommodate the connective-tissue cells that press against their lower extremities. The latter becomes a bulblike structure that houses the dermal papilla (pl. 7). With the exception of the part directly connected with the dermis, the papilla is enveloped by follicular epidermal cells. A portion of the bulb cells becomes particularly active to form the matrix of the bulb. A basal membrane separates the bulbar cells from those of the papilla (pl. 7, D).

The arrangement and size of the dermal papilla of primary follicles in angoras accommodate blood capil-

laries, and blood is pulsating there near the 100th day of fetal life. Blood capillaries are seen in the secondary follicles from about the 120th day, and later about a few weeks postnatally in the later-developing secondaries (pl. 7, E).

This is not the case in all the secondary follicles of the Toggenburg goat, the common American goat, nor apparently in the Afghan goats of the Kabul breed. The delicate secondary follicles of these breeds have narrow, small bulbs and papillae incapable of accommodating a blood capillary. This lack of direct blood supply of certain follicles resembles the situation found in human lanugo hair (19).

At this stage (90 days), the recently delineated cord of mesodermal cells on the obtuse side of the slanting primary follicle transforms itself into hair-muscle fibers. These fibers arrange themselves into an elongated body called the *arrector pili* muscle. When barely differentiated, these cells stain more intensely than the surrounding mesenchymal cells. When fully developed into muscle fibers, they stain differentially with the orcein, Mallory II, orange G stain. The upper part of the muscle extends upward close to the epidermis and above the sudoriferous gland duct. The *arrector pili* of the angora consists of no less than one-half dozen fibers in cross section and has an unbranched capillary that runs through its main axis (pl. 9, B). Once established, the hair muscle is a fairly stable structure, recognizable throughout the cyclical performances of the follicle.

The sebaceous gland cells of primary follicles appear toward the 90th day of gestation. As shown by the oil red O stain (pl. 10, A), these glands never fail to function, even when they consist of barely one or two cells.

Although the sudoriferous glands develop about 2 months before the angora's birth, their function in prenatal stages is questionable (14).

One hundred days' gestation.—Shortly after the establishment of the primary generation of follicles, the secondaries are gradually introduced and developed (pl. 9, C). In angora goats, as in merino-type sheep, quite a few secondary follicles bear sebaceous glands. Several weeks after the angora's birth, the sebaceous glands of the secondary follicles reach and may even surpass postnatally the size of the primary ones (pl. 10, B).

Space within a bundle appears to be the limiting factor to sebaceous gland expansion in strains that produce heavy fleece and in the presence of direct blood supply. Competition must be considered, too, because usually the earlier follicles produce larger sebaceous glands. This picture contrasts sharply with the secondary

follicles of other sheep and goats, where small, sparse glands fail to fill the amply available space within the dermis.

Disregarding variations, the established number of follicles remains constant throughout the animal's life, while the space occupied by connective tissue increases progressively.

In the angora, as in other goats generally, secondary follicles invariably lack sudoriferous glands and hair muscles.

One hundred and ten days' gestation.—Keratinization of the hair cone and production of the hair of the primary follicles follow a few days after the establishment of the blood capillary in the papilla. Some early secondary follicles may not reach the sebaceous gland level of the primary follicles.

One hundred and twenty days' gestation.—At 4 months of fetal age, some of the secondary follicles have sebaceous glands, while others are still bare plugs, and still others are in only the early anagial stages. Toward birth, most, but by no means all, secondaries reach maturation and pierce the skin. The latter process extends for the primary follicles of the dorsum and ventrum from approximately the 110th to the 120th

day; for the secondaries, it begins when the fetus is about 4 1/2 months old and is not completed until the first postnatal months of life.

Prenatal growth of primary follicles.—Unless follicular slanting in the dermis is comparable in different animals, penetration in the skin is hardly an exact criterion of follicular growth. Nevertheless, penetration does offer an idea of development. Penetration of the primary follicles in the fetuses of common American goats apparently is accomplished toward the 4th month, while that of the angora occurs several weeks later.

In no case was there any semblance of more than one hair produced per follicle. Neither was there any sharing of a pilary canal by several hairs. No papillae or matrixes showed any splitting that could lead to possible branching of hairs. Thus, as in other goats examined, the angora bears one hair per follicle.

Medullation.—In strains of angora goats with fine fibers, medullation is restricted to the hair of primary, central follicles. When complete, it is the unbroken type (pl. 11). The chromatin dispersed in the nuclear network of the medullary cells persists in the "soft" keratin of these structures (15).

THE POSTNATAL ANGORA GOAT

Development, Differentiation, and Shedding

Follicular growth.—Compared with prenatal growth of follicles from the time of the establishment of the trio group until birth, follicles increase very little in length during postnatal life. Thus, the primary follicles are four to six times longer at birth than during the fetal stages. On the other hand, the same follicles and many secondaries are about 1 1/2 times longer at maturity and old age than at birth (table 2).

The possibly slightly deeper penetration of the skin by South African than by Texas follicles is not necessarily due to hereditary causes. To start with, the measurements of the African samples were taken from one specimen only per age group; hence, allowances have to be made for considerable variations. They were also taken at a different season and possibly under different conditions than those prevailing at McGregor, Tex.

Follicular width at the largest diameter, including the sebaceous glands, depends on type of follicle, position within the group, and age.

The sebaceous glands of the McGregor, Tex., angoras were usually longer and considerably wider than those of

ordinary dairy goats. In mature animals, they range from 0.3 to 0.45 mm in length. They are permanent organs and have a remarkable capacity for continuously producing sebum. Cholesterol was assayed, but its presence was not clearly demonstrated during the seasons of testing. To a lesser or more pronounced extent, keratin covered the epidermal surfaces. It was persistent in the club portions of resting and shedding mohair, but it was never observed in any parts of growing mohair follicles.

