中國豬皮組織學彩色圖譜

HISTOLOGICAL ATLAS OF CHINESE PIGSKIN IN COLOUR

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前　言

我國從50年代初期開始利用豬皮製革以來迄今已有30餘年的歷史，豬皮現已成爲我國製革用主要原料皮，目前正向製造更多更好的高檔豬輕革方向發展。了解豬皮組織構造特點及其在製革主要工序的組織結構變化情況，對製訂合理的工藝方案，充分利用我國豬皮資源製造高檔產品是十分必要的。爲此，我們特將成都科技大學皮革組織學研究室30餘年來在豬皮組織學方面的研究成果系統整理，編著了這本豬皮組織學彩色圖譜。

本圖譜共附有豬原料皮及浸灰、軟化、鞣製等主要工序組織結構的彩色圖片及電鏡圖片共約200幅，每幅圖片均附有簡要的中英文字說明，直觀易懂，既可供製革、畜牧及生物研究工作者、工程技術人員及技術工人閱讀，也可作爲有關高校及中等專業學校的參考資料。

本書英語部份承華西醫科大學外語系許南姓教授編審，出版過程中承中國大地出版社及香港李先連國際有限公司總經理蔡維榮先生大力支持，使本書得以及早問世，在此，謹向以上單位和個人表示衷心感謝！

1989 年 8 月於成都　作者

Preface

We have had a history of pigskin leather industry of more than three decades since the first use of Chinese pigskin for the manufacture of leather in the country in the 1950s. Pigskin has now become a main source of raw skins in the domestic leather industry, in which the present trend is to develop pigskin leather greater in quantity and better in quality. So, to realize such an aim, it is necessary to know and study the histology of Chinese pigskin and the conditional changes in the skin in some key procedures during processing. Without such scientific knowledge rational schemes in technical processes are imposible and full exploitation of the nation's rich pigskin resources cannot rapidly be achieved.

Here is our presentation of the book, a collection of colour micrographs of Chinese pigskin tissue structure, for our technicians, manufacturers, and scientists, dealing with leather technology. The work, it is hoped, will provide them with needy useful reference in the professional field. It goes without saying that the material will also be valuable as a complement to relevant textbooks for technical schools and colleges at home and abroad.

The illustrative plates sorted out from the numerous samples collected by Leather Histological Laboratory of Leather Research Institute, Chengdu University of Science and Technology, in the past thirty years or more, are direct and comprehensible in showing the tissue structure of Chinese pigskin in some important processing stages, such as liming, bating, tanning, as well as in raw skin and finished products, each plate with explanation in both Chinese and English attached to it. The number of figures amounts to 198, systmatically arranged for easy reference.

Lastly we should like to acknowledge the indispensable helps and supports extended to us during the prepartion and publication of this book by our colleagues and friends with many thanks; and to express our gratitude especially to professor Xu Nan Shen of Department of Foreign Languages, West China University of Medical Sciences for his hard work in compiling the English text of this Atlas, the staff of China Da Di press, Beijing, and Mr. Cai Wei Rong of EVEN LEE International Co., Ltd. Hong kong Without their assistance and enthusiasn the Atlas might not have been able to be issued on time with satisfaction.

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The Authors

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豬皮的組織構造特徵概述

我國是世界上豬皮資源最爲豐富的國家，豬皮是我國製革工業中最主要的原料皮。我國幅員廣闊，豬種甚多，近年來爲了滿足人民對肉食的需要，各地相繼發展了一些瘦肉型雜交豬。豬種不同，豬皮的組織構造略有差異，但其基本構造是相同的。了解豬皮組織構造特點，對改進豬皮製革工藝，提高產品質量及充分利用我國豬皮資源有着十分重要的作用。總的看來，豬皮有以下一些特徵。

一、脂肪組織

豬皮的脂肪組織發達，其皮下層幾乎全由脂肪細胞組成。這些發達的皮下脂肪細胞在毛根底部長入皮內，形成許多大小不一、高低不同、疏密各異的上小下大的圓形或橢圓形錐體，這種由脂肪細胞組成的錐體，我們稱之爲“脂肪錐”。除脂肪錐外，在眞皮的膠原纖維束之間還存在一些脂肪細胞，這種脂肪細胞稱之爲游離脂肪細胞。

脂肪錐嵌入眞皮內，當錐內的脂肪細胞除去後，豬皮肉面便會出現許多凹窩，俗稱“油窩”。針毛的毛根下段就長在脂肪錐內，此外，脂肪錐內還有汗腺和血管等。

豬皮汗腺的分泌管長在脂肪錐內，而其排汗的細長導管則長在膠原纖維束中，故汗腺對豬皮的强度影響不大。

豬皮脂肪錐的大小、高低、疏密隨部位不同而異，例如：臀部的脂肪錐長得高而小，並且密集，所以，這個部位的油窩多而深，有的深度竟達皮厚的$\frac{1}{2}$；而腹部和頸部的脂肪錐卻長得大、淺、少，其深度僅爲皮厚的$\frac{1}{3}$或更少。由於油窩深淺不同，它們對豬皮的脫脂和脫毛關係極大。例如：用機械刮油時，臀部因油窩深，油脂不易刮淨，脫毛時，脫毛劑往往從肉面透入，它們要穿過或破壞脂肪錐內很厚的脂肪細胞層才能達到毛根，然後才能削弱和破壞毛囊與毛根的聯系使毛根鬆動，再經機械作用即行脫落，油窩淺的腹肷部，窩內的油脂較易刮淨，脫毛劑能較快到達毛根，所以，腹肷部的毛常較臀部的毛容易脫落。

豬皮中的游離脂肪細胞一般分佈在膠原纖維束之間和毛囊周圍，以頸部和腹部較多，臀部極少；同一部位中，以眞皮上層最少，下層較多。豬種不同略有差異，如四川資中豬皮頸部及腹部分佈有較多的游離脂肪細胞，而臀部則沒有；上海豬皮除頸部及腹部長有較多的游離脂肪細胞外，臀部也有少量這類細胞。眞皮內的這些游離脂肪細胞是不能用機械方法除去的，在生產過程中，只有當這些脂肪細胞受到擠壓及摩擦等作用，破壞其細胞膜，使其內的油脂溢出，化學藥劑與脫脂劑才能與油脂作用而將皮內的油脂除去。

在毛囊中部還長着一至數個脂腺。脂腺分爲分泌部分（即腺體）和排泄部份（即導管），導管上端與毛囊相聯，腺體中充滿油脂的細胞成熟時，即解體而成分泌物，稱爲皮脂。皮脂沿導管流入毛囊，並從毛囊流到皮的表面，使表皮和毛幹得到滋潤。豬皮頸部的脂腺特別發達，尤其是在鬃毛的毛囊周圍，常長有數個巨大的脂腺把毛囊緊緊地包圍住，這些脂腺腺體之間有膠原纖維束和彈性纖維組成的分隔層把它們分開，當腺體破壞之後，這些分隔層仍然存在。

所以，在豬革生產中，脫脂極爲重要，應儘可能將油脂除去，否則，不但會影響染色，往往還會在成品上出現“浸油”現象。因此，既要加强機械作用以儘量除去皮下脂肪和油窩中的油脂，同時，還應採用機械作用和化學作用相結合的方法（如多工序分階段脫脂法）以除去皮內油脂及脂腺所分泌的油脂（即皮脂）。通常在脫脂工序中使用的純鹼只具有表面脫脂作用，故在復灰及軟化工序中尚可加入表面活性劑脫脂，必要時在浸酸、鉻鞣工序中還可再進行脫脂處理。

