THE COMPARATIVE HISTOLOGY OF PRIME AND UNPRIME MUSKRAT PELTS.

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ABSTRACT.

Primeness in Muskrat pelts and probably in other fur pelts is shown to be not a condition of the leather, but a function of the pigment distribution in the hair-roots and intimately associated with shedding and the growth of new fur, but independent of thickness in the leather. The microscopic factors of prime and unprime pelts are discussed in correlation with the gross differences they cause in the skin. A knowledge of the sequence of primeness increases the practical application of the test devised for the detection of primeness in the living animal, based upon the histological differences of the hairs.

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Introduction.

Furs have been an important commodity in Canada, from the time Jaques Cartier first set foot upon the shores of the St. Lawrence to the advent of the Overton-Dalton fox farms, which marked the inauguration of another important national industry. Furs are now obtained from over one hundred species of mammals, or fur-bearing animals, as they are called. These are wild, domesticated and semi-domesticated. Fur farming is fast becoming the backbone of the fur industry and will inevitably replace the rapidly diminishing and more uncertain methods of trapping. In the early stages it was almost wholly confined to fox-raising and fox-breeding, but of late rearing methods have been applied to Mink, Badger, Muskrat, etc.

Probably the trend towards different kinds of fur ranching is influenced to some extent by prevailing styles, with the resulting greater popularity of garments made from pelts of certain fur-bearing animals, and also by the facility with which others lend themselves to the more technical processes of dyeing and dressing, such furs are always in great demand. Thus, in recent years the Muskrat has become one of the most important of fur-bearing animals, owing to its value as a natural fur and also as a dyed fur. The effect has been a great development of Muskrat ranching throughout the Dominion and especially in Manitoba, where the natural geographical condition lends itself, in particular, to this form of fur farming.

It is the relative importance of the Muskrat among the

fur-bearing animals that ~~first~~ suggested it as a subject for investigation. . In it, however, not only does the necessity of uniformity reach its maximum, but also the variations in size, colour and quality of the pelts taken from different sections of the continent. The skins to be used in the manufacture of fine garments, must be as nearly alike as possible with regard to the three factors mentioned above, also it is known that color and quality vary as we pass from East to West across the North American continent, the colour changing from dark to lighter respectively. Hence it may be assumed that some or all of the differences in soil, water, food, altitude, temperature and humidity of the different geographical zones play a deciding part in bringing about these variations. This fact makes it imperative to sort the pelts into large groups, according to their geographical origin, with subsequent grading among the skins from each section.

In estimating the value of furs many factors have to be considered. There is no single standard by which the skins are judged, each kind having its own criterion of perfection. However, the general points by which the raw furs are graded are character, colour, size, origin, quality, density, and date of season of trapping and methods of handling. But a more careful scrutiny of these points classifies them into two main groups,- those pertaining to the hair and those pertaining to the hide or so-called leather.

A note on the nomenclature adopted may be of value here for a clear and exact understanding of the structure referred to, in the subsequent account of the investigation. Fur-bearing animals are mammals whose skins are used in the manufacture of

fur garments and other fur-wearing apparel. The skin, when it is removed from the animal is called a pelt, or sometimes in the case of larger animals, a hide. The pelt, after having been dressed and dyed, is called a fur, the skin part being referred to as the leather, the hair as the pelage.

Since the factors which determine the value of a pelt are based upon the characters of the hair and the leather, a detailed knowledge of these structures is of great importance. Since the hair is a product of the leather and is ultimately dependent upon it for its many variations, such as character, colour, skin, quality, density and length, it seems logical to assume that an exact knowledge of those characters of the leather which combine with an optimum state in the hair must be of the greatest importance.

In the leather there are two variable factors of primary importance. These are, firstly,- the thickness of the leather which facilitates the more technical process of dressing and dyeing, and also gives durability to the manufactured product.

The second, and more important factor, is primeness during which all the attributes of the hair are in their optimum condition and the leather is also devoid of the devaluating and marring blue areas of pigmentation. It is evident that an exact knowledge of the condition of primeness ~~PRIMENESS~~ which, in the final analysis is the ultimate criterion of the leather, is of fundamental importance. Not only does unprimeness affect the fur as a garment of wearing apparel, but in the grading and money value this plays an important role in

materially decreasing the value of the fur harvest.

So far most of our knowledge of the phenomena of primeness is empirical, although of practical value.. However, an investigation of the constituent materials, anatomical structure and physiological processes, entering into the development of the phase, known as primeness, based on an accurate, scientific investigation, should not only throw light upon some of the more obscure underlying phenomena, but also aid materially in laying a foundation for future progress. The value of such a study is that it would demonstrate histologically the nature and the difference between the tissue constituents of prime and unprime pelts, and would provide fur-dressers and dyers with a more accurate knowledge of the factors which play a part in the formation of pelts and enable them to place the tanning and dyeing processes on a scientific basis. It would not only determine the order of occurrence in which primeness takes place throughout the various regions of a pelt, but would also show the precise relationship of unprimeness to shedding of the fur.

From the analogy of the distribution of pigment in the hair of other fur-bearers, an hypothesis might be suggested as to the reason for the reasonable change in colour of the fur in such animals as the rabbit, weasel and arctic fox.

Finally, from the knowledge gained in the microscopic study of the underlying sections, we might suggest a method for the detection of prime from unprime pelts by means of the histological differences in the hairs of each, and so enable unprimeness in the pelts of <u>living</u> fur-bearing

animals to be detected in a similar manner ~~as to~~ thus giving the fur-breeder an exact external indicator of the invisible underlying phenomena taking place in the skin.

Methods.

I am indebted to Mr. Eudore Chevrier, the president of the Muskrat ranches of Northern Manitoba, for specimens of living muskrats out of season.

The variety used was that commonly known as the Hudson Bay Muskrat, (Fiber zibethicus albus). The specimens were obtained from the eight thousand-acre muskrat ranch situated on Washow Bay on the west coast of Lake Winnipeg, which has an abundant natural food supply well below the freezing level of the ice.

Male animals were used to avoid any variations in the pelt which might result from secondary efforts caused by the oestrous periods. One rat pelted on September 28th, showed those characteristics commonly seen in an autumn pelt. The ventral portion was prime while the dorsal region showed on the flesh side the familiar patches of pigmentation seen in an unprime pelt. From these pigmented areas pieces of skin were taken from the mid-dorsal region, and the unprime microscopic sections were prepared from them.

Similarly sections of prime pelt were made from the same regions of a Muskrat pelted by the writer on February 1st, received from the same ranch. The microtechnical procedure followed was the usual Bouin - Haematoxylin - Paraffin routine.

The unstained horizontal sections of skin from which the microphotographs of the pigmented hair roots were taken, were previously made translucent by clearing them in cedar oil

and by removal of the P.cornosus muscle.

The Structure of the Pelt.

By taking the untreated dried pelt, shearing the fur and carefully stripping the layer of muscle (Panniculus cornosus) from the inside, it is possible to examine and study the remaining portion of the leather directly with the low power of the microscope.

(1) In this manner portions of leather cut from the blue or unprime areas of the Muskrat pelt were studied. Here the microscopic field was seen to be strewn with irregular groups and rows of densely pigmented hair roots, embedded in a fleshy coloured connective tissue substance, with blood showing in the numerous blood vessels throughout the field. (Plate I and Fig. 9). The hair roots on further examination proved to be of two kinds. The larger type, the guard-hair roots, sparsely scattered over the field with the pigment less densely concentrated in the bulbous portion of their roots. A much smaller, but more numerous variety, the underfur hair roots arranged in groups, either around the larger roots of the guard-hairs, or in clusters or rows without a central guard-hair. In these the melanin granules are seen to be so densely concentrated in the ampulla of the root, that each appears as a black-wedge-shaped structure. From the outer end of this wedge small blocks of pigment pass into the adjoining portion of the root, at first closely packed together, but becoming more definitely separated from each other, as they pass into the portion of the hair root nearer to the mouth of the follicle. In the roots of the underfur hairs, the melanin

is confined completely to the medulla, while in the case of the guard-hairs it also permeates the cortex and is not distributed in a block formation.

(2) Examination of a portion of flesh coloured or prime Muskrat pelt, prepared in a similar manner, shows neither evidence of hair roots nor pigmentation (Plate I, B), but all that is visible is a whitish connective tissue ground substance with numerous small blood vessels traversing it. To determine if the roots are hidden from view by a layer of connective tissue, the remaining portion of the leather was teased, and with some difficulty it was possible to distinguish some clear translucent structures, which, on further examination proved to be the hair roots, completely devoid of any pigmentation.

Thus, it is not due to any external layer or envelopment of the roots by fibrous tissue, that they are invisible, but owing to the fact that in a prime skin the roots are completely devoid of melanin.

Thus the blue coloration visible on the inside of the skin in the gross examination, and which is commonly accepted in the fur trade as betraying unprimeness in pelts, is due to the massedeffect of the pigmented roots. The pink fleshy colour of the prime skin is due to the absence of pigmentation in the hair-roots, which, if present, alone account for any coloration in the leather. Thus, it is possible to understand why a Muskrat pelt may be as thin as paper but be fully prime, and why the skin may be approximately an eighth of an inch thick in certain pelts and yet be unmarkedly unprime.

The condition of primeness or unprimeness is not dependent upon thickness of the leather. In short, it is not, as is commonly understood, a pigmented condition of the leather, but of the hairs, and is due to a different distribution of the pigment within the proximal portion of the hairs and their roots.