Primary follicles of angoras mature about 35 days after their initiation and pierce the skin about 10 days later; that is, after approximately 110 days of fetal life. The process is less regular and possibly somewhat slower in the secondary follicles, particularly in those that are initiated last. A portion of the secondaries does not mature until the first month or later.

Medullation.—The coat of the pure angora at McGregor, Tex., contains proportionately more medullated mohair at birth than at 2 months, when the total population of secondary follicles has been established. Some medullated primaries begin to produce discontinuous medullae, or after shedding and regenerating this hair, even develop like fine wool fibers that

Table 2.—Average depth of penetration of primary follicles in the dermis of Texas and South African does

Age of does	Depth of penetration in—	
	Texas angora ¹	South African angora ²
<i>Days</i>	<i>Mm</i>	<i>Mm</i>
1	0.85	0.80
1090	(3)
30	1.05	1.20
<i>Months</i>		
2 to 3	⁴ 1.05	(3)
6	1.45	⁵ 1.95
<i>Years</i>		
1	1.25	1.70
2	1.25	1.70
3	1.30	1.65
4	1.25	1.85
5	(3)	1.75
5 ½	⁶ 1.45	(3)
6	(3)	1.60
9	1.35	(3)

¹ 3 to 6 samples per age group.

² 1 sample per age group.

³ Samples not available.

⁴ Early summer.

⁵ Fall specimen; all others, spring samples.

⁶ Early fall; all others, winter specimens.

consist of cortex and epidermis only. At any rate, the coats of pure angoras 2 to 3 years old consisted of 1 ½- to 3 ½-percent medullated fibers. Since the reverse process never occurs in goats as it does in man, where nonmedullated lanugo hair may develop medullae after shedding, 3 ½ percent is apparently at the highest permissible number in determining angora purity. Most dependable counts should be conducted during the summer months; that is, during June, July, and August.

Mohair-fiber density.—Follicular distribution at different ages is shown in plate 12, which illustrates the disposition of follicles and their groups as the does mature. Plate 12, *E* shows a group of follicles of a common American goat, with their typically sparse number of secondary follicles, a bare nine here.

The potential middorsal mohair population of pure McGregor, Tex., angoras 2 to 3 years old, as judged by follicular counts, averages 3,000 per cm². This amount fits within the range of American merino sheep.

Follicular ratios.—Counts of primary and secondary follicles per group, indicating the proportion of second-

ary to primary follicles (the so-called s/p ratio), were conducted on biopsies performed during two succeeding seasons at McGregor, Tex., and on a limited number of South African samples (table 3). Considering maturation

Table 3.—Incidence of secondary follicles in South African angora does¹

Age	Range
1 day	18-22
6 months	17-27
1 year	16-25
2 years	21-24
3 years	20-27
4 years	24-31
5 years	17-24
6 years	18-23
8 years	20-25

¹ Based on counts of no less than 200 secondary follicles per sample (taken in 1960).

and growth characteristics, the s/p ratio of mature, pure angora goats is about 8 to 1 (table 4).

Maintenance.—As one observes biopsies from the angora's birth to its old age, one cannot but marvel at the regularity of the well-balanced metabolism that must maintain the histologic picture of the skin, with no more pronounced changes than those exhibited in connection with the seasonal pattern.

What are the most impressive age differences? The epidermis remains a thin, continuously metabolizing layer, reminding one of fine-wooled sheep. An irregularly present *stratum granulosum*, absent in young skins, may appear close to regions of follicular orifices in some older skins. Melanocytes occur more frequently about the epidermal-dermal junction in some older animals. Whatever pigment granules or melanocytes are encountered about the epidermis appear to have an affinity for follicles during early anagen stages, when they are present at the upper limit of the growing hair germ.

Elastic fibers are oriented differently in club and early anagen stages of mohair follicles than in mature stages. Their role appears to be connected with the shedding of individual fibers; as such, they bear no relation to age or season. Occasionally, follicles with widely open bulbs have been found in older skins. The papillary contents of such bulbs appear to flow into the dermis.

All in all, with the exception of the general loosening of dermal structures, there is not much difference in the skins of young, mature, and old animals.

Table 4.—Range and average of secondary follicles in a follicular group from Texas angora does, 1959-60 and 1960-61 seasons¹

Age of does	1959-60 season		1960-61 season		Both seasons	
	Range	Average	Range	Average	Range	Average
	Follicles		Follicles		Follicles	
1 to 2 days	13-27	18.50	11-28	18.00	11-28	18.25
9 to 10 days	13-27	22.00	—	—	13-27	22.00
1 month ²	16-25	20.50	18-30	23.75	16-30	22.12
2 to 3 months	20-29	24.10	—	—	20-29	24.10
8 months	18-28	24.25	—	—	18-28	24.25
1 year	18-26	23.40	18-27	22.75	18-27	23.10
2 years	—	—	21-26	23.50	21-26	23.50

¹Figures are based on counts of about 200 secondary follicles per angora skin biopsy obtained from each of the 3 to 6 specimens available.

²Biopsy from 1 animal only.

Shedding. The manner of shedding and regeneration of the angora is the characteristic brush type, as found in

Table 5.—Percentage of nongrowing mohair fibers in Texas angora does during the winter season¹

Age (years)	Total number of samples	Date	Number of samples	Percent
1	10	Feb. 19, 1959	1	10.50
		Feb. 2, 1960	6	
		Jan. 12, 1961	3	
2	6	Feb. 19, 1959	1	19.00
		Feb. 9, 1960	2	
		Jan. 13, 1960	2	
		Jan. 16, 1962	1	
3	6	Feb. 19, 1959	1	24.45
		Feb. 9, 1960	2	
		Jan. 13, 1961	2	
		Jan. 16, 1962	1	
4	3	Feb. 19, 1959	1	39.00
		Feb. 6, 1960	2	
6	5	Feb. 19, 1959	1	27.00
		Jan. 31, 1966	4	
8	3	Feb. 19, 1959	1	42.50
		Feb. 10, 1960	1	
		Jan. 31, 1966	1	
9	2	Feb. 25, 1959	1	60.00
		Feb. 10, 1960	1	

¹Figure closest to 300 follicles was counted per sample.

other goats and sheep. There are practically no resting and shedding follicles at birth. However, soon after the complete follicular population becomes established, the first nongrowing follicles appear. Starting with the primaries at about 75 postnatal days, a limited number of secondary follicles gradually follow in cyclical regression and regeneration.