二、毛和毛囊的構造特徵

豬皮毛被稀疏，皮上有兩種毛，粗而長的稱針

毛，細而短的爲絨毛，針毛一般多以三根爲一組呈品字型排列，但也有兩根一組或單根的。絨毛則呈不規則的點狀排列。呈品字型排列的三根針毛的毛根集中長在一個脂肪錐內。這三根針毛長的深淺也不一樣，一般中間的一根最粗，毛根長得最深，且較傾斜（即毛與皮面的夾角小些），在頸部及腹部這種毛甚至伸出脂肪錐外而深達皮下脂肪層；旁邊的兩根毛一般都長在脂肪錐頂上，較細也較直豎些。頸部的針毛特別粗而長，稱爲“豬鬃”或“鬃毛”。豬鬃的經濟價值較高，通常由屠宰場拔下。

針毛在皮面的出口處呈喇叭型，俗稱“毛眼”或“毛孔”，毛孔一邊圓一邊稍尖，毛孔的深淺、大小、疏密都關係到粒面的粗細。頸部的毛孔特別粗大，所以，製成革後頸部比其它部位粗糙。

針毛從毛囊長出，毛囊分爲兩層，外層叫毛袋（即結締組織鞘），由膠原纖維束和彈性纖維構成；內層叫毛根鞘（簡稱毛鞘），由表皮細胞構成。毛根鞘又分爲兩層，內層是由表皮角質層衍生的，稱內毛鞘；外層是由表皮粘液層（即生發層）衍生的，稱外毛鞘。豬皮毛根鞘的厚度很不均勻，在毛根鞘下段（即脂腺以下）內毛鞘特別厚，因其系表皮角質層衍生的，故抗酸鹹能力較强，製革生產中如不將它除去，在成革的肉面會出現“糙手”的硬刺。

脫毛浸灰可以除去大部份毛根及毛根鞘，復灰及軟化又能進一步將它們除去，但要完全除淨是困難的，故成革中一般尚能見到少量殘存的毛根及毛根鞘。

毛袋的膠原纖維束細小，編織緻密，由膠原纖維束交織而成。由於毛袋是粒面衍生的，故毛袋的膠原纖維束與粒面的膠原纖維束粗細相同。在粒面以下，膠原纖維束逐漸變粗，因此，在磨去粒面製造正絨面革時，磨面深度應仔細掌握，如磨得過深，則磨後的革面上毛袋處的纖維細，毛袋以外的纖維粗，由於纖維粗細不同，便會顯“毛眼”。在磨肉面製造反絨面革時，在皮的同一深度，若毛袋以外的膠原纖維束分散不好，所起的絨毛與毛袋處絨毛的細度不一致，亦會顯“毛眼”。但毛袋的膠原纖維束也應分散好，否則難起絨或所起絨毛難以遮蓋住毛孔。

三、豬皮的肌肉組織

豬皮眞皮中的肌肉組織比較發達，每根針毛都具有多股豎毛肌，可能是由於豬毛粗大，要拉動這樣粗大的毛使之豎立，勢必需要比較粗壯發達的豎毛肌才行。豎毛肌是狹長的平滑肌，它的一端附着於毛囊下部，另一端伸向粒面。此外，還有一種肌肉，它平行於粒面，生長在稍高於豎毛肌與毛囊聯結處，這種肌肉暫稱爲“束毛肌”，它的兩端分別聯結在三根一組的旁邊兩根針毛的毛囊下部，把三根毛聯結起來。束毛肌的作用可能是當肌肉收縮時，豎毛肌從毛囊下部牽動針毛使之直豎，而束毛肌則將三根毛聚攏。在兩根及單根一組的針毛毛囊下部也長有這種特殊的肌肉——束毛肌。

豬皮的肌肉組織生長情況隨部位不同而異，頸部的豎毛肌及束毛肌較粗大也較多，腹部次之，臀部則較細較少。

由於豬皮內肌肉組織比較發達，可能還有加强豬皮强度的作用。在生產過程中，肌肉組織是不會被除去的，但要受到一定程度的分散，製造鞋面革時分散度較小，製造服裝革等軟革時分散度較大，明顯可見粗肌纖維分散爲細肌纖維，這對成品革的柔軟度可能有一定好處。

四、豬皮的彈性纖維

豬皮的彈性纖維呈沒有樹葉的樹枝狀，分佈於整個眞皮層，而不形成纖維束。以靠近粒面和靠近皮下層處較多，眞皮中層則較少。彈性纖維在豬皮各個部位的分佈情況也不相同，腹部及頸部分佈得多而密且較粗，這些部位的眞皮中層亦可見到較密集的彈性纖維交織成網。臀部的彈性纖維則較細小、稀少，且主要分佈在眞皮上層，而在眞皮中層及下層則極少。此外，毛囊周圍、豎毛肌上，毛囊底部、脂腺周圍及血管上也有密集的彈性纖維，但較細小。所以，豬皮中彈性蛋白含量較多，約爲皮重的2.1%。豬種不同，彈性蛋白含量略有差別。

彈性纖維有加强各種組織的作用，所以，過去有人認爲在製革生產過程中，適當削弱或破壞彈性纖維可以獲得柔軟的革，但據我們的研究，成革的柔軟度與皮內的彈性纖維破壞與否關係不大。例如豬正面革彈性纖維基本未被破壞，豬正面服裝革僅靠近粒面處的彈性纖維受到一定程度的破壞，皮內仍存在着大量

的彈性纖維，但有的彎曲變形或碎斷成節，而成革卻十分柔軟。

五、豬皮的膠原纖維與部位差別

豬皮也與其它家畜皮一樣，分爲三層：即表皮層、眞皮層和皮下組織層。

眞皮層主要由膠原纖維束編織而成。由於針毛長得較深，特別是腹部和頸部針毛往往貫穿整個眞皮層，故不能像牛皮那樣以針毛毛囊底部爲分界綫來劃分乳頭層和網狀層，但仍可根據皮中膠原纖維束的粗細和編織的緊密度而將豬皮的眞皮層分爲三層：眞皮上層（絨毛毛囊底部以上的區域），這層相當於乳頭層（即粒面層）；眞皮中層和眞皮下層，這兩層相當於網狀層。

眞皮上層的膠原纖維束細小，編織較疏鬆，織角低（即大多數膠原纖維束走向與皮面幾乎平行），生產中處理不當則豬革易在這層產生鬆面。眞皮中層膠原纖維束粗壯，互相交織很緊密，織角高，豬革之所以有較大强度主要是由這層決定的。眞皮下層膠原纖維束逐漸變細，編織也較眞皮中層疏鬆，織角較低，至近皮下組織層處膠原纖維束幾乎呈水平走向。由於針毛長得較深，加之毛根底部還有“油窩”，這就使得眞皮中層及下層的膠原纖維束還需繞過毛囊和油窩，而不能很好地連成一片，當毛和油窩內的脂肪在生產過程中被除去以後，肉面就會留下許多大小不同的空洞，越到眞皮下層空洞越大，所以，靠近豬皮肉面的剖層皮往往像一張魚網，這樣一來必然要大大影響成革的强度，這種剖層皮在製革工業上沒有什麼用處。