(3) If vertical sections of a portion of prime skin be examined, the skin is seen to be composed of a relatively thin layer of epidermis, below which lies a thick dermal layer containing the hair roots and follicles with sebaceous glands and arrector pili muscles. Beneath the skin are found the longitudinal muscle fibres of the Panniculus carnosus muscle, which is attached by a thin layer of fascia to the body musculature. The epidermis consists of a stratified epithelium giving protection to the whole external body surface and lining the external orifices opening upon it. In the sections it is seen to be situated upon microscopic dermal papillae from which it received nerve and vascular supplies. It is composed of a number of layers of cells, the deeper of which are softer and protoplasmic forming the stratum mucosum, while the superficial layers are hard and cornified. The basal or Malphigian layer is set upon the surface of the dermal papillae, the cells of this layer exhibit well defined almost spherical nuclei which show evidence of mitotic activity. The protoplasm of these cells is enclosed in poorly-defined cell walls and is devoid of pigmentation throughout the portion of the skin used commercially as a pelt. Above the former layer, two or three

layers of cells may be recognised, but only by their well-defined oval nuclei.

The next layer shows a sudden transition in structure and staining quality from the two former strata. Its deep staining properties are probably due to the presence of Eliden granules which cause it to assume the appearance of a homogeneous structureless layer serving to seperate the softer underlying cellular portions from the external stratum corneum which is constantly renewed from this layer as it becomes worn off externally. The stratum corneum or outermost layer consists of scale-like flattened, horny cells in which the nuclei are no longer visible. It shows not only a weak affinity for the stain but also for the underlying tissues, hence is often seen torn away in the sections. In the Muskrat it is relatively unimportant as a protective layer, due to the presence of a dense coat of fur, so is not very thick.

Although the epidermis is a relatively thin portion in the Muskrat skin, nevertheless it is a very important factor since the all important coat of fur is entirely a product of this layer. At the mouth of the hair-follicles the epidermis becomes continuous with the epithelial portion of the follicule and also is modified in this region to form sebaceous glands.

The dermis or true skin, lies deep to the epidermis and is composed of dense connective tissue which becomes more open or reticular in texture in its deeper part, where it is attached to the fibres of the Panniculus carnosus muscle. The outer edge of the dermis is thrown into small papillae many of which are vascular and here the connective tissue is

matted into a dense reticulum not showing the loose wavy bundles characteristic of the deeper parts. Scattered among the bundles of white collagen fibres are various shaped connective tissue cells and also numerous elastic tissue fibres which endow the leather with its stretching qualities.

Blood vessels are most abundant in the deepest portion of the dermis from which they wend their way up between the groups of fat cells to the root papillae. From the layer of fat lying deep to the hair-roots a series of fat laden follicles curve up beneath each group of prime hairs.

The hairs have their roots embedded in the connective tissue of the outer half to two-thirds of the dermis and are arranged in definite groups averaging thirteen to the group in the prime pelt. The angle at which the hairs leave the skin varies in the different regions of the body surface, that of the dorsal being more acute than in the ventral region, but all of the hair groups show variation depending upon their relative state of primeness.

The bulbous portion of each of the roots is surrounded by a follicular coat of epithelial cells which in the external portion of the roots gives place to form a common follicle continuous with the epidermis at the surface of the skin. Near the base of the common follicle several sebaceous glands are situated in each group of hairs. While extending towards the surface from the portion of the follicle surrounding the root bulbs may be seen the arrector pili muscle situated in the obtuse angle formed by the group of hairs with the surface

The general arrangement of the hair roots in the groups is such that the slightly bulbous portions of the roots are spread out in a manner which causes the group to assume the shape of a pyramid; the expanded roots forming the broader base, while the more compactly bound outer portions of the roots, enclosed in the common follicle, simulate the apex. Thus, due to their mechanical arrangement, the roots are firmly wedged in the skin. (Plate II).

Just beneath the dermis lies the Panniculus carnosus muscle which Langworthy describes "as a thin layer of muscle found only in mammals, lying just beneath the skin, of variable extent, but often stretching as a broad sheet over the thorax, abdomen and proximal portion of the posterior extremities. Indeed so close to the skin does it lie, within the superficial fascia and panniculus adiposis, that it is often spoken of as a "Skin Muscle. Only its position makes the name of "Skin Muscle" appropriate, for it is really a derivative of the pectoral musculature and has only secondarily acquired its position near the skin. Although the edges of the superficial fascial musculature and the panniculus carnosus may lie close together, overlap or even secondarily fuse, yet they are to be considered as entirely separate and derived phylogenetically from two distinctly separate regions, as is their nerve supplies; for the superficial facial musculature is enervated by the facial nerve while the superficial trunk musculature is innervated by the nn. thoracales anterior branches of the brachial plexus."

The panniculus carnosus muscle although now a skin muscle, is usually included with that structure when the

animal is pelted, and in the Autumn and Winter seasons lends its characteristic fleshy colour to the pelt. It also plays a very important role in the formation of the leather and is of special significance when the roots of the hairs extend to the deeper portion of the dermis, then it forms an inner protective layer of leather covering them. (Figs. 8,11 and 12).

As we have stated this muscle is attached in vivo to the underlying body musculature by a thin layer of fascia. The importance of this innermost fascial layer of pelt is the relative strength of its attachment to the p.carnosus muscle, compared to that of the dermis for this muscle, which determines whether the muscle remains attached to the body musculature or is pelted with the skin and so takes part in the formation of the leather.

(4) If vertical sections of an unprime portion of pelt be examined it will be seen that they show several remarkable differences from the prime condition, particularly with regard to the pigmentation of the hair roots, the relative position, angle and depth of the hairs in the dermis, and the appearance of the root-bulbs in relation to the root papillae.

The melanin in the unprime roots is concentrated into a dense, black bulbous mass in the region of the root bulb from which it passes out in a characteristic blocked formation into the medullae of the remaining portion of the under-fur roots, while in the guard-hairs the pigmentation is of a more uniformly granular character and permeates the cortex also.

Another important feature is the relative depth of the hair roots in the dermis. The unprime or pigmented

roots originate in the deepest part of the dermis and at a very acute angle. (Plate III.), while in the fully prime pelt the hair roots are situated in the outer half to two thirds of the dermis and have assumed almost a vertical position, (Plate II). Below these groups of prime hairs is seen a train of follicular cavities curving up from the deeper part of the dermis, from a more horizontal plane than that now assumed by the prime hairs. These cavities from all evidence were formerly occupied by the unprime hairs, which having lost their direct connection with the root papillae and thus becoming depigmented, migrated outwards at the same time Assuming a more vertical position. The fat cells from the underlying layer of lipoidal substance then migrated into these cavities and filled them with fat. At first sight these hairs might appear to be shedding, but the sections were made from a typically prime portion of a muskrat, pelted by the writer of February 1st, and in the final stage of becoming fully prime.

Another noticeable difference is the appearance assumed by the superficially placed prime roots in contrast with that of the deeply situated, pigmented unprime roots. The latter have more bulbous root ampullae fitting like inverted cups over the vascular papillae, (Fig. 4), while prime roots appear as unpigmented, translucent, very slightly bulbed stalks with frayed extremities, (Fig. 3).

From an extensive examination of sections showing the variations present in extreme prime and unprime pelts, as well as those exhibiting the intermediate or transitional stages, I conclude that the variations are merely different phases in the life cycle of the hair.

The very young hair has a bulbous root, densely pigmented and situated in the deepest portion of the dermis. The pigment is continued into the young hair as a continuous core which is often seen to end by tapering off to a sharp point. Frequently the bulbous part of the root makes a sharp loop or is angled at its junction with the remaining portion of the root, (fig. 9). This is evidently due to the young hair following the old follicular cavity which was kinked when the hair became prime and assumed a more vertical position.

As this hair grows older the pigment becomes less dense and assumes a granular appearance, and often shows an irregular distribution at the basal extremity, (Fig.10). It has now a characteristically blocked arrangement, the medulla showing alternating pigmented and non-pigmented areas. In stained specimens at this stage they have a cup-shaped ampulla over the papilla, (fig. 4).

Later the root appears to undergo a process of absorption and atrophy in the region just above the papilla and the root now assumes a depigmented, hyaline appearance throughout, and also shrinks in diameter. Meanwhile the root is migrating outwards devoid of an ampulla and pulled away from the papilla, which remains in the deeper part of the dermis surrounded by a remnant of epithelial cells, from which the next hair generation will probably arise.

This maturing or priming process although it brings about a separation of the hair-root from the papilla, does not

sever the hair from all vital connection, however, for when such hairs are clipped from the body of the animals which exhibit seasonal colour change in the external parts of the hairs, the process of colour change is discontinued.

Another structure which may play an important role in bringing about the outward migration and assumption of a more vertical position in the groups of hairs on becoming prime, is the errector pili muscle, which in a few sections is seen attached to the base of the follicle of the group of hairs in its new position, (fig. 2). Hence the prime roots are surrounded by individual epithelial follicles at their deeper extremities, but the outer portions of the roots are more compactly wedged into a common follicle, and by this mechanical arrangement are firmly fixed in the prime pelt.

The Relationship of Unprimeness to moulting.

The pelt of the Muskrat consists of two kinds of hair; a soft thick hair comprising the under-fur, and a longer, stouter hair, which overlies the fur hair, individually called guard-hairs, and collectively the protective hair, which as its name implies, protects but also prevents matting of the under-fur.

Examination of the flesh side of an Autumn pelt, taken about October 1st, will show the belly and ventro-lateral regions to be prime, but there may be large blue unprime areas in the region of the neck, around the root of the tail and scattered irregularly along the dorso-lateral areas. On examining the fur, the guard-hairs may be found to be plentiful and the

under fur dense in the belly region of the pelt, but on the dorsal region, the guard-hairs may appear relatively long, owing to the fact that the under-fur here has not attained its full length.