The number of nongrowing follicles in animals up to 1 year of age ranges from 1 to 5 percent. Shedding in summer specimens, beginning with yearlings and ending with older animals, ranges from 3 to 9 percent, and tends to be higher in animals older than 3 years of age.

Their winter condition is much more extreme (tables 5 and 6). The January and February figures of nongrowing follicles at McGregor, Tex., gradually increased from 9 percent in yearlings up to 70 percent in does 9 years old.

Observations of a few biopsies from animals 80 to 90 percent purebred did not deviate in any way from the shedding pattern of pure angoras.

Table 6.—Percentage of nongrowing mohair fibers in South African angora does¹

Age	Season	Percent
6 months	Fall	1.00-2.00
1 year	Spring	5.00
2 years	do	3.00
3 years	do	9.50
4 years	do	5.75
5 years	do	9.25
6 years	do	8.75

¹300 follicles counted per sample.

LITERATURE CITED

- (1) Bergen, W. von.
1963. Von Bergen's wood handbook. V. 1. 800 pp. Interscience Pub. Inc., New York and London.
- (2) Duerden, J. E., and Spencer, R. M.
1930. The coat of the angora goat. Dept. Agr. Union of South Africa, Bul. No. 83, Pretoria.
- (3) Eaton, O.
1952. Weight and length measurements of fetuses of karakul sheep and of goats. *Growth* 16(419): 175-187.
- (4) Green, W. W., and Winters, L. M.
1945. Prenatal development of sheep. Univ. of Minn. Agr. Expt. Sta. Tech. Bul. No. 169.
- (5) Gurr, E. A.
1956. A practical manual of medical and biological staining. Pp. 117-119, Interscience Pub. Inc., New York.
- (6) Hardy, M.
1951. The development of pelage hairs and vibrissae from skin in tissue cultures. *Ann. N.Y. Acad. Sci.* 53: 546-561.
- (7) Henrici, A. T.
1945. Henrici's yeasts, molds, and actinomyces. P. 68. John Wiley and Sons, New York.
- (8) Jourbet, D. M.
1956. A study of prenatal growth and development in the sheep. *Jour. Agr. Sci.* 47(4): 382-428.
- (9) Levy, M. F.
1956. Goat husbandry. In *Sheep and goat husbandry*, ed. by P. A. Esaulov. State Pub. Agr. Lit. Pp. 540-619 (in Russian). Moscow.
- (10) Lydekker, R.
1898. Wild oxen, sheep and goats. 318 pp. Rowland Ward Pub., London.
- (11) Mackenzie, D.
1956. Goat husbandry. 349 pp. Faber & Faber Ltd., London.
- (12) Margolena, L. A.
1933. Phloxine with orange G as a differential counterstain. *Stain Technol.* 8(4): 157.
- (13) Margolena, L. A.
1959. Skin and follicle development in dairy goats. *Va. Jour. Sci.* 10(1): 33-47.
- (14) Margolena, L. A.
1962. Sudoriferous glands of sheep and goats. *Zeitschrift Mikr. Anat. Forschung* 69(2): 217-225.
- (15) Margolena, L. A.
1963. Ziehl Neelsen's stain for skin sections to show wool and hair follicles. *Stain Technol.* 38(3): 145-148.
- (16) Margolena, L. A.
1966. Lock type, follicular characteristics, and medullation in Texas and South African angora does. *Va. Jour. Sci.* 17(1): 32-39.
- (17) Margolena, L. A., and Dolnick, E. H.
1951. A differential staining method for elastic and collagenic fibers and keratin. *Stain Technol.* 26(2): 119-121.
- (18) Marincowitz, G.
1959. Pleece sometimes overemphasized at expense of conformation and production. *Farming in South Africa* 34(11): 38-41.
- (19) Montagna, W.
1962. The structure and function of the skin. 454 pp. Academic Press, New York.
- (20) Nathusius, W. von.
1866. Das wollhaar des schafs. 200 pp. Wiegandt and Hempel Pub., Berlin.
- (21) Pearse, A. G.
1960. Histochemistry, theoretical and applied. Pp. 860-861. Little, Brown and Co., Boston.
- (22) Pinkus, H.
1944. 1% orcein-giemsa. (Mod. of Unna Taenzer method.) *Arch. Dermat. Syph.* 69: 335-336.
- (23) Schied, R. J.
1964. Minimizing curling of skin biopsies by blotting paper support during fixation. *Stain Technol.* 39(4): 252.
- (24) Zimmermann, A. A., and Becker, S. W., Jr.
1959. Precursors of epidermal melanocytes in Negro fetus. In *Pigment Cell Biology*, ed. by Myron Gorson. Pp. 159-170. Academic Press, New York.

PLATE 1



A



B

A, Texas angora doe with ringlet locks; B, angora kids at salt lick and shorn doe in background.