豬皮的粒面由一層厚約0.1—0.2毫米的細膠原纖維束緻密編織而成。粒面在有毛生長的地方長入眞皮內形成毛袋。粒面若被破壞，革面則無光澤。

豬皮粒面由於乳突高大、毛孔粗、皺紋深故顯得十分粗糙。豬種不同，粒面的粗糙程度差別較大，如丹麥長白豬的豬皮毛孔小、乳突低、皺紋淺、粒面則較細緻；四川內江豬、資中豬及成都豬的豬皮毛孔粗、乳突高大、皺紋深、粒面則粗糙；而長白豬和成都豬或內江豬雜交後的新品種豬的豬皮毛孔較小、乳突較低、皺紋較淺，粒面較細緻，這就爲製造高檔豬革提供了優質原料皮。

豬皮膠原纖維束的編織形式和緊密度隨部位不同而異，從縱向切片（即順毛生長方向垂直於皮面的切片）看，臀、腹、頸三個部位膠原纖維束均無一定織型，但臀部編織較頸部及腹部緊密，織角高；而頸部及腹部編織較疏鬆，織角也較低。從水平切片（即平行於皮面的切片）看，各部位眞皮上層的膠原纖維束仍無一定織型，而眞皮中層及下層則有一定規律，如臀部及皮心部膠原纖維束粗壯、筆直、呈十字型交織，編織十分緊密，所以，這些部位强度大、耐磨性高而延伸性小，在製革生產中不易變形。腹部膠原纖維束細小、彎曲、呈波型編織，且編織疏鬆，故腹部强度低而延伸率特大。頸肩部膠原纖維束編織的緊密度、粗細度都介於前二者之間，呈斜交型編織。尾根部膠原纖維束的粗細度和緊密度稍次於臀部，但交織複雜，是豬絨面革較難起絨的部位，不過這個部位所佔比例很小。

豬皮各部位除膠原纖維束的織型和緊密度不同外，各部位的厚度差別也相當大，同一張皮中，以臀部爲最厚，腹部最薄，最薄部位與最厚部位的厚度比稱爲部位之間的厚度差或稱爲部位差，四川內江豬皮的厚度差約爲1：5.1；成華豬皮約爲1：4.9。由此可見，同一張豬皮厚度差特別明顯，這樣大的差別必然會給加工生產帶來不少困難。所以，豬革生產中，一開始就應注意到消除或減輕部位差別，以便使製出的革整張軟硬程度接近一致。

實際上部位差別主要包括以上兩個方面，即膠原纖維束編織緊密度的差別和部位之間的厚度差別。不同豬種的豬皮部位差別也不同，如四川內江豬皮膠原纖維束粗壯，編織十分緊密；而丹麥長白豬皮膠原纖維束較細，編織不及內江豬皮緊密，其厚度差僅爲1：3.1；長白豬與內江豬雜交後的新品種豬的豬皮厚度差也只有1：3.4，其部位差明顯小於內江豬皮。

減小豬皮部位差，必然給加工生產帶來極大好處，不僅取消了許多對臀部的特殊處理，節省工時、材料，並且可以提高產品的質量，取得明顯的經濟效益。由此可見，提高我國豬革質量最有效的方法之一在於改良豬種。

Introduction

Characteristics of Histological Structure of Chinese Pigskin

China is well-known as the richest country in pigskin resources in the world and the pigskin is the most important raw material for the domestic leather industry. There are many pig species distributed in the nation's vast expanse of territory. However, some hybrid pigs of the lean meat type have incessantly been developed throughout the country to meet the demand of meat by the people. Differences in histological structure are observed among the various species; nevertheless, the basic structure is very similar. It is of great importance to know the histological and structural characteristics of the pigskin in order to develop our own pigskin leather technology for the production of good quality leather and full exploitation of our potential resources.

1. Fat Tissue

The fat tissue of pigskin is highly developed. The subcutaneous layer of the skin is almost entirely composed of fat cells. They expand into the skin from the basal part of the hair root, forming numerous round or elliptical cone-shaped bodies with a small point at the top and a large base at the bottom and of various sizes, heights, and densities. These bodies are called fat cones because of their composition of fat cells. In addition to fat cones there are some free fat cells occurring among the collagen fiber bundles of the dermis.

Fat cones are embedded in the dermis. When the fat cells are eliminated from the cones, numerous pits, commonly known as fat pits are exposed on the flesh side of the skin. It is here, in the cone where the lower section of the hair root of a bristle grows. Besides, there are sweat glands and blood vessels in the cone.

The secretory duct of the sweat gland is also in the cone, but its narrow, elongated tubules exist among the collagen fiber bundles. Therefore, the effect of sweat glands on the strength of the skin is insignificant.

The fat cone varies with its location in the skin in size, height, and density. For example, in the butt the cones are dense, tall, and slender; and the fat pits in this locality are plentiful and rather deep, may be even to the extent of half the thickness of the skin. However, the cones in the belly and neck are large, short, and few; and the depth of fat pits is only about one fourth of that of the skin or even less. The difference between fat pits in size and depth affects greatly the efficiency of defatting and depilation. For example, in defatting by mechanical means it is rather difficult to scrape the fat off the deep fat pits completely. In depilation a depilatory or proteinase generally has to infiltrate into the flesh side and pass through the very thick fat cellular layer in the cone in order to reach the hair root and weaken or destroy the connection between the follicle and the root so that the unhairing process can be done with ease. On the other hand, the fat in the shallow fat pits in the belly is scraped off with much less difficulty and the depilatory can rapidly reach the hair root. This is why in unhairing process the hair in the belly falls off easier than that in the butt.

Fat cells of the pigskin are generally distributed in the midst of collagen fiber bundles and around the follicle, abundantly in the neck and belly, and in one and the same locality sparesely in the upper layer of the dermis and numerously in its lower layer. Difference in the distribution is noted in various species. For example, in the Zi Zhong pigskin in Sichuan Province the fat cells are distributed numerously in the neck and belly, but very few in the butt. In Shanghai pigskin there are quite many fat cells in the neck and belly, but a few in the butt. These cells in the dermis cannot be eliminated by mechanical means. Only when they are squeezed and rubbed, the cell membrane disrupted and the fat spilt, can chemical agents and depilatories react with the fat to be removed from the dermis.

In the central part of the follicle there are sebaceous glands, numbering from one to several. The sebaceous gland is divided into two portions, namely the secretory portion (gland body) and the excretory portion (duct). The upper extremity of the duct is linked to a follicle. The gland is filled with fat cells, which, when mature, disintegrate to form the product of secretion, called sebum. The sebum flows into the follicle through the duct, and then from the follicle to the surface of the skin, causing the epidermis and hair shaft to become oily and moist. Sebaceous glands are highly developed in the neck of pigskin; especially, there are usually several large sebaceous glands surrounding the follicle of a bristle closely. These glands are separated by partition layers composed of collagen fiber bundles and elastic fiber groups. The partitions remain even after the glands have been destroyed.

Therefore defatting process plays an extremely important role in the manufacture of pigskin leather. Any fat left behind after the processing would affect the later dyeing process and cause the 'fat infiltration' phenomenon in the finished product. Tanners always prefer to use the combination method of reinforced mechanical action plus chemical reaction so as to remove the fat and lipids as much as possible in the hypodermis, fat pits and sebaceous glands. As pure alkali can only remove the fat on the surface of pigskin, addition of surface active agents in re-liming and bating is beneficial to defatting. When necessary, degreasing treatment can still be repeated in such procedures as pickling and chrome tanning.