A fully prime pelt, taken in the latter part of March, while at the peak of primeness, shows the optimum conditions of sheen, colour texture and density of fur; and shows a fleshy side of the leather devoid of pigmentation. This is the period when the pelt is at the apex of condition and from this time on it usually declines in colour, sheen, etc.

A Spring Pelt shows the presence of the initial stages of moulting. Here the guard-hairs are beginning to shed, especially from the belly region. An examination of the leather side, however, shows no sign, as yet of pigmentation, but does show a marked change in colour from a bloody or fleshy colour, as seen in Autumn and Winter, to a whitish colour. This is due to a decreased vascularity accompanied by a deposition of fat on the dermal and fascial sides of the P. cornosus muscle.

Pelts taken in the early summer show a slight amount of matting, especially in those regions from which the old guard-hairs have completely disappeared, and in which the young ingrowing guard-hairs are not as yet very long. Thus the under fur constitutes the main portion of the coat of the animal at this season in which the guard-hairs are noticeably absent. But here there is also evidence of the initial stages of shedding of the under-fur in the ventral regions. The flesh side of the leather at this season shows a dense pig-

mentation due to the presence of heavy deposits of melanin in the roots of the young ingrowing hairs. The pigmentation which at this time is most dense in the ventral region and least along the mid-dorsal line,(Plate VII), owing to the ingrowth of young under-fur hairs, as well as the guard-hairs, reaches a maximum concentration first in the ventral portions of the pelt.

An examination of a pelt later in the summer shows evidence of moulting as before, but not in the same regions. Now, the shedding process is confined more to the sides and back of the animal and is that of the under-fur from these regions. In the ventral regions the young guard-hairs are in evidence and so is the short under-fur of the new coat.

In conclusion, to summarise the information available concerning the relationship between moulting and unprimeness, and the new growth of fur. It is quite evident that the shedding process does not take place simultaneously in the guard-hairs and under-fur, nor does it occur uniformly throughout the different regions of the surface of the body, but takes place over the various body areas at different intervals of the moulting season, following a definite sequence, namely:

(1) First the guard-hairs are shed from the ventral regions of the body surface, and then the underfur. This process, in this order, then spreads to the lateral and finally into the dorsal areas of the trunk of the animal.

(2) First to appear in the new coat are the guard-hairs in the ventral region, then the under fur. Thus it is evident the undergrowth of the new coat follows the sequence of the moult.

(3) The last place to become fully furred is the dorsal

portion of the body surface - and here first the guard hairs and later the under-fur grow into the new coat.

Thus nature has provided that the animal should have an adequate coat of fur and at no time to be completely devoid of protection, whether it be from the rigors of winter or the heat and actinic rays of summer.

But what are the normal factors taking part in the process of anchoring the hairs in the dermis of a pelt and what changes are effected in these during the shedding process?

Microscopical examination shows the following structural characteristics which play an important part in anchoring the hairs.

(1) The hairs grow in groups with their roots embedded in the deeper portion of the dermis in a mass of loosely bound epithelial tissues, which constitute the inner root sheath in this area, but on examination of a cross-section of a group of hairs near the epidermis we see that the connective tissue surrounding such groups of hairs,(Plate IV) has become compressed into a definite sheath of smaller diameter. The resulting effect of this structural arrangement is clearly evident (Plate II) namely:- that the group of hairs forms a pyramidal cone with the upper small end of the cone bound tightly by a definite sheath of connective tissue, while the deeper bulbous ends are loosely embedded and somewhat spread out to form the wider base of the pyramid. Hence any tendency to pull the hairs out only wedges the broad end of the pyramid more tightly into the sheath near the apex of the pyramid.

(2) Each individual hair has a bulbous root of greater

diameter that the surrounding follicle, so a resistance is offered to any force tending to pull the root-bulb outwards; just as the bulbous end of an onion offers resistance to its being pulled from the soil.

(3) In the process of hair formation a single layer of the corneum or shingle-like scaly cells covering the external surface of the skin, continues down into the hair follicle and forms the innermost layer of the inner follicular cont.

These cells are arranged like shingles with the projecting edges directed downwards, but when the base of the follicle is reached they turn upward again and form the cuticular or outer layer of the hair-roots, with the projecting edges directed upwards. So as the inner layer of the follicle and outer cuticular layer of the hair are squeezed together, near the apex of the pyramid, these oppositely directed shingle-like cells interlock and offer resistance to any outward passage of the hairs.

(4) Another characteristic of importance is the direct attachment of the root to the underlying tissues, which can be shown to vary in its different phases. The unprime root has a cup-shaped ampulla over the root papilla, but when the hair reaches maturity or primeness, absorption and atrophy takes place above the papilla when the resulting decrease in its calibre and pigmentation. The root bulb then shows a frayed end which is, however, firmly attached to the surrounding epithelium; the bulb then begins to migrate outwards and assumes a more erect position and owing to the mechanical arrangement previously described plus the direct attachment, it remains firmly wedged in the skin, until the direct connection is severed as

it nears the external surface. Then, if the old hair is not forcibly pulled out by external friction it is pushed out by the young ingrowing pigmented hair which arises beneath it from the original papilla. Thus the shedding process is accompanied by the growth of the new coat, but during this period the pelt is unprime and microscopic examination shows pigment in the young bulbous hairs.

The Sequence of Primeness and the Seasonal Changes in the appearance of the Leather.

From a study of pelts taken at different seasons of the year and studied in conjunction with the shedding process and ingrowth of new hair, it becomes evident that the order of priming follows the same sequence as the ingrowth of the new fur, only at a slightly later date. Thus we see primeness appears first in the ventral region around the forelimbs, thence extending posteriorly over the thorax, abdomen and lastly into the perineum. From the former areas it then extends up, each side of the body surface later over the thoracic and lumbar regions and finally above the root of the tail and dorsal surface of the neck.

But since the dorsal surface is the chief criterion of beauty and perfection in a fur it is very essential that the pelt be taken when it is in its optimum condition, a condition found to coincide with primeness or depigmentation in the underlying leather of the pelt. It is evident that if an animal is found to be prime in the dorsal regions, then the rest of the pelt must be prime. A knowledge of the order of priming is therefore important in the detection of unprimeness in the living animal.

The seasonal changes in the character of the fleshy side of a pelt vary according to the season in which the animal is pelted. The fleshy side of an autumn and winter pelt is red in colour owing to the presence of a copious blood supply to the panniculus carneous muscle and underlying connective tissue, but the fleshy appearance gives place to

a blue black pigmentation, limited to several large well defined unprime areas in the lateral and dorsal regions, especially evident in the skin from the back of the neck, along the mid-dorsal line and above the root of the tail. These are the last areas to become prime and may even show evidence of pigment in late winter Muskrat pelts, but have usually reached the prime state by the end of March or April.

When animals are trapped in the late Spring of the year, the colour is seen to be changing from red to a white ~~colour~~, owing to the diminishing blood supply to the pelt, and the deposition of fat in the skin. Although the guard-hairs at this season pull out more easily, there is as yet no sign of pigmentation in the leather. Later in the spring the pelt becomes dark red and feels thick, greasy and board-like on the leather side when eased, and the fur is found to be scanty in amount. This type of pelt is known in the fur trade as "Springy".

Finally, if we examine pelts taken in mid-summer, they are found to be blue on the ventral surface owing to the very dense pigmentation of the roots of the new ingrowing young hairs. At this season the densest pigmentation is seen in the ventral areas of the pelt. The initial stages of pigmentation are seen in the shoulder areas, thence extending posteriorly along the ventro-lateral aspects of the thorax, abdomen and covering the perineum, (Plates VII). At a slightly later period of the summer this black coloration is visible on the sides and back on the body surface, but unlike the autumn condition, the pigmentation is speckled over

this region. (Plate VI).

Muskrat pelts taken in June and July are densely pigmented throughout the whole skin or may show the first stages of primeness along the ventral regions. Thus a pelt may be valuated by the coloration of the leather, since this is merely an expression of the phenomena taking place in the fur and therefore is indicative of its condition.

The Detection of Primeness or Unprimeness in the Living Animal.

The principle of this test is based upon the facts derived from the microscopic study of prime and unprime sections. Primeness or unprimeness, as designated by the fur graders, from inspection of the fleshy side of the pelt, is fundamentally dependent upon the distribution of the pigment in the roots of the hair and the condition of the fur is dependent on the latter. Thus primeness is a function of optimum coloration, sheen, length of fur and density, etc. The different areas of the skin surface of an animal however, become prime at different times and remain at the peak of condition over a short period of the season. The order of priming in a pelt is as follows:

1st. the Ventral regions.
2nd. the Lateral regions.
3rd. the Dorsal regions.

The last portions of the dorsal area to become prime are the portions at the back of the neck and just anterior to the root of the tail.

It has been pointed out that the guard-hairs in the new coat appear first and the under-fur comes later, so that the last fur in the Muskrat to become prime is the under-fur of these dorsal regions.

Now, if reference be made to the horizontal section (Plate I), which was taken from a winter Muskrat pelt at the junction of an unprime portion with the surrounding prime skin, it will be obvious that to the left (L) the heavily

pigmented roots of the guard and under-fur hairs are visible. (Unprime area). On the right at (R) there is no visible evidence of pigmentation in the roots. (Prime area). At X X) there is a rather sudden transitional area in which some of the roots show definite signs of undergoing a depigmentation process, that is, the melanin granules are less densely aggregated in the roots. Thus it would be possible to detect primeness from unprimeness if the hairs with the roots could be extracted, but this is impossible. Also, if this were possible, it would only injure and excite the living animal.

However, a study of vertical sections and especially by examining the hair-side of the pelt with a dissecting microscope, will show that the depigmentation process of the root does not stop at the level of the epidermis, but is continued out into the hair to a variable extent in different animals, (Fig. 1). If the hair be examined a short distance out from the epidermis the pigmentation is seen to return, at first in small irregular groups of melanin granules in the medulla, but which soon assume the characteristically blocked arrangement common to the outer portions of all the under-fur hairs.