PLATE 2



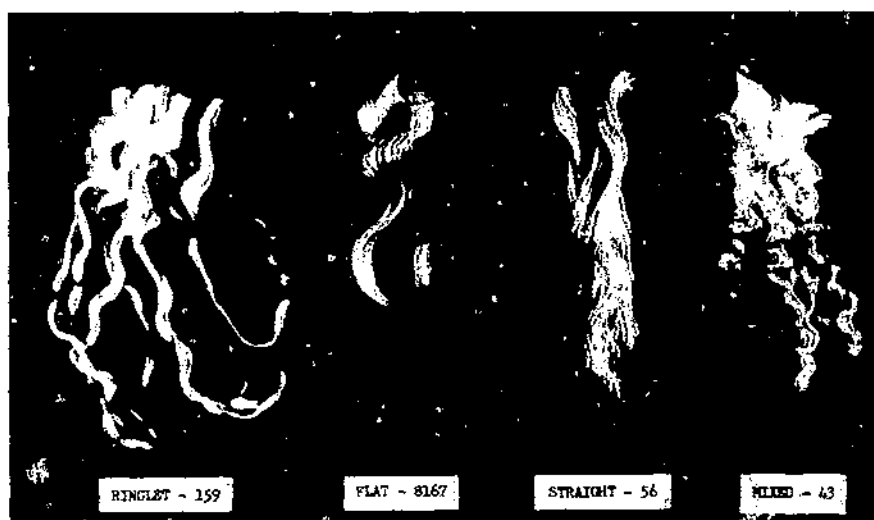
A



B

A, Angora bucks, Fred Earwood Ranch, Sonora, Tex.; note curved horns; B, angora bucks, just weaned.

PLATE 3



A

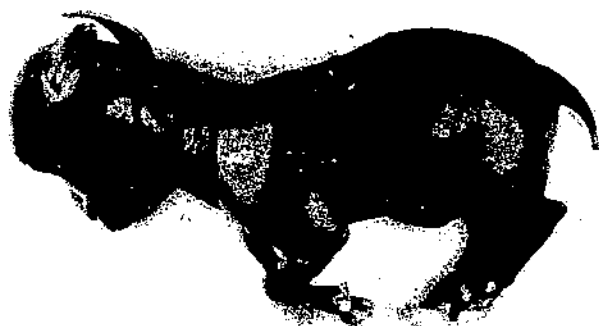
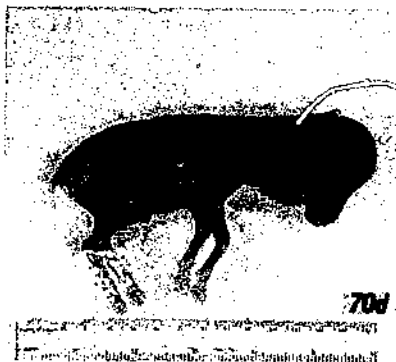


B

A, Types of angora fleece locks; B, examining angora fleece.

PLATE 4

PRENATAL ANGORA GOATS



90d



100d

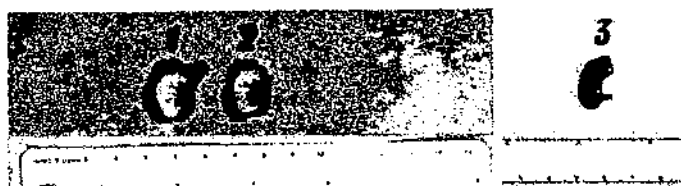


110d

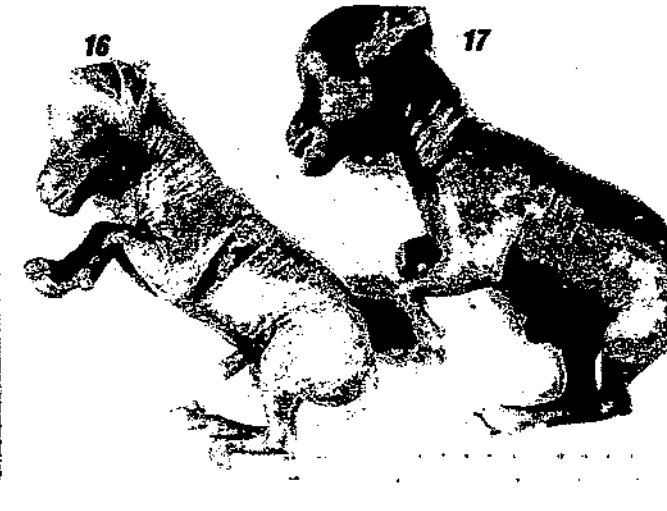
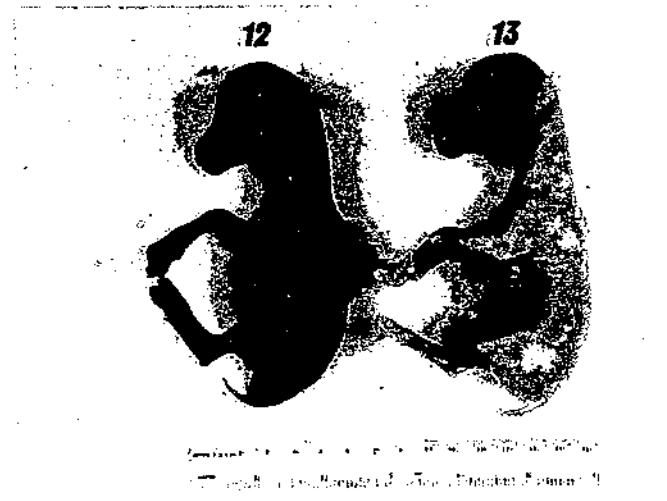


Prenatal angora goats 60 to 120 days of age, McGregor flock, Tex.

PLATE 5



3



Comparative stages in the development of fetal goats and sheep. With the exception of angora goat fetuses, all specimens were obtained from ewes and does of the USDA Beltsville (Maryland) flock. 1 and 2, 35-day angora twins; 3, 34-day common American goat; 4 and 5, 49-day angora twins; 6, 50-day Toggenburg goat (approximate age); 7, 50-day angora goat; 8, 65-day Karakul sheep; 9, 60-day angora goat; 10, 70-day Toggenburg goat (approximate age); 11, 60-day angora goat; 12, 70-day Toggenburg goat (approximate age); 13, 70-day angora goat; 14, 81-day Toggenburg goat; 15, 80-day angora goat; 16, 90-day angora (twin); 17, 90-day angora goat (single).