2. The characteristic structure of hair and follicles

The hair of pigskin is divided into two kinds of hair: the thick and long one is called bristle and the fine and short one called fine hair. The bristles are mostly arranged in 3-strand hair groups, having the form of a dome. But there are 2-strand hair groups and single strand hair groups. The fine hair is irregularly distributed in dots. The roots of the 3-strand hair group are concentrated in a fat cone. The depths of the roots of the three bristles are different: the one in the middle is the deepest, and rather oblique, forming a low angle between the hair and skin surface; this hair in the neck and belly even extends to the outside of the fat cone and dips into the subcutaneous

fatty layer; the other two side strands are rather fine and upright, and usually grow on the point of the fatty cone. The bristles in the neck are particularly thick and long. They have a high economic value and are depilated at slaughterhouses.

The exit of a bristle takes the shape of the flared bell of a bugle. The opening is commonly known as "hair eye" or "hair pore". The pore is rounded on one side and rather pointed on the other side. Its deepness, size, and spacing have a bearing on the coarseness of the grain surface. Hair pores in the neck part are particularly large, and so the neck part is coarser than any other part of the finished leather.

A follicle, out of which the hair grows, is divided into two layers: the outer layer called connective tissue sheath, consisting of collagen fiber bundles and elastic fibers; and the inner layer called hair root sheath being again divided into two layers: the inner layer, which is derived from the stratum corneum, called inner hair sheath; and the outer layer, which is derived from the mucous layer (stratum germinativum) of the epidermis called outer hair sheath. The thickness of the hair sheath is particularly thick in the lower segment of the hair sheath (below the fatty gland). Since it is derived from the corneum, it is rather resistant to acid and base. If it is not eliminated in processing, it will stay on the flesh surface of the finished leather as a hard thorn, which can be felt by the hand.

Depilation and liming would remove most of the hair roots and hair sheaths; and re-liming and bating further get rid of some of the remainders. But it is difficult to remove all of them, and so in the finished leather there are usually some discernible remaining hair roots and sheaths. Connective tissue sheath is made up of interweaving collagen fiber bundles, which are fine and compact. As the connective tissue sheath is derived from the grain layer, the collagen fiber bundles of the tissue are as fine as those of the grain. Below the grain layer the collagen fiber bundles gradually become coarse; therefore, in the manufacture of suede leather by buffing off the grain surface, the depth of the grinding surface must be handled with great care. If the grinding goes too deep, hair pores will be exposed on the ground surface due to the difference in coarseness between the fine fibers at the connective tissue sheath and the coarse ones outside it. In preparation of suede leather by buffing the flesh side, hair pores may also be shown, if the fibers of the connective tissue sheath are improperly split. However, the collagen fiber bundles outside the connective tissue sheath must also be split properly; otherwise it is difficult to make nap, or the nap so formed is not able to cover up the hair pores.

3. The Muscle Tissue of Pigskin

Muscle tissue of the dermis of pigskin is quite well-developed. Every bristle possesses several strands of erector pili muscle. It is quite likely that in order to pull such a coarse hair as the bristle and make it stand up it is undoubtedly necessary to have such well-developed stout erector pili muscle for the work. Erector pili muscle is slender smooth muscle. One of its extremities is attached to the basal part of the follicle and the other is extending toward the grain surface. Besides, there is another kind of muscle which is generally at a level a little higher above the basal part of the follicle, parallel to the skin surface, arbitrarily named "hair-binder muscle". Its extremties link up separately with the basal parts of the follicle of the side strand of the 3-strand hair group of bristles, thus joining the three strands together. It seems that the function of the hair-binder muscle is to draw the three strands of hair together when the muscle contracts; and simultaneously, the erector pili muscle pulls the bristle upright at the basal part of the it. This particular kind of muscle also occurs on the follicles of the 2-strand hair group and the single strand hair group of bristles.

Development of muscle tissue of pigskin varies with its location. In the neck part the erector pili muscle and hair-binder muscle are well-developed, strong and plentiful; in the belly part they come second; and in the butt delicate and scanty

Muscle tissue of pigskin on the whole is well-developed, which may enhance the strength of the skin. In processing the muscle tissue is not likely to be removed. But it has to be split to a certain extent. In making upper leather the extent of splitting is small, whereas the extent is great in preparing soft leather such as garment leather. Obviously, splitting the coarse muscle fibers into fine ones may be beneficial to the attainment of softness in the finished leather.

4. Elastic Fiber of Pigskin

Elastic fibers appear as tree branches without leaves. They are distributed throughout the whole dermis layer, not forming any fiber bundles; rather abundant in the neighbourhood of the grain surface and subcutaneous layer; and rather sparse in the middle layer of the dermis. The distribution of elastic fibers varies with their location. In the belly and neck part they are dense; and in the middle dermic layer of these locations, they are interweaving to form nets. In the butt they are fine and sparse, and mainly distributed in the upper dermic layer; and in lower part the middle of layers there are very few of them. Furthermore, fine and slender elastic fibers are concentrated around the follicle, on the erector pili muscle, in the basal part of the follicle, around the fatty gland, and on the blood vessel. Therefore, the content of elastic protein is rather high in pigskin, approximately 2.1% of its weight. This content varies to some extent with the species.

Elastic fibers have a strengthening effect on various tissues. Some researchers have thus considered that a proper weakening or destruction of elastic fibers in processing would produce soft leather. But our study shows that the softness of finished leather is not quite related to the destruction of elastic fibers. For example, the finished leather is all the same very soft in spite of the fact that elastic fibers of pigskin upper leather are basically intact; that elastic fibers near the grain surface of garment leather are damaged only to a slight extent; and that in other parts of the skin large quantities of elastic fibers remain, but with some in crooked, deformed, or broken segments.

5. Pigskin Collagen Fibers and Their Relation to Location Difference

Pigskin, just like the other livestock skin, is divided into three layers: epidermis; dermis; and hypodermic tissue layer.

The epidermis consists mainly of interweaving collagen fiber bundles. Since the bristle grows rather deeply into the dermis, especially the ones in the belly and neck, which penetrate the whole dermic layer, the basal part of the follicle cannot be based on to distinguish the papillary layer from the reticular layer, as it is done so in cow hide and goat skin.

Nevertheless, based on the coarseness of the collagen fiber bundles and compactness of their weave, it is still possible to divide the dermis of pigskin into three layers, namely, upper dermic layer (region above the basal part of the follicle of fine hair), which is equivalent to the papillary layer (grain layer); middle dermic layer; and lower dermic layer. These two layers are equivalent to the reticular layer.

Collagen fiber bundles of the upper dermic layer are fine and small, and loosely interweaving with a low weave angle (running direction of most fibers being parallel to skin surface). Improper handling in processing may easily cause the grain in this layer. Collagen fiber bundles in the middle dermic layer are coarse and strong, and interweaving compactly with a high weave angle. The good strength of pigskin is mainly determined by this layer. The collagen fiber bundles in the lower dermic layer gradually become finer and more loosely interweaving with a low weave angle than in the middle dermic layer; and the fiber proximal to the hypodermic tissue layer runs almost horizontally. Because of the fat pits in the deep basal part of the bristle root the collagen fiber bundles in the lower part of middle layer have to pass round the follicle and fat pits and are not able to join themselves together to form an entirety. After the hair and fat in the pits are eliminated, numerous vacant pores are left on the flesh surface. The deeper they are in the lower dermic layer, the larger they become. Therefore, the split leather near the flesh side would often look like a fishing net. Hence, the strength of the finished leather would certainly be affected to a great extent. This kind of split leather is of not much use in the leather industry.