Thus the detection of prime from unprime portions of a pelt simply requires samples of under-fur hairs cut close to the skin, and the examination of the root-ends of these with a low powered microscope. Here (Figs. 14, 16) the hair from the unprime pelt shows pigmentation of a heavy blocked type extending down to the cut end, while the hair from a prime pelt shows as a clear hyaline structure, devoid of pigmentation for a variable distance from the cut end, (Figs. 15,13).

The difference is very obvious in hairs derived from prime and unprime areas of a pelt.

Another factor which helps to make the test accurate is that the last stages of unprimeness in the Muskrat and Silver Fox, are seen as well defined patches of pigmentation, the line of demarcation between prime and unprime areas being narrow and thus the test is positive or negative, owing to the absence of gradation in the depigmentation process. (See width of transition X X Plate II).

Practical Technique.

(1) The animal is held while the fur in the region of the back of the neck is blown apart and then held so by the fingers. By means of a straight-edge safety razor a small lock of under-fur is shaved off close to the skin. The lock is picked up with forceps just behind the former point of attachment to the skin, so that the ends of the hair are held together. The lock is then drawn through 95% per cent alcohol which being miscible with the oily surfaces of the hairs, binds them into a small wet tuft. This tuft is placed on a microscopic slide and a long-cover-glass is lowered over it. Now owing to the capillary attraction, the cover-glass is pulled towards the slide, with the result that the root ends of the hairs are spread out like fingers and thus are most conveniently examined.

(2) This method is repeated with samples taken from both sides of the mid-dorsal line and finally from the region anterior to the root of the tail, and from the study of the sequence of primeness it is evident if the samples taken from

these areas are prime, the rest of the pelt is already prime.

In obtaining the samples it is very important to have a sharp safety razor and to shave or scrape off the hair at the epidermal boundary. The epidermal cells (dandruff) are often seen in the sample and are useful in that, frequently the hair can be seen entering these scales. Thus, the use of such hairs as indicators, eliminates any source of error due to faulty technique.

Thus the distribution of the pigment in the hairs serves as an exact external indicator of the condition of the skin in estimating the relative primeness of different animals which may show wide variation in time of reaching the peak of primeness, due to age, sickness, or other natural causes. Again, the test is simple, quick and accurate, causing no pain to the animal, nor injury to the pelt, and requires only a razor and low-power microscope. It is applicable to all fur-bearing animals except Albinos, but probably lends itself to more practical use in the Mink, Silver, Blue and Red Fox industries.

Discussion:

It is evident from the histological examination of pelts taken at different seasons of the year, that many features such as unprimeness or pigmentation in the leather, clear unpigmented prime pelts, shedding of the fur, etc., are merely the outward expression of the hair and its roots during the different phases of its life cycle. Pigmentation is present in the actively growing young hairs which are in direct communication with the vascular papillae while primeness is associated

with depigmentation in the root and hair shaft, in the latter to a variable distance in different animals. This blanching process is probably seen in its most exaggerated form in such animals as the Varying Hare, Jack Rabbit, Weasel and Arctic White Fox, in which primeness means, not only depigmentation of the root and proximal part of the hair, but also of the outer hair shaft.

This view would account for most of the facts put forward in a recent paper on colour change in Lepus americanus (Hadwen, 1929) which states: "Probably the most convincing proof that the change takes place in existing hairs is to be found in the skin itself when the hair roots are examined. The fact that the roots cease to function as the hair turns white, and that it is a progressive change, offers conclusive evidence that the alteration is destructive.

We cannot agree with the view that seasonal colour change in Rabbits, etc., is consequent upon a depigmentation process in the roots, since it is evident from the study of primeness in other coloured fur-bearing animals, such as the Muskrat, that the roots here also become depigmented when the prime state is reached, without the outer fur blanching. Hence we suggest that the seasonal depigmentation with the consequent colour change is merely an exaggerated state of the priming process which occurs annually in all fur-bearing animals to a variable but lesser extent, (excluding albinos).

The shedding process has been discussed somewhat in detail, because so many different statements are offered by various authors and fur ranchers with regard to the frequency and season of the year that fur-bearing animals shed their coat.

Probably much of the confusion is due to the animals showing more definite signs of shedding at certain phases of the sequence of this process, which therefore has led to many wrongly based conclusions as to the number of moults and the season of the year in which they take place.

In view of the great importance attributed to primeness not only in the grading of furs from the aspect of their consequent money value, durability and beauty, but from the stress laid upon this condition in the legal interpretation of certain clauses of the Game Act, a clear and definite standard of what constitutes primeness and unprimeness seems of due importance. The impression that the hairs pull out more easily from an unprime than from a prime pelt is a mistaken interpretation of the facts, although it is stated thus by most fur men. From the study of the relationship of shedding to unprimeness in pelts, it is evident that young or pigmented hairs are present where shedding is in progress, and it has been wrongly supposed that these are the hairs that come out more readily. On the other hand, as is seen in the microscopic sections of unprime skin, these hairs are more deeply embedded in the dermis and exhibit a definite ampulla firmly attached to the root papilla which anchors them even more firmly in the skin than the prime hairs, which have partly lost this attachment. The hairs which pull out more easily represent a remnant of the former coat which is in the process of shedding in this unprime area.

A defect which cannot wholly be attributed to unprimeness, is that often when unprime pelts have passed through the

tanning and dressing processes, the hairs seem to be projecting from the flesh side of the leather. This may be the result of two features of improper handling.

Firstly, if in the scraping, the P. carnosus muscle is detached from the skin (XX Fig. 6) and partly or wholly removed; then, since the hair roots are embedded in the deepest part of the dermis in an unprime pelt, and when in the tanning process the fat in the deepest layer of the dermis is dissolved away from around the roots, they become exposed and project upon the inner surface of the leather (Plate V and Figs. 7,8).

The other feature which may cause a similar condition is the "fleshing process". Since the roots of the hair are so near the inner surface of the leather in the unprime pelt they are often cut off in this process and owing to the serrate edges of the hair cuticle which project towards the external surface thus causing the hairs to work towards the inner side of the leather when the pelt is subjected to the further manipulation necessary in the dressing process.

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PLATES.

I. A horizontal section of Muskrat pelt from the junction of prime and unprime areas. x 60.

II. A Vertical section of prime Muskrat pelt. x 65.

III. A vertical section of unprime Muskrat pelt. x 65.

IV. An oblique section, showing the relative dispersion of the hair roots. x 65.

V. A vertical section of unprime skunk skin with the Fanniculus carnosus muscle absent. x 60.

VI. A late spring pelt with dense pigmentation in the ventral area and the initial stages of unprimeness showing as irregular patches on the dorsal surface.

VII. A late spring pelt showing pigmentation in the ~~initial~~ ventral portion while the dorsal region is still prime.

FIGURES.

1. A diagram to illustrate the relative distribution of the pigment in prime and unprime conditions.

2. A typical group of prime hairs with its arrector pili muscle. x 98.

3. A prime Guard-hair root. x.210.

4. An unprime guard-hair root. x. 180

5. Microphotograph of unprime Muskrat pelt, showing the break between the F. carnosus muscle and dermis.

6. Microph. similar to Fig. 5, but the hair roots are covered by a layer of connective tissue.

7. Microph. of a Muskrat pelt without the F.carnosus muscle.

8. Microph. of a skunk pelt without the F. carnosus muscle.

9. Microph. of pigmented young hair-roots.

Figures, (2).