PLATE 6



A



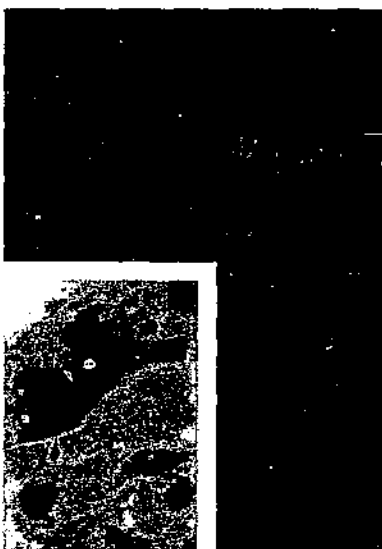
B



C



D



E



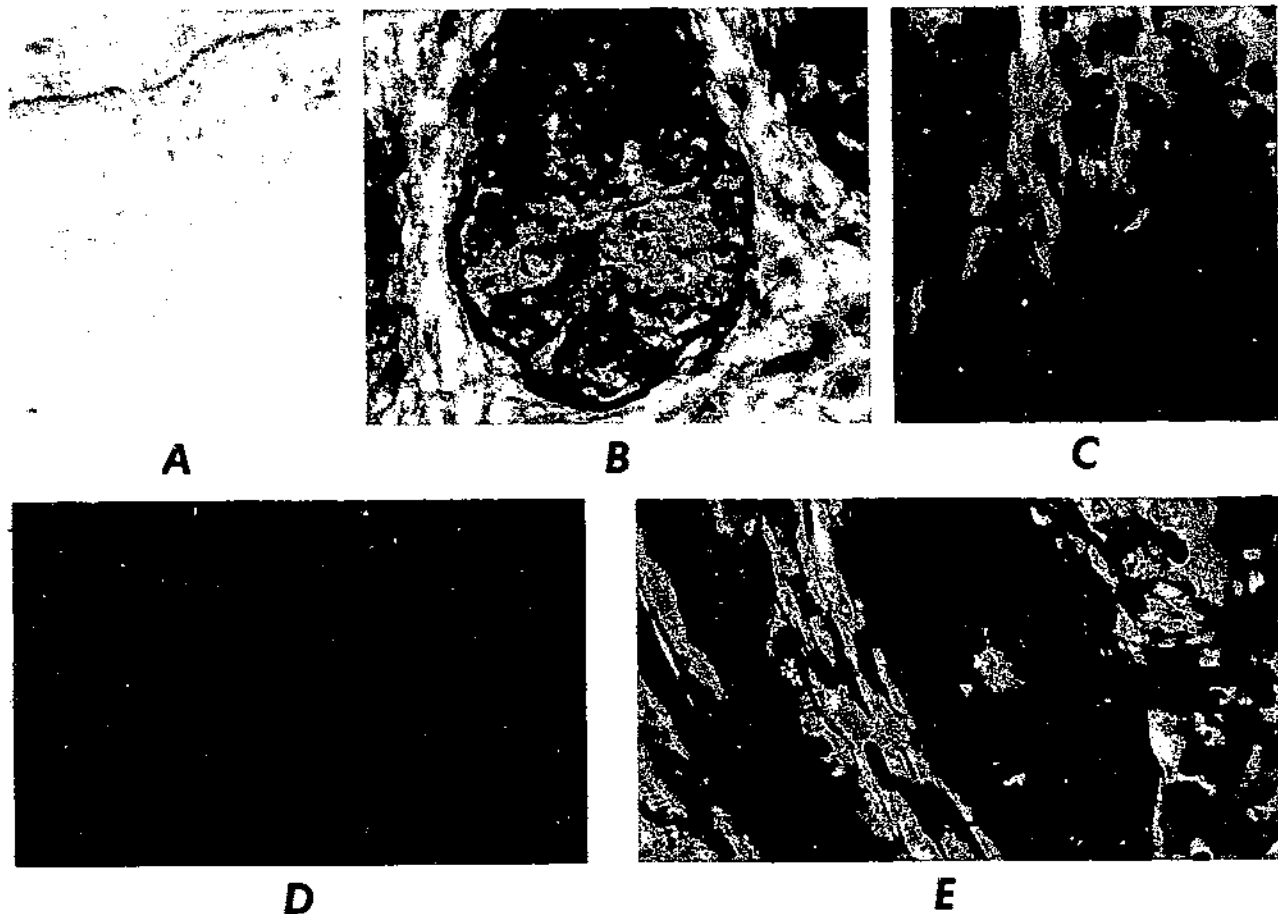
F



G

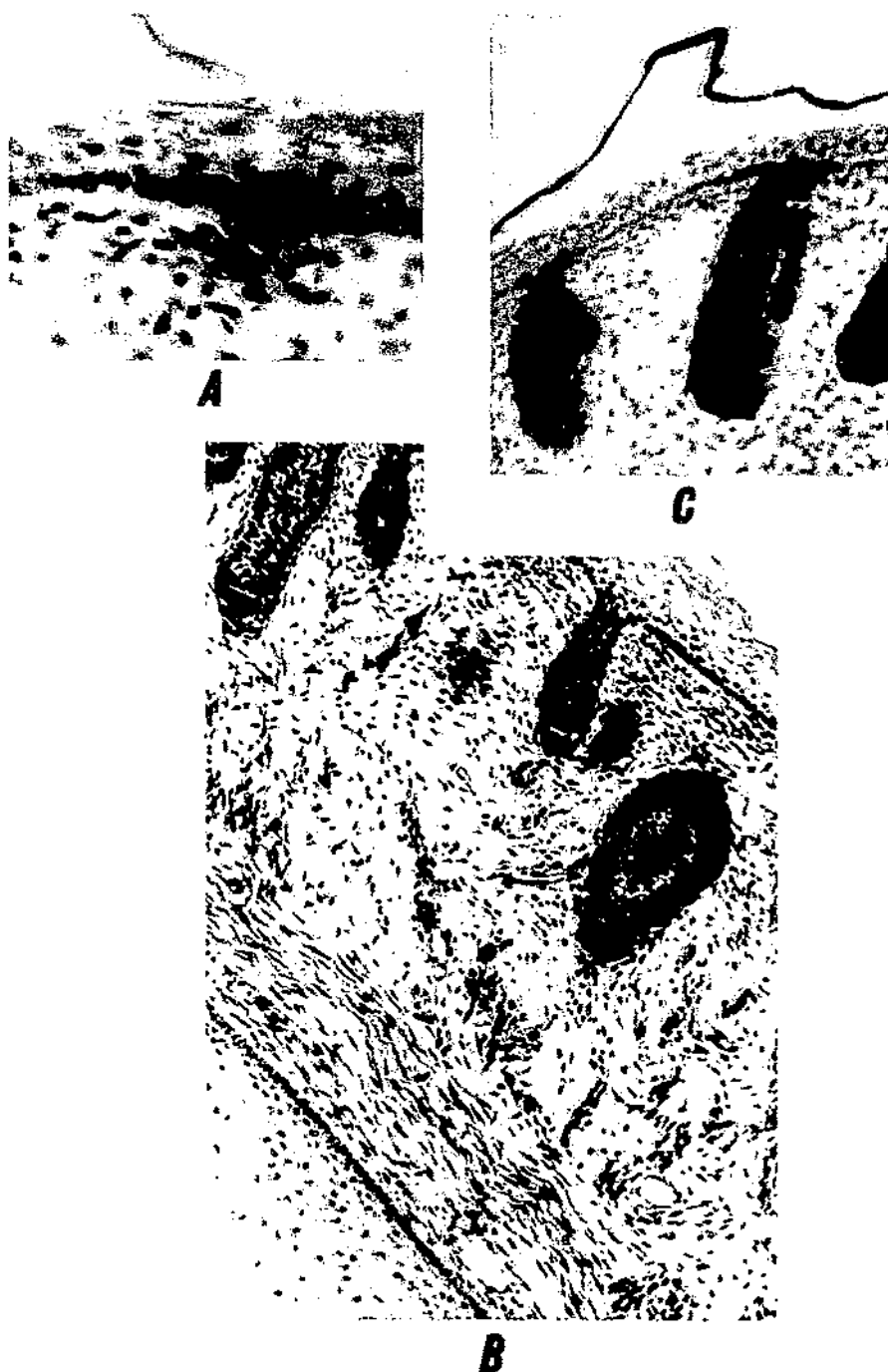
A, Melanocytes and pigment distribution about the epidermis, follicular anlagen, and developing follicles in the skin of the head of a 60-day-old Karakul fetus. Hematoxylin, phloxine, orange G; B, pigment-carrying cells (immature melanocytes of Zimmermann) near blood vessels in 70-day-old fetal dermis, Toggenburg goat. Orcein, Mallory II, orange G. 450 X; C, pigment in outer epidermal root-sheaths and in hairs of primary and secondary follicles, 30-day-old postnatal common American goat (cross section below sebaceous glands) Saffranin (upper center - club hair); D, melanocytes surrounding outer epidermal-sheath cells, 5-day-old postnatal Toggenburg goat. Z. N. Fuchsin, hematoxylin, orange G. 450 X; E, melanocyte in the basal layer of the epidermis, 30-day-old postnatal angora goat skin. Z. N. Fuchsin, hematoxylin, orange G. 450 X; F, melanocytes in the basal layer of the epidermis, 8-month-old postnatal angora goat. Orcein-geimsa. 450 X; G, melanocytes in the basal layer of epidermis, 1-year-old angora goat. Hematoxylin, phloxine, orange G. 450 X.

PLATE 7



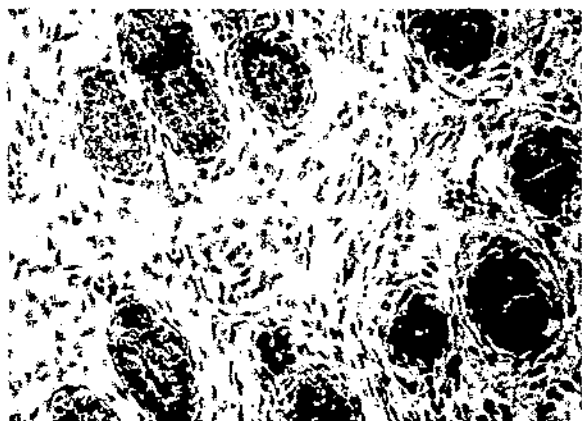