The grain surface of pigskin is formed by delicate and compactly interweaving collagen fiber bundles, forming a layer of about 0.1 to 0.2mm in thickness. The grain grows into the dermis to form connective tissue sheath in the area where the hair grows. If the grain is damaged, the leather loses its glossiness.

The grain surface looks very rough when the papilla is high, the hair pore large, and the wrinkle deep. The smoothness of grain surface varies greatly with the species. For example, of Danish Landrace pig the hair pore is small, papilla low, and wrinkle shallow, and so its grain surface is rather fine and smooth; of Nei Jiang, Zi Zhong and Chengdu pigs in Sichuan province the pore is large, papilla high and wrinkle deep, and so the grain surface is coarse and rough; and of a new hybrid species by crossing Danish Landrace pig with Chengdu pig or Nei Jiang pig the hair pore is small, papillae rather low, wrinkle rather shallow, and so the grain surface is fine and delicate. Apparently improvement in pig breeding will help provide good quality raw pigskin for the manufacture of high grade light pigskin leather.

Weave pattern and compactness of pigskin collagen fiber bundles vary with their location. As seen from the vertical cross-section (cross-section prepared in the hair growing direction and perpenticular to the skin surface), the collagen fiber bundles located in the butt, belly, and neck possess no definite weave patterns, but the weave with a high weave angle in the butt is more compact than that in the belly and neck, where the weave with a low weave angle is loose. As seen from the parallel cross-section (cross-section parallel to the skin surface), the collagen fiber bundles in the upper dermic layer in different locations still do not possess any definite weave patterns; but those in the middle and lower dermic layers are quite regular, e.g. the collagen fiber bundles in the butt and the central part of the skin are thick and upright, showing a cross-shaped interweaving; and the weave is very compact. Therefore, good strength and high resistance to abrasion, but low stretchability are shown in these locations; and malformation is rare in processing. In the belly the collagen fiber bundles are fine and delicate, crooked, showing a wave-shaped weave,which is loose, and so the belly shows a low strength but particularly high stretchability. The compactness and fineness of the collagen fiber bundles in the neck stand between those of the butt and the belly; and the weave is of an oblique interweaving pattern. The fineness and compactness of the bundles in the tail part are somewhat inferior to those of the bundles in the butt, but the weave is complex.

This is the part where it is difficult for the suede leather to become nappy. However, this locality occupies only a small proportion of the whole skin. In addition to the differences of collagen fiber bundles in weave patterns and compactness, the locations of pigskin differ quite greatly in thickness. In the same sheet of pigskin the butt is the thickest, and the belly the thinnest. The ratio between the thinnest and thickest parts is known as thickness difference between locations (briefly thickness difference). The thickness difference of Nei Jiang Pigskin is about 1:5.10; and of Chengdu pigskin about 1:4.90. Obviously the thickness difference of the pigskin cited is particularly significant. Such a significant difference is sure to entail difficulties in processing and manufacturing. Therefore, attention should be paid, right at the beginning, to the elimination or minimization of thickness difference, in order that the whole finished leather could be approximately homogeneous in softness or hardness.

Location difference mainly includes the above mentioned two aspects: one is the compactness difference between the weaves of the collagen fiber bundles, and the other is the thickness difference between locations. Location difference varies with species difference. For example, the collagen fiber bundles of Nei Jiang pigskin are thick and compact in weave, whereas those of Danish Landrace Pig are rather fine and not so compact. The thickness difference of Danish Landrace Pig is only about 1:3.10. The thickness difference of a new hybrid pig bred by the crossing between Danish Landrace Pig and Nei Jiang pig is also only about 1:3.40. pparently The location difference is smaller than that of Nei Jiang pigskin or Chengdu pigskin. The minimization of pigskin location difference is sure to bring great benefit to the production of pigskin leather. It not only eliminates many of the special treatments required especially for the butt part, saves working hours and material, but also raises the quality of products for making substantial profits commercially. Thus improvement of native pig species is one of the most effective ways to elevate the quality of our pigskin leather.

Ⅲ. 豬皮組織構造的圖片
MICROGRAPHS OF PIGSKIN TISSUE STRUCTURE

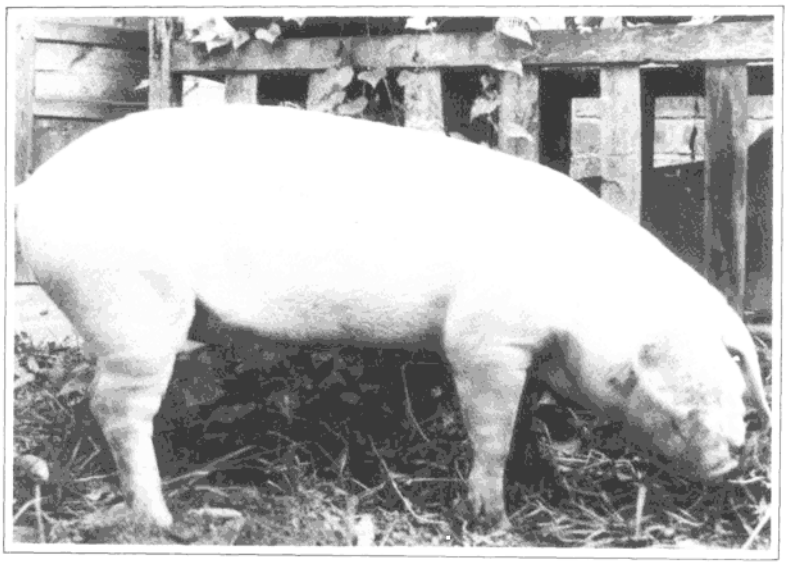

圖1. 丹麥長白豬
Fig. 1 Danish Landrace pig.

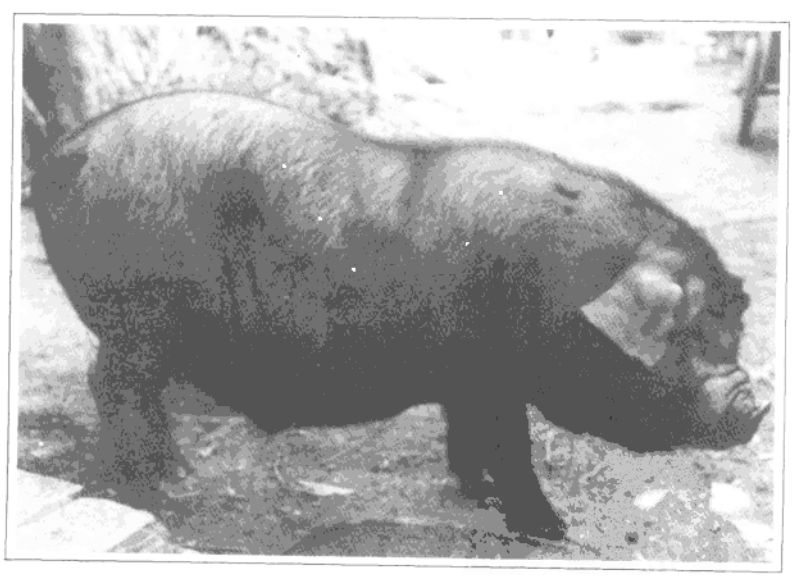

圖2. 四川成華豬
Fig. 2 Sichuan Chengdu pig.