10. Microph. of hair-roots in Autumn, undergoing depigmentation.

11. Microph. showing the arrangement of pigmented hair-roots in unprime Muskrat pelt.

12. Microph. of the Panniculus carnosus muscle, and fascia which attaches the pelt to the body musculature.

13. H.F. microph. of the proximal ends of unprime hairs.

14. H.F. microph. of the proximal ends of prime hairs.

15. L.F. microph. of the proximal ends of unprime hairs.

16. L.F. microph. of the proximal ends of prime hairs.

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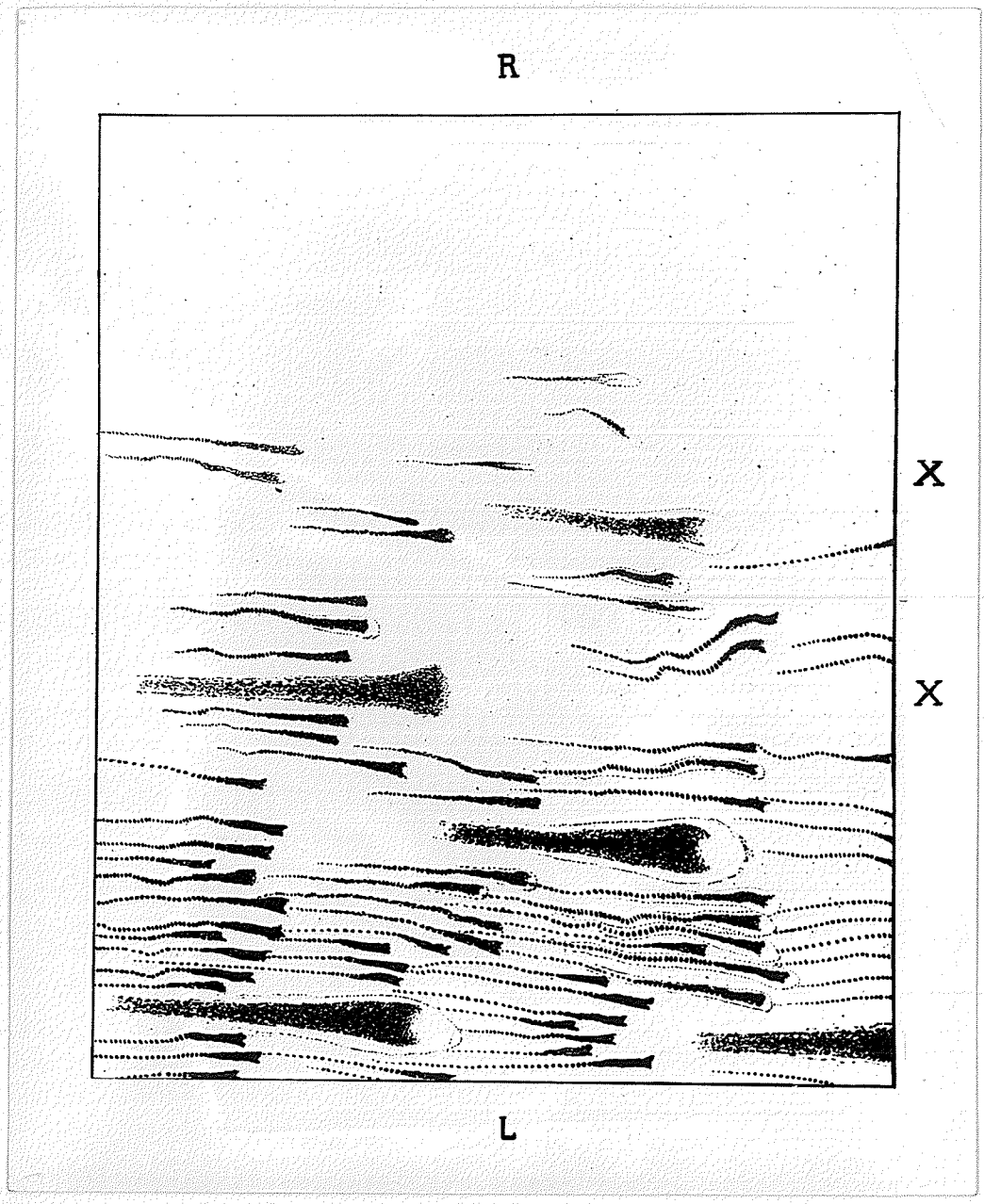

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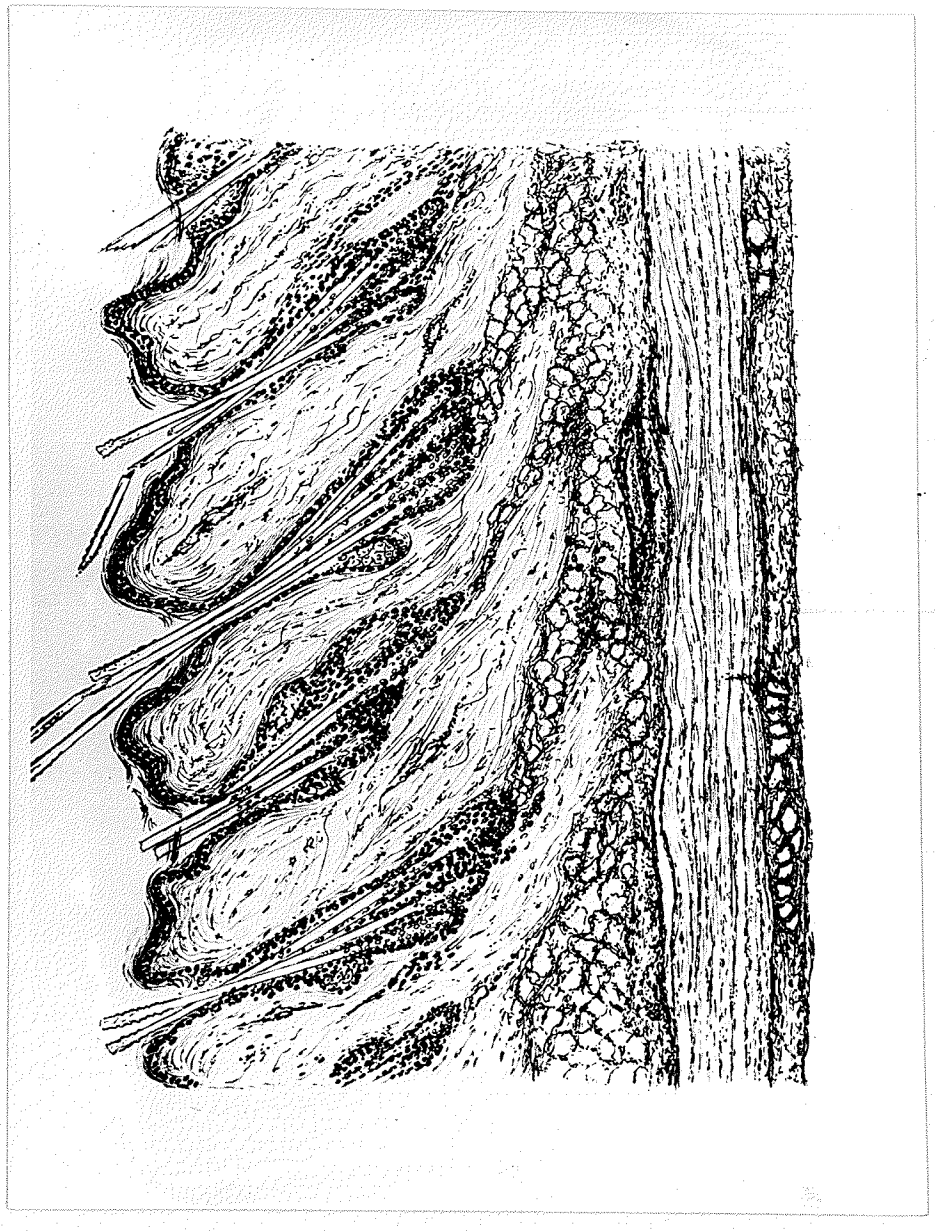

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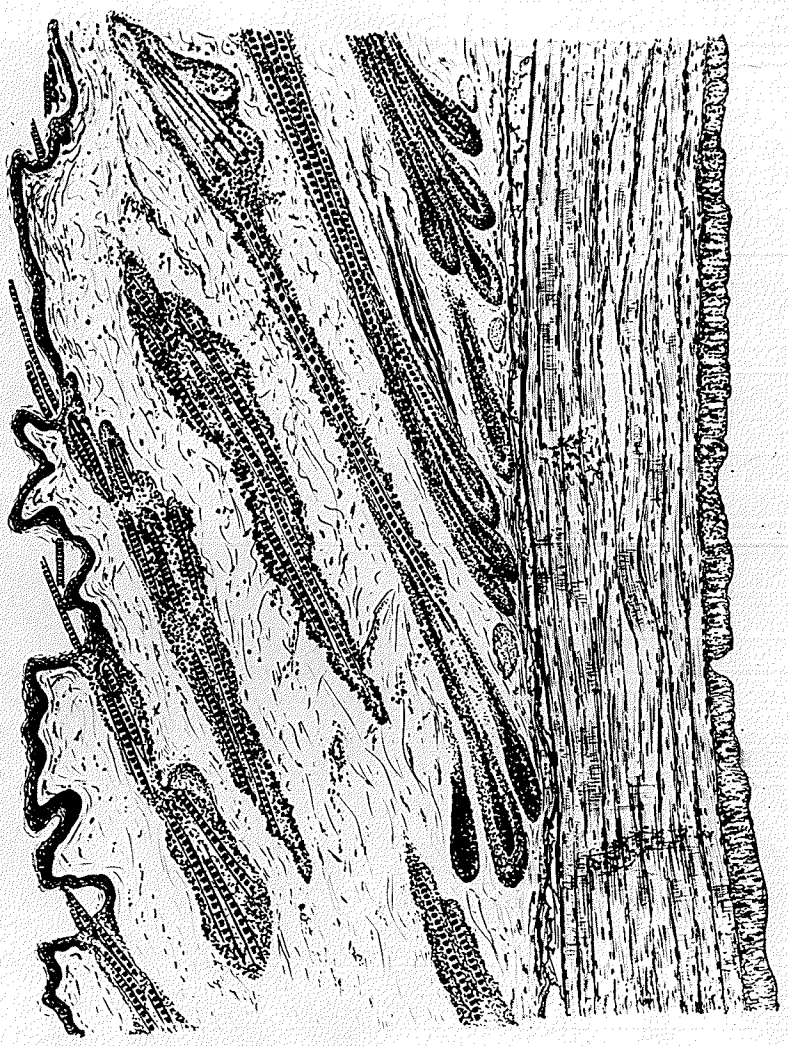