A, Basement membrane under columnar layer of epidermal cells in 60-day-old fetal skin. Note earliest follicular anlage and blood capillary. Orcein, Mallory II, orange G. 200 X; B, cross section of primary follicle in 90-day-old fetal skin. Note basement membrane about the follicle and the sudoriferous canal; also note sebaceous cells and a mitosis in a sebaceous cell (upper right). Orcein, Mallory II, orange G. 450 X; C, plug of developing secondary follicle in 100-day-old fetal skin. Note sebaceous gland cells of a primary follicle (lower left) and heavy epidermis. Hematoxylin, phloxine, orange G. 450 X; D, dermal papilla of a primary follicle in 90-day-old fetal skin. Note basement membrane separating the papilla from the surrounding matrix cells. Orcein, Mallory II, orange G. 450 X; E, bulb of secondary follicle in 140-day fetal skin showing a capillary entering its lower extremity. Hematoxylin, phloxine, orange G. 450 X.

PLATE 8



A, Mohair follicle anlage in 60-day-old fetal skin of ventrum. Note accumulation of mesodermal cells under the anlage. Frozen section, hematoxylin, 450 X; B, sinus hair follicle (upper left) and primary and secondary mohair follicles in various stages of development in 70-day-old fetal skin of the jaw. Hematoxylin, phloxine, orange G, 100 X; C, developing primary follicles and sudoriferous glands in dermal skin of the 80-day-old fetus. Note lifted periderm. Frozen section, hematoxylin, 100 X.