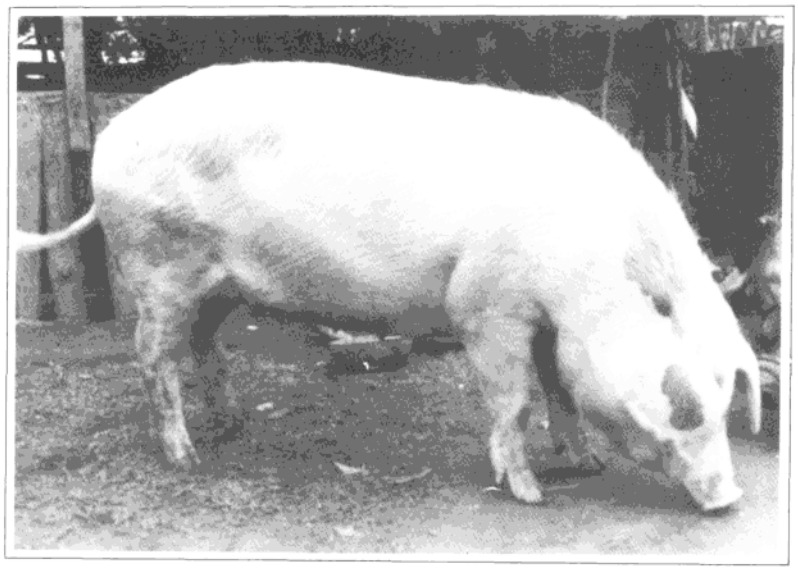

圖3. 長白豬與成華豬雜交後的新品種豬

Fig. 3 A new pig species from crossing between Danish Landrace pig and Chengdu pig.

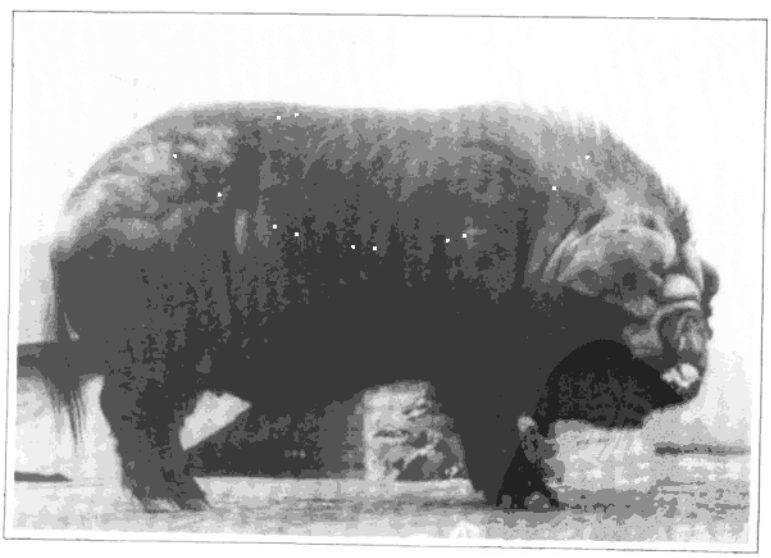

圖4. 四川內江豬

Fig. 4 Sichuan Nei Jiang pig.

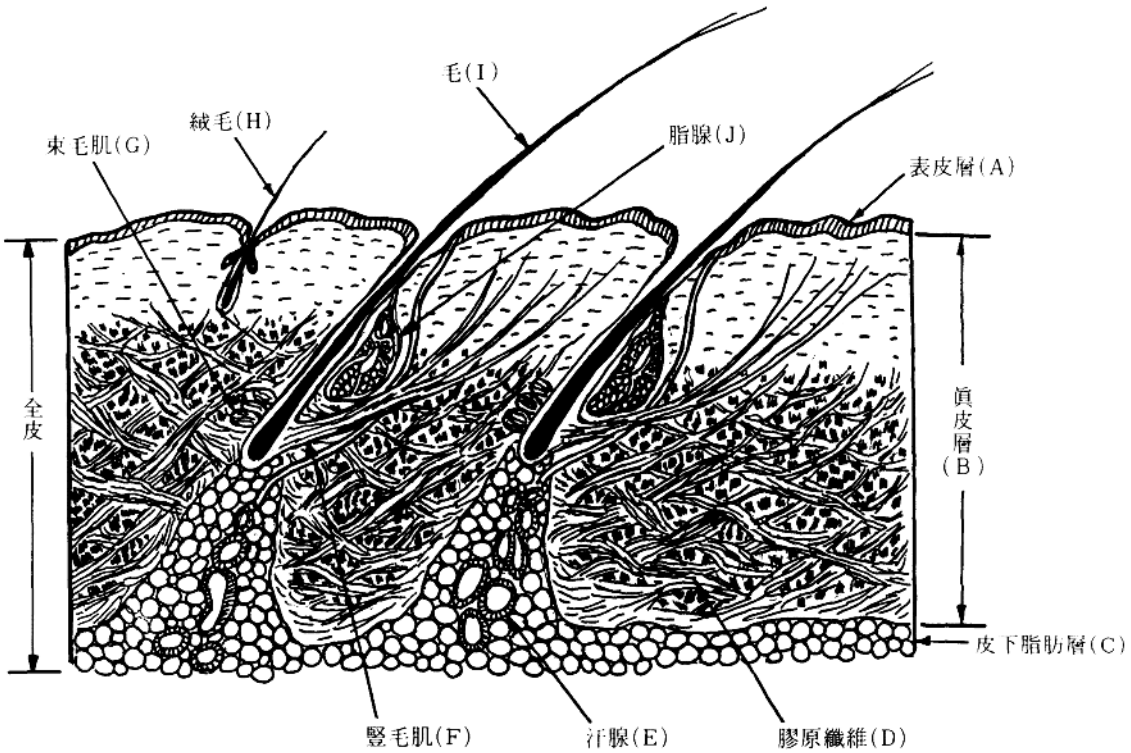

圖5. 豬皮組織結構示意圖

A. 表皮層	F. 豎毛肌
B. 眞皮層	G. 束毛肌
C. 皮下脂肪層	H. 絨毛
D. 膠原纖維	I. 針毛
E. 汗腺	J. 脂腺

Fig. 5 Diagram to show the general structure of pigskin.

A. Epidermic layer	F. Erector pili muscle
B. Dermic layer	G. Hair-binder muscle
C. Subcutaneous fatty layer	H. Fine hair
D. Collagen fibers	I. Bristle
E. Sweat gland	J. Sebaceous gland