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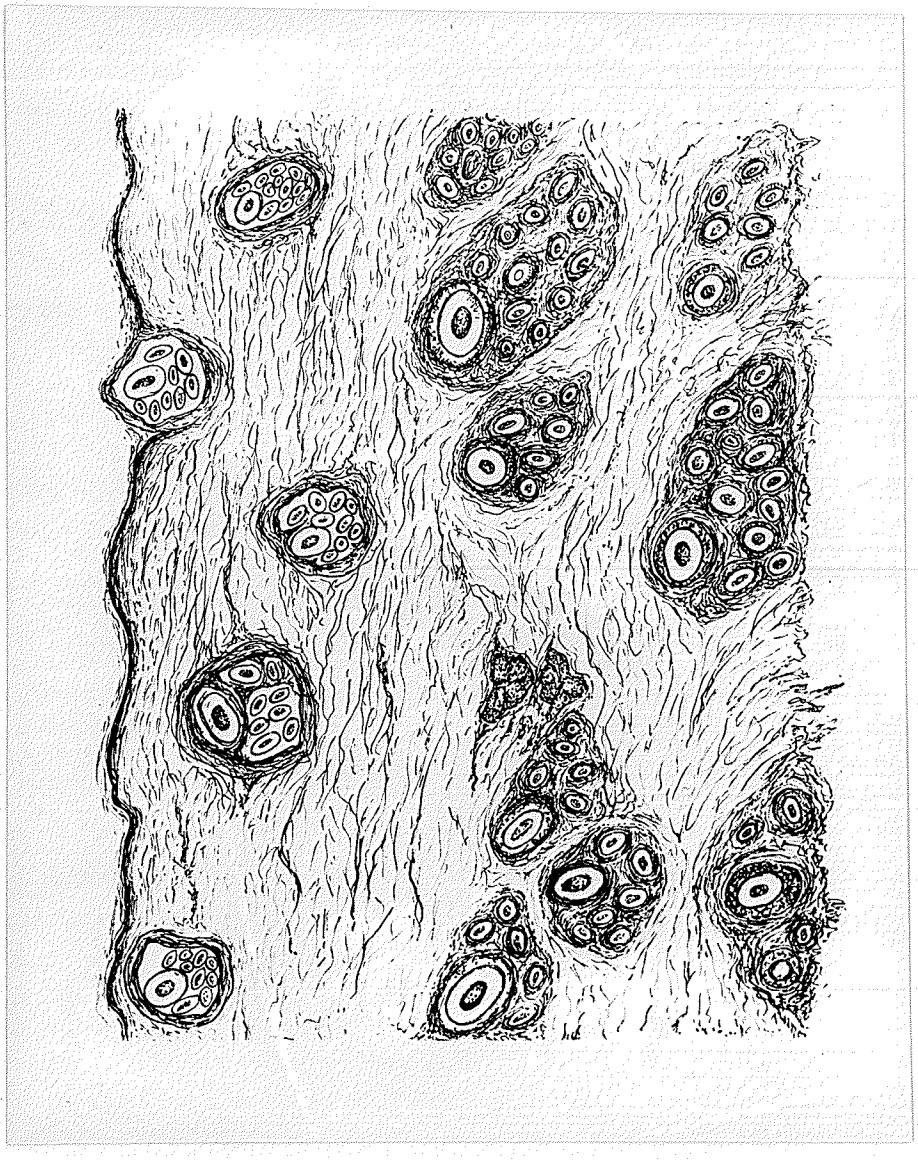

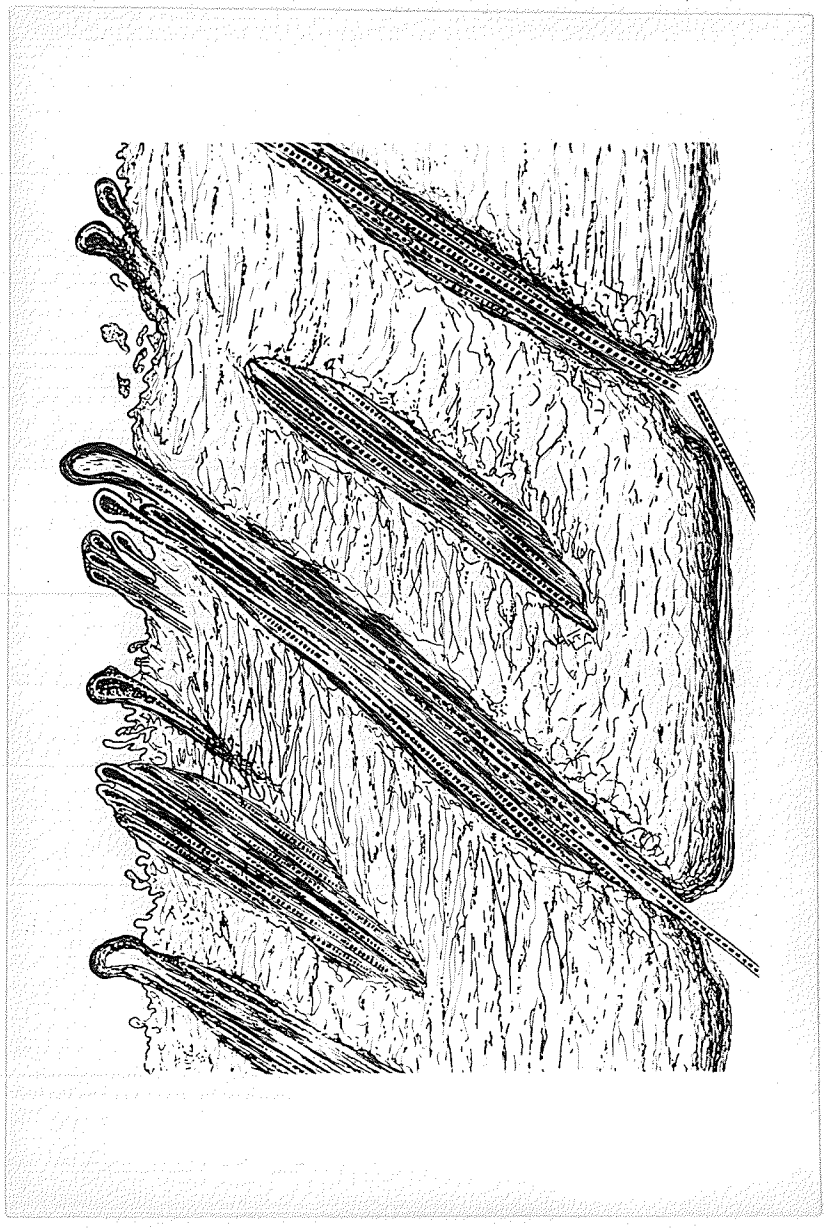

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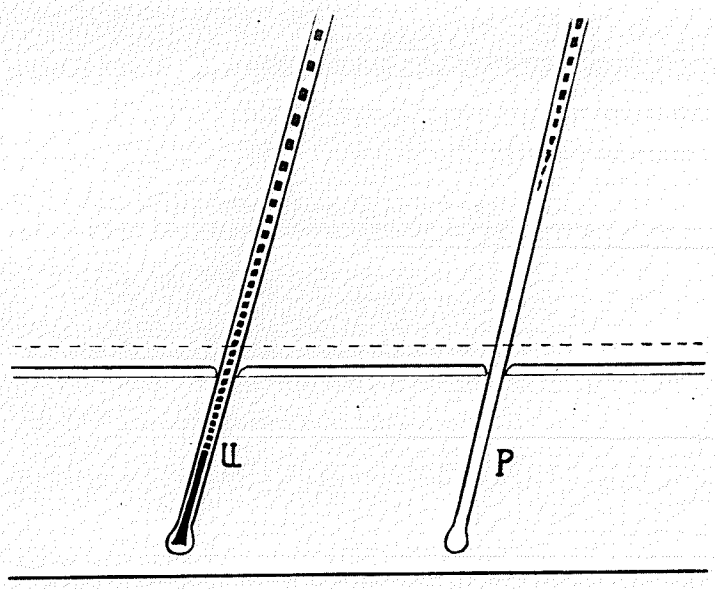

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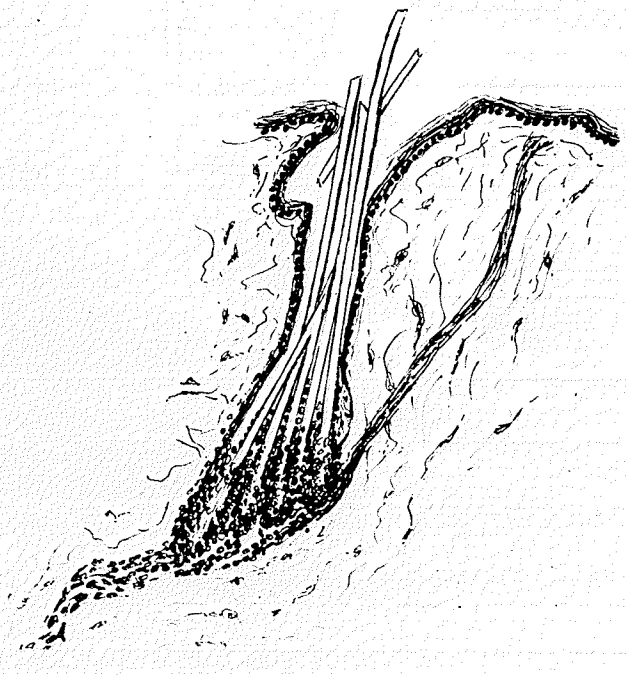

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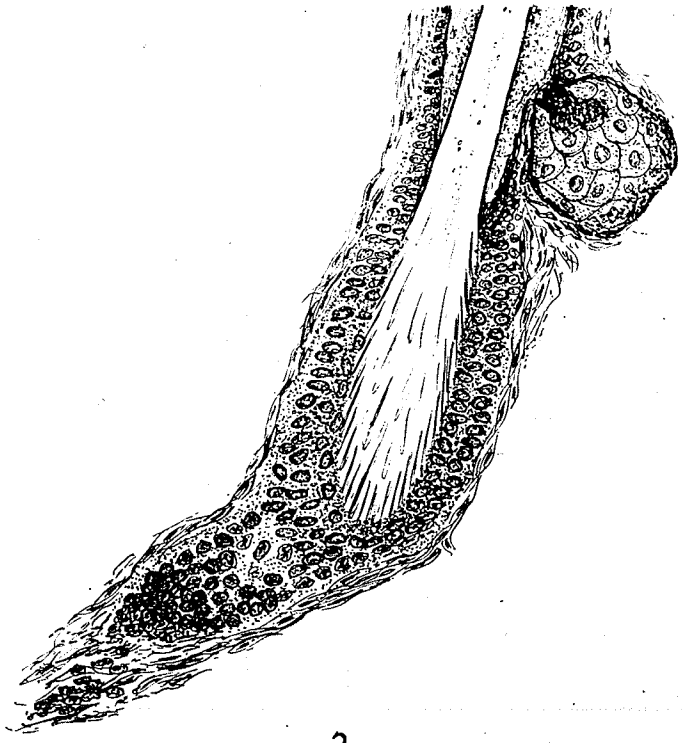