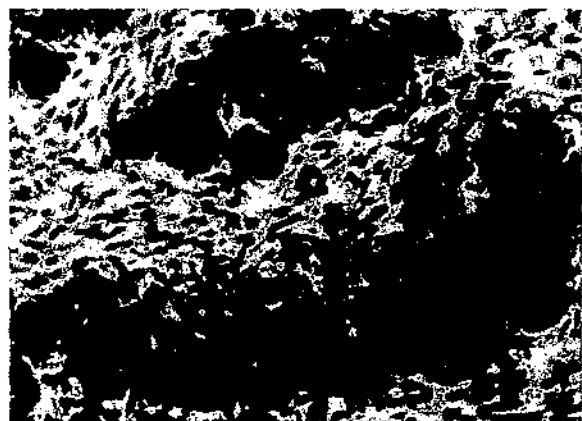
PLATE 9



A

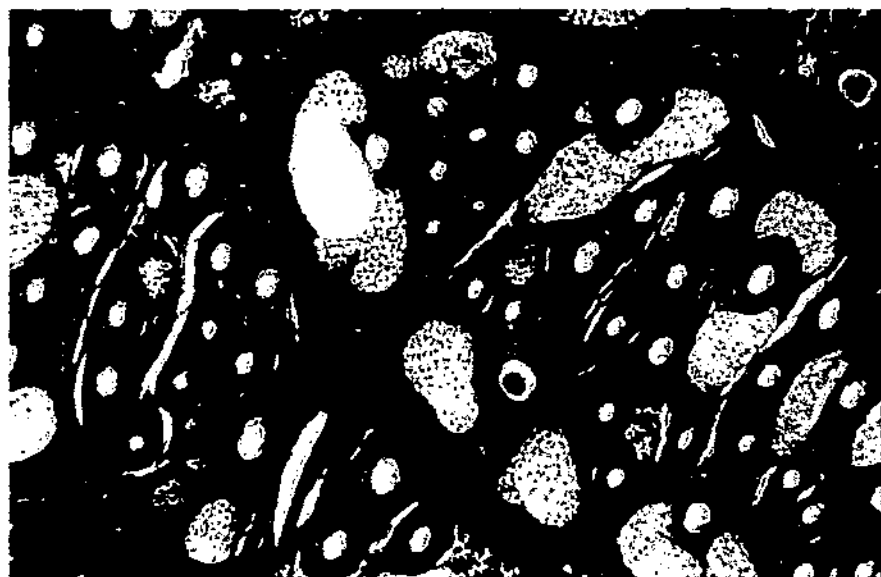


B



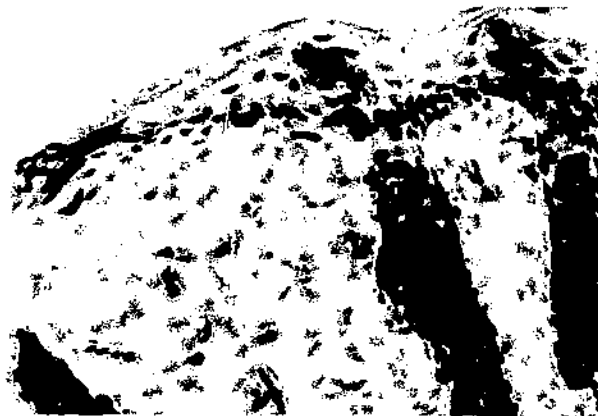
C

A, Primary follicles in trio groups in 90-day-old fetal angora skin, cross sections. Hematoxylin, phloxine, orange G. 100 X; B, *Arrector pili* in 90-day-old fetal angora skin. Note capillary running through the muscle fibers. Orcein, Mallory II, orange G. 450 X; C, developing secondary follicles amidst the primary in 100-day-old fetal angora skin, a cross section. Hematoxylin, phloxine, orange G. 100 X; D, bundle consisting of 30 follicles and carrying large sebaceous glands, cross section. Hematoxylin, phloxine, orange G. 40 X. (Angora doe, 8 months of age.)

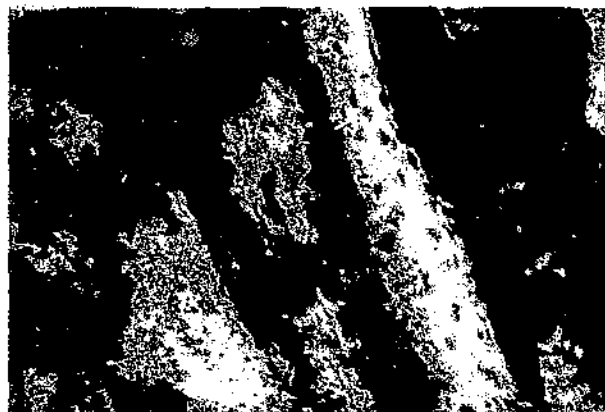


D

PLATE 10



A



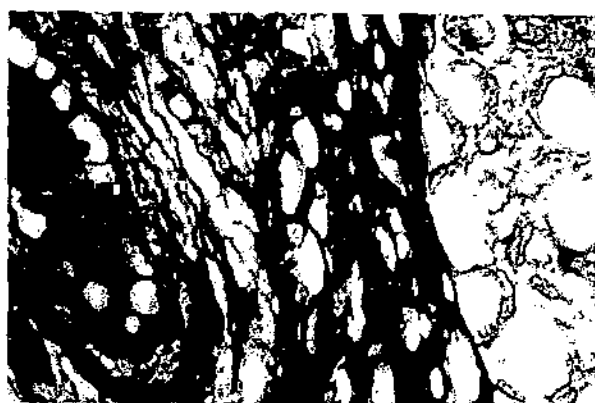
B



C



D



E

A, Sebaceous gland cells and sebum in 100-day-old fetal angora skin. Hematoxylin, oil red O. 200 X; **B**, portion of a sebaceous gland of a medullated, primary 140-day-old fetus (right); sebaceous gland of a secondary follicle (left). Hematoxylin, oil red O. 200 X; **C**, sebaceous cells in the lower portion of a lobe of a primary follicle, 130-day-old fetal angora skin. Note granules, lipid reaction, and nuclei in these young sebaceous cells. Amann, Aniline blue, oil red O. 450 X; **D**, portion of a lobe of a sebaceous gland in a 130-day-old fetal angora skin. Lipid reaction. Immature secondary follicle on the left. Hematoxylin, oil red O. 200 X; **E**, Areolar tissue of fat cells, collagen fibers, and blood vessel in skin of a 100-day-old angora fetus. Orcein, Mallory II, orange G. 450 X.