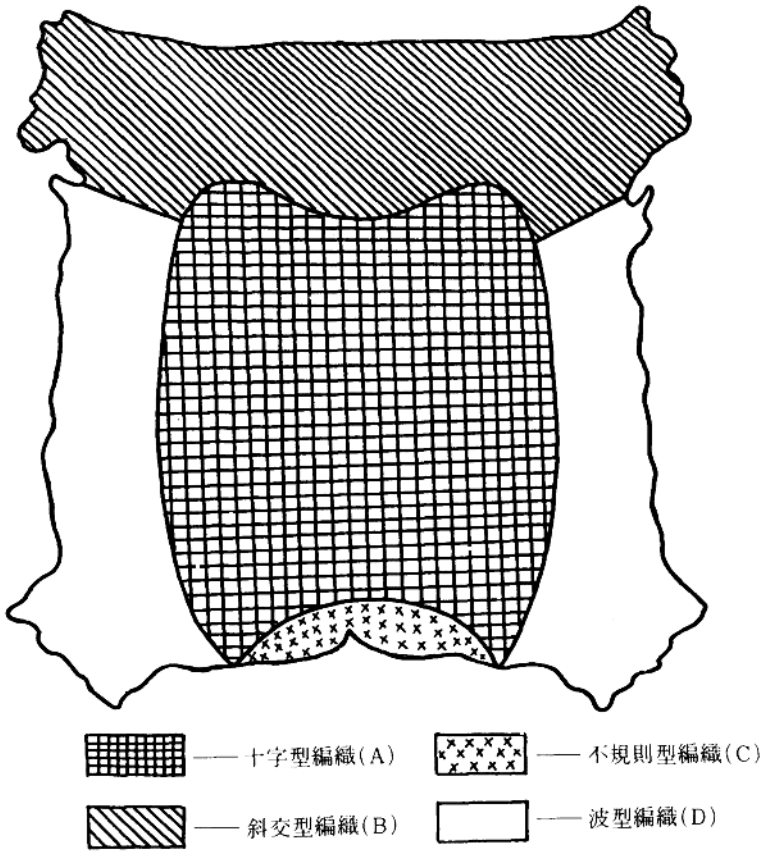

圖6. 豬皮各部位織型示意圖

A. 十字型編織（皮心部）

B. 斜交型編織（頸肩部）

C. 不規則型編織（尾根部）

D. 波型編織（腹部）

Fig. 6 Diagram to show the variation in the weave pattern of collagen fibers in different locations of pigskin.

A. Cross-shaped pattern. butt part.

B. Oblique pattern. Neck and front butt part.

C. Irregular pattern. Tail root part.

D. Crinkly pattern. Belly part.

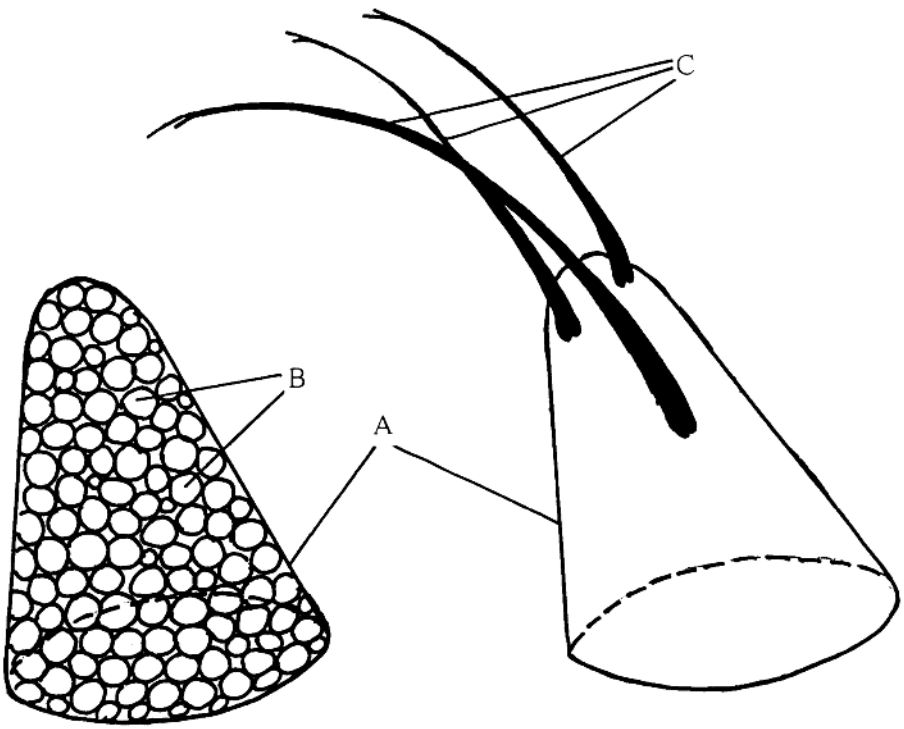

圖7. 豬皮的脂肪錐示意圖

A. 脂肪錐

B. 脂肪細胞

C. 豬毛

Fig. 7 Diagram to show the fat cone.

A. Fat cone

B. Fat cells

C. Bristles

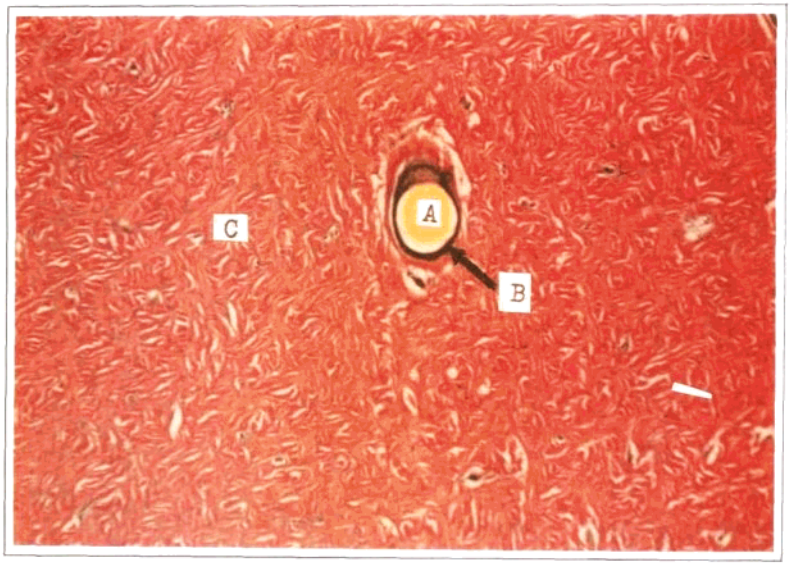

圖8. 單根分佈的針毛
A. 毛根　B. 毛根鞘　C. 膠原纖維　（×10平切）

Fig. 8 The bristle of the single-strand hair group.
A. Hair root　B. Hair root sheath　C. Collagen fibers　(X10 hor. sec.)

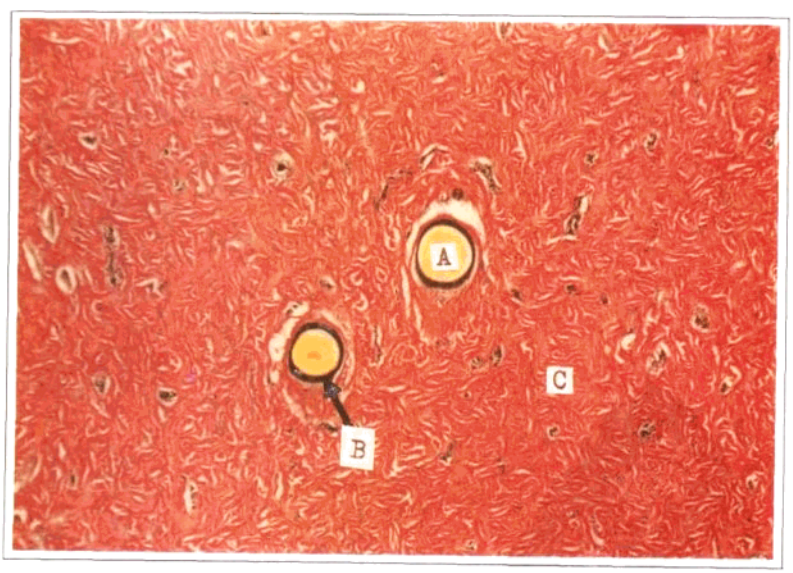

圖9. 兩根一組的針毛
A. 毛根　B. 毛根鞘　C. 膠原纖維　（×10平切）

Fig. 9 The bristles of the Two-strand hair group.
A. Hair　B. Hair root sheath　C. Collagen fibers　(X10 hor. sec.)