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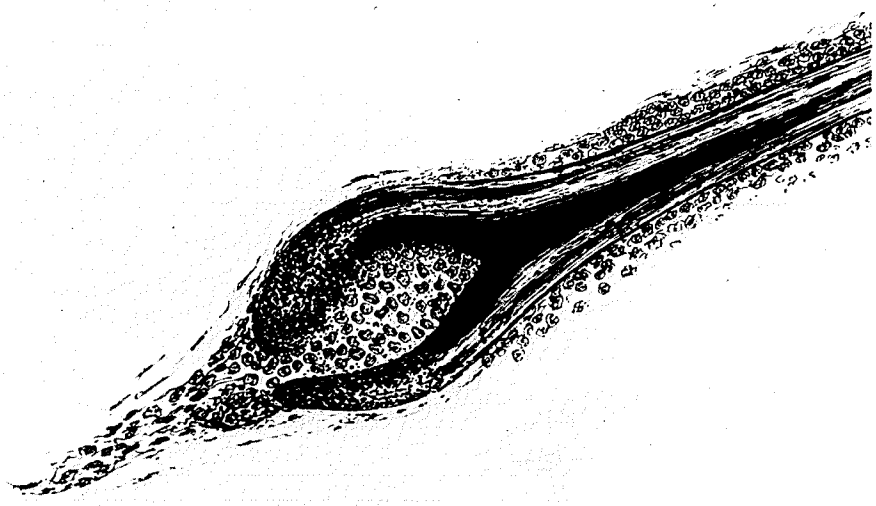

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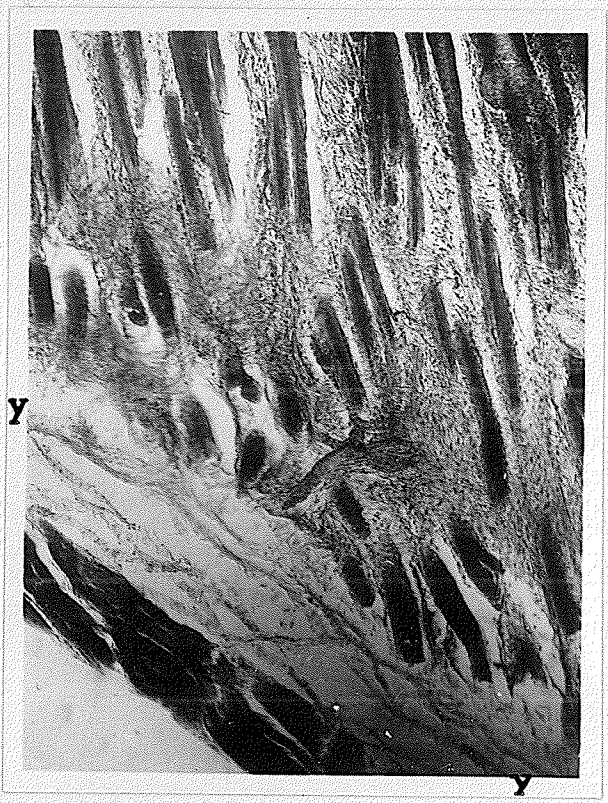

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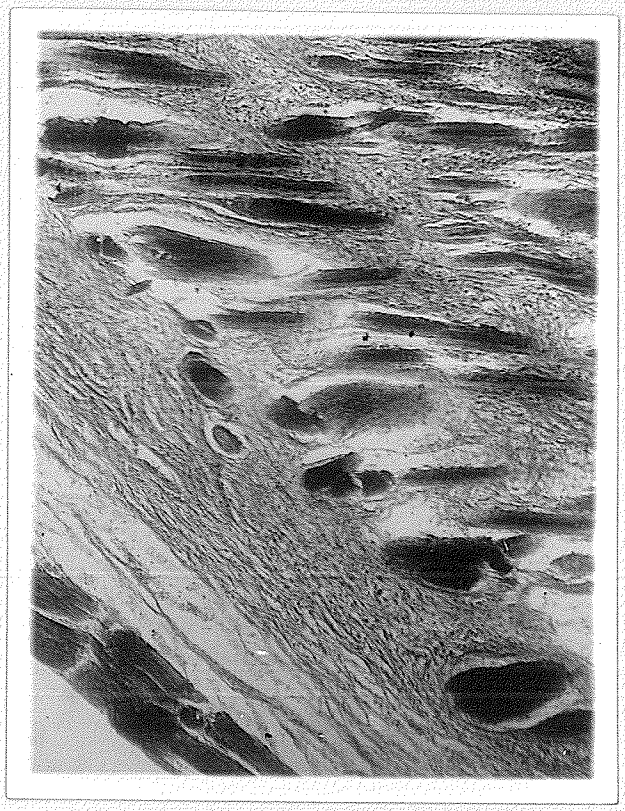

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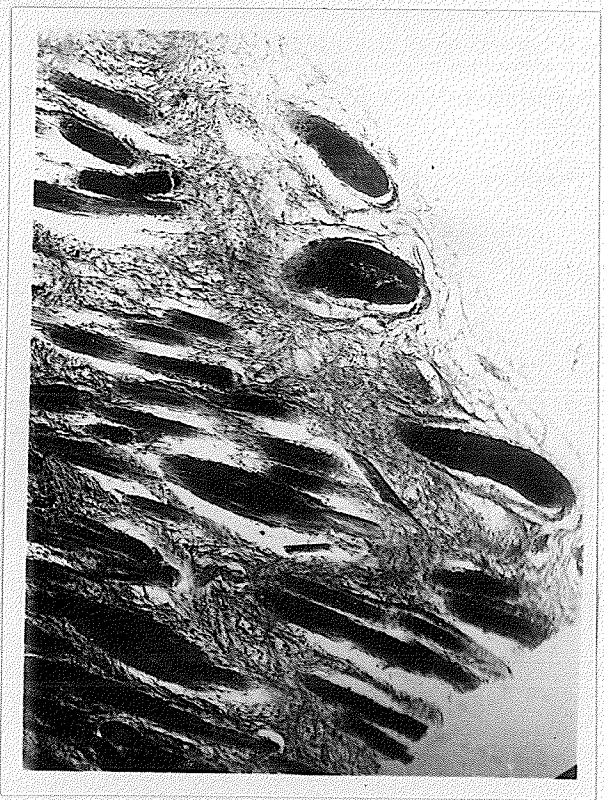

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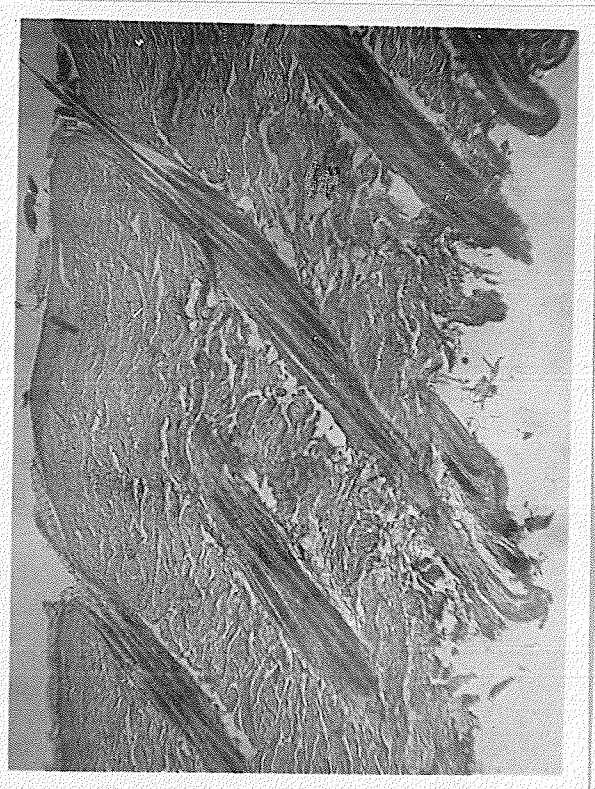

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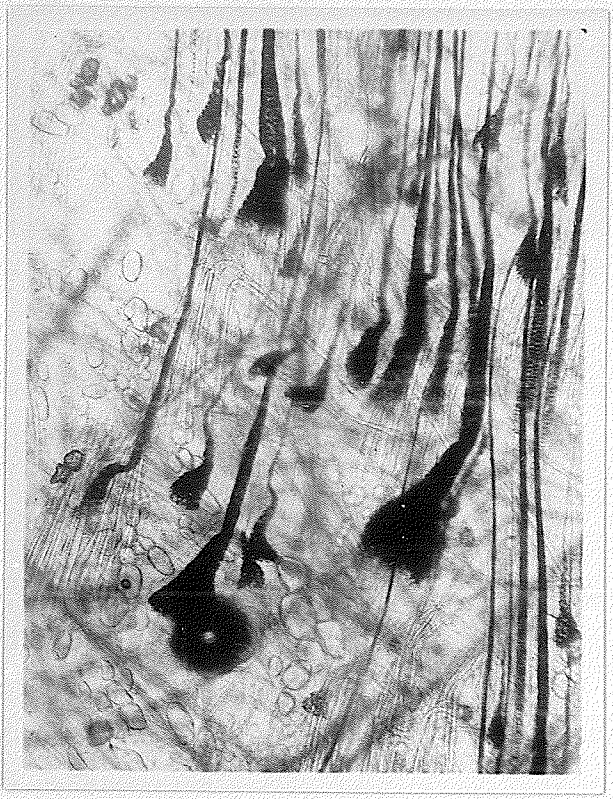