PLATE 11



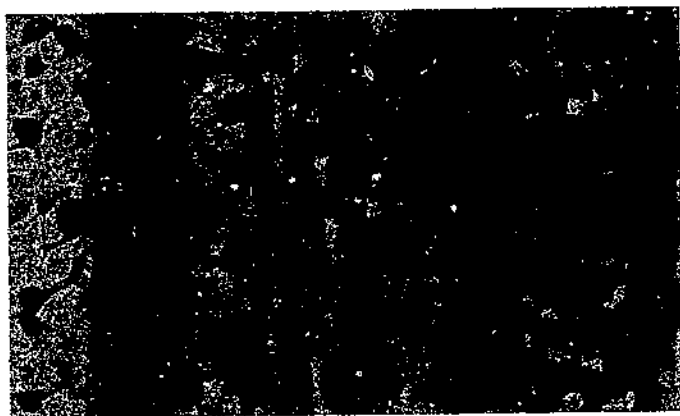
A



B



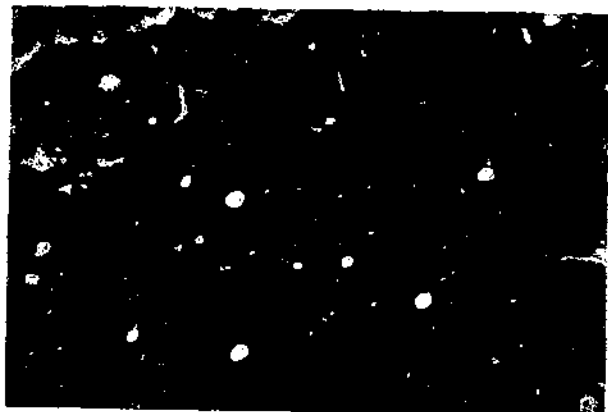
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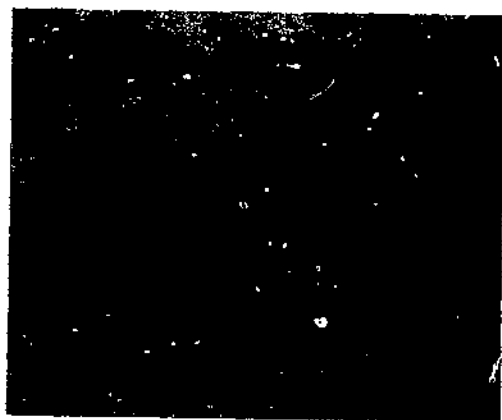
D

A, Medullated mohair in primary follicle and two immature secondary follicles in 130-day-old angora fetus. Hematoxylin, phloxine, orange G. 200 X; **B**, chromatin in medullary cells and in the cells of the inner root-sheath of a primary follicle in 140-day-old angora fetus. Feulgen, picric acid, fast green. 200 X; **C**, medullated primary follicle and two immature secondary follicles (left center) in 1-day-old postnatal angora skin. Hematoxylin, phloxine, orange G. 200 X; **D**, medulla of primary mohair follicle (right), 1-day-old postnatal angora skin. Hematoxylin, phloxine, orange G. 450 X.

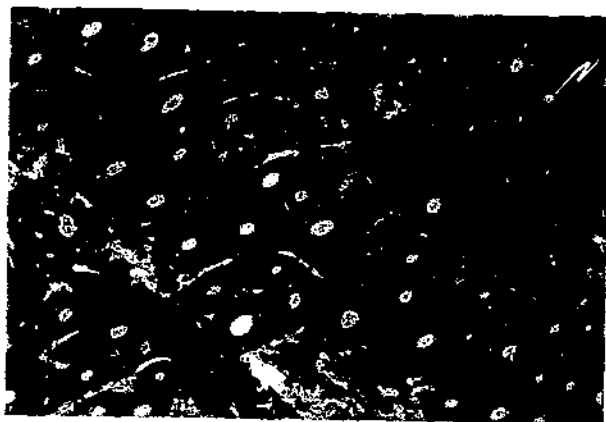
PLATE 12



A



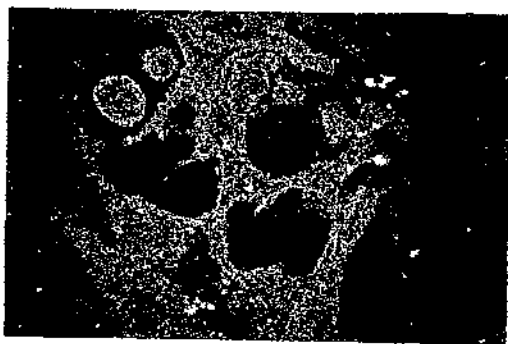
C



B



D



E

Density of follicular population in cross sections of angora and dairy goatskins: A, 1-day-old angora. Orcein, Mallory II, orange G. 40 X; B, 2-year-old angora. Orcein, Mallory II, orange G. 40 X; C, 1-day-old angora. Note also immature follicles. Hematoxylin, phloxine, orange G. 100 X; D, 30-day-old angora. Hematoxylin, phloxine, orange G. 100 X; E, 30-day-old dairy goat. Saffranin, orange G.

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