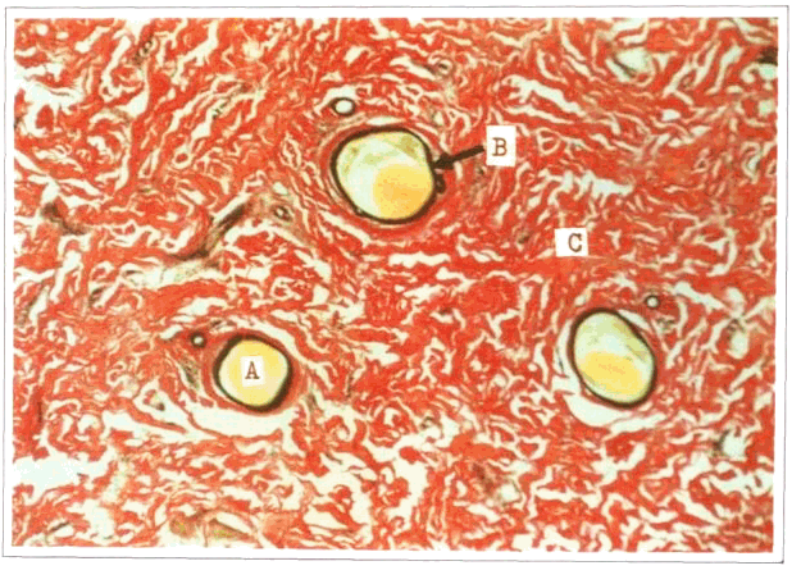

圖10. 三根一組的針毛，在皮面呈品字型排列
A. 毛根　B. 毛根鞘　C. 膠原纖維　（×10平切）

Fig. 10 The triangular arrangement of the three-strand hair group.
A. Hair root　**B.** Hair root sheath　**C.** Collagen fibers　(X10 hor. sec.)

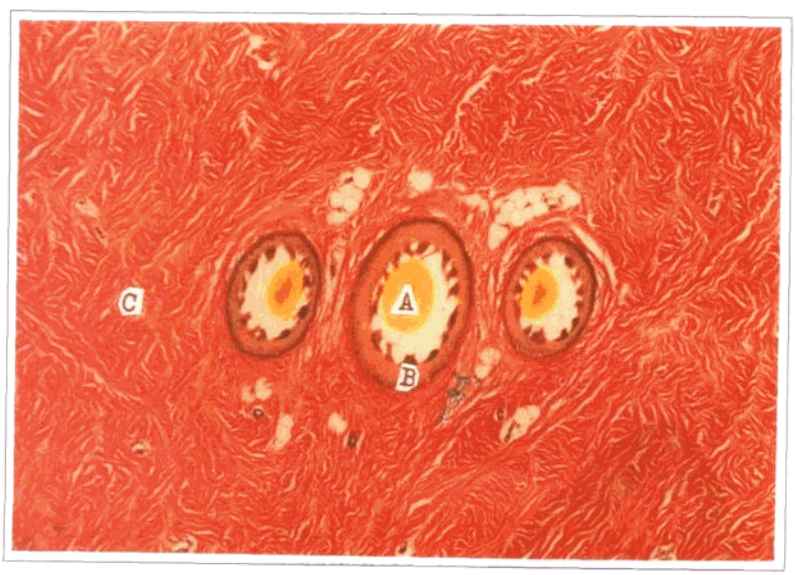

圖11. 三根一組的針毛，在脂腺以下排成一排，中間一根針毛較粗
A. 毛根　B. 毛根鞘　C. 膠原纖維　（×10平切）

Fig. 11 The three-strands below sebaceous gland are arrangeed in alignment in the triad with the middle strand which is rather thick.
A. Hair root　**B.** Hair root sheath　**C.** Collagen fibers　(X10 hor. sec.)

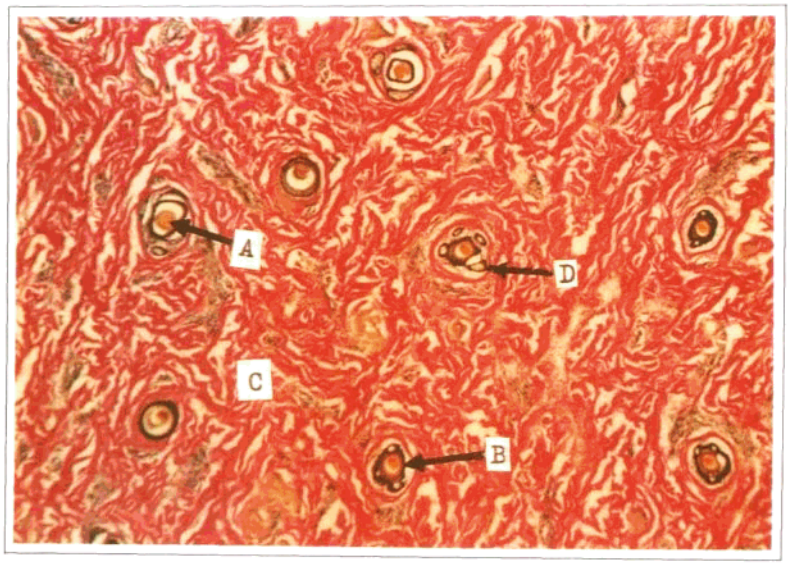

圖12. 絨毛在皮面呈不規則的點狀排列
A. 毛根　B. 毛根鞘　C. 膠原纖維　D. 脂腺　（×10平切）

Fig. 12 Fine hair arranged in irregularly scattering dots on grain.
A. Hair root　B. Hair root sheath　C. Collagen fibers
D. Sebaceous gland　(X10 hor. sec.)

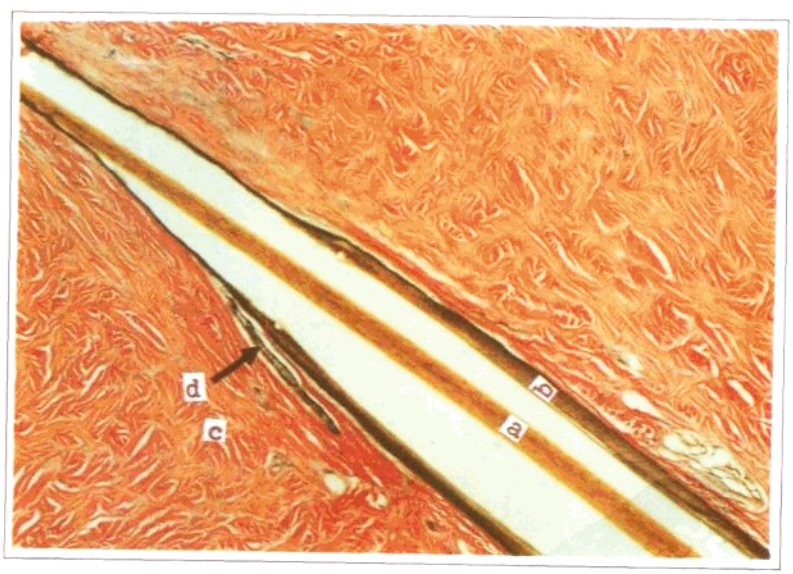

圖13. 脂腺以上毛根鞘較薄，脂腺以下毛根鞘明顯增厚
A. 毛根　B. 毛根鞘　C. 膠原纖維　D. 脂腺　（×10縱切）

Fig. 13 The hair root sheath above sebaceous gland being rather thin; the sheath below the gland being obviously thickend.
A. Hair root　B. Hair root sheath　C. Collagen fibers
D. Sebaceous gland　(X10 vert. sec.)