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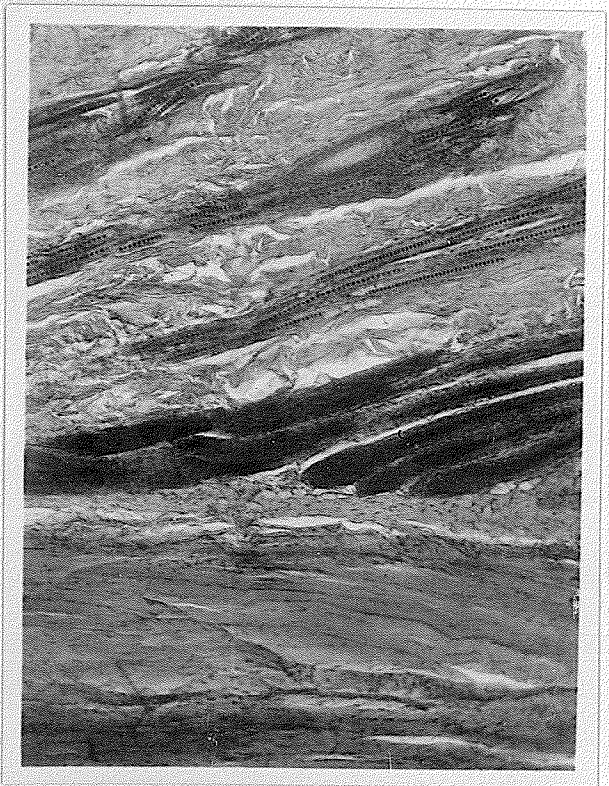

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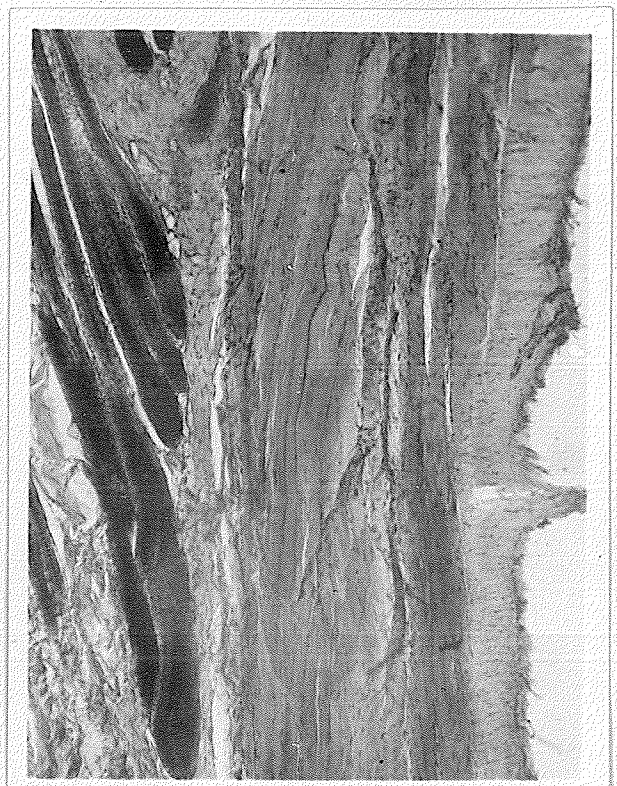

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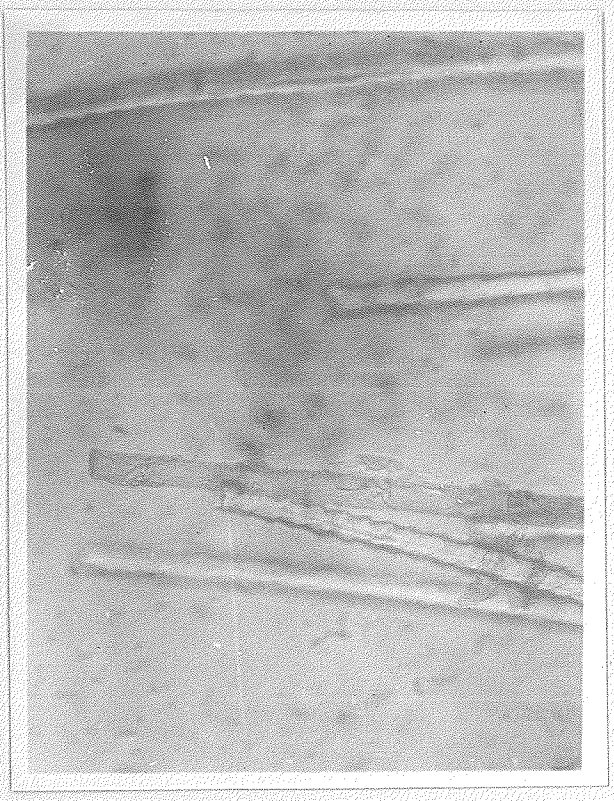

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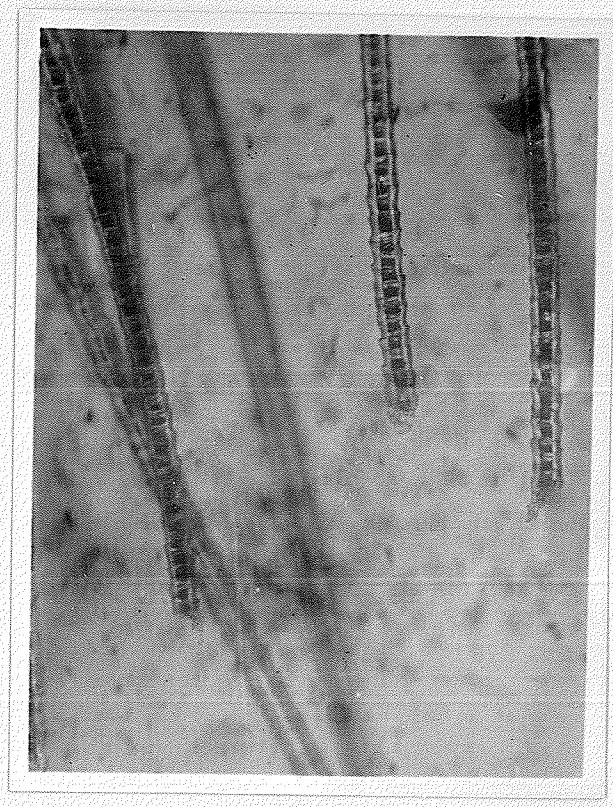

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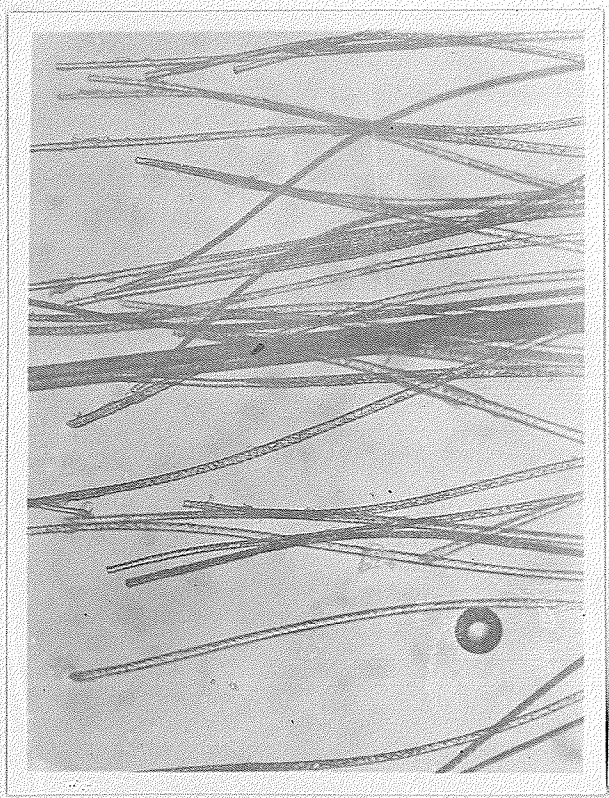

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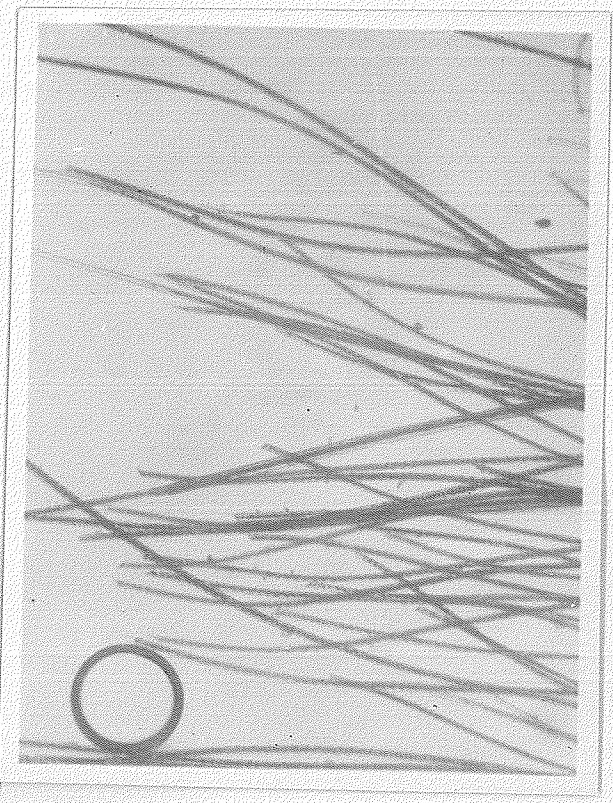

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