H. R. PROCTER

A TEXT-BOOK OF TANNING

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A treatise on the conversion of skins into leather, both practical and theoretical

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PREFACE.

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The aim of the following handbook is two-fold; to give, in a compendious form, such a summary of our scientific knowledge as may be useful to the practical tanner; and such a sketch of manufacturing processes as may enable the chemist to apply his knowledge to their improvement. Each may, therefore, find some superfluous matter, for which his indulgence is asked. The book is an expansion of a short article which appeared in Spons' 'Encyclopædia of the Industrial Arts,' and to some extent still bears traces of its origin; and, having been written under stress of limited leisure, and defective eyesight, is very far from being so perfect as I should desire. For the sake of completeness it has been necessary to describe many processes which are outside the range of my own manufacturing experience, and in doing so I have generally referred to the sources of my information. Chapters III. and XXIV. are written by Mr. C. G. Warnford Lock, to whose kind assistance I am much indebted. It may be well to state in conclusion, that while the work is not intended for a cram-book for technical students, it is hoped that it may be an assistance to teachers of the subject.

HENRY R. PROCTER.

TYNEMOUTH,
August 1885.

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ETC., ETC.

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INTRODUCTORY NOTE.

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LEATHER manufacture may be broadly divided into two stages: "tanning," in which the raw hide is converted into the imputrescible and more or less flexible material known as "leather"; and "currying," in which this leather is further manipulated, and treated with fatty matters, to soften and render it more waterproof, and to improve its appearance. Glove-kid, and certain other leathers, however, are not tanned at all, but "tawed," or prepared with a mixture in which alum and salt are the most active ingredients; chamois, "shammy," or "wash" leather, is produced by fulling with oil alone, and many leathers can scarcely be said to be curried, although more or less oil is used in the final processes of "finishing" or "dressing." The first subject to be treated of in this work will be the operation of tanning, properly so called, taking for example the tannage of sole- and belting-leather. This demands thorough explanation, in both its practical and theoretical aspects, not only because it is one of the most important branches of the trade, but because the principles involved are those which equally underlie all other tanning methods. The next to be dealt with will be the modifications of the process which are necessary in tanning the more flexible leathers used for boot-uppers, hose-pipes, and saddlery purposes; then the currying of these leathers; and finally, the manufacture of moroccos, Russian, and japanned leathers, calf- and glove-kid, &c.

CHAPTER I.

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ANATOMICAL STRUCTURE OF HIDE.

BEFORE speaking of actual processes of manufacture, it is necessary to devote some attention to the structure and chemical constitution of hide or skin, which forms the raw material. Although a great variety of skins are employed in tanning, they are all constituted on the same general type, and an anatomical description of the hide of the ox will apply almost equally to those of the calf, sheep, and goat; but from differences in thickness and closeness of texture, their practical uses differ widely. Fig. 1 shows a section of ox-hide, cut parallel with the hair, magnified about 50 diam.: *a*, epithelial layer or *epidermis*, consisting of horny layer above, and *rete malpighi* below; *b*, *pars papillaris*, and *c*, *pars reticularis* of *corium*, *derma*, or true skin; *d*, hairs; *e*, sebaceous or fat-glands; *f*, sudoriferous or sweat-glands; *g*, opening of ducts of sweat-glands; *h*, *erectores pili* muscles, for erecting the hair.

The fresh hide consists of 2 layers: an outer, the epidermis; and an inner, the true skin. The epidermis is very thin as compared with the true skin which it covers, and is entirely removed preparatory to tanning; it nevertheless possesses important functions. It is shown in Fig. 1 at *a*, and more highly magnified in Fig. 2. Its inner mucous layer *b*, the *rete malpighi*, which rests upon the true skin *c*, is soft, and composed of living nucleated cells, which are elongated in the deeper layers, and gradually become flattened as they approach the surface, where they dry up, and form the horny layer *a*. This last is being constantly worn away, and

thrown off as dead scales of skin; and as constantly renewed from below, by the continued multiplication of the cells. It is from this epithelial layer that the hair, as well as the sweat- and fat-glands, are developed. It will be seen in Fig. 1 that each hair is surrounded by a sheath, which is continuous with the epidermis. In embryonic development, a small knob of cells forms on the under side of the epidermis, and this enlarges, and sinks deeper into the true skin, while the root of the young hair is formed within it; this is shown in Fig. 3, *a b*. Smaller projections also form on the stalk of the knob, and in due time produce the sebaceous glands. The process of development of the sudoriferous glands is very similar to that of the hairs. There is a great analogy between this process and that of the ordinary renewal of hair in the adult animal. At d^1 Fig. 1, is seen an old and worn-out hair. It is shrunken and elongated, and is almost ready to fall out. It will be noticed that its sheath or follicle projects somewhat below the hair to the right. This is the first production of a young hair, and is quite analogous to the knob of epithelium which has been described as forming the starting-point of a hair in embryo. At d^2, the same process is seen further advanced, the young hair being already formed, and growing up into the old sheath. At d^3, it is complete, the old hair having fallen out, and the young one having taken its place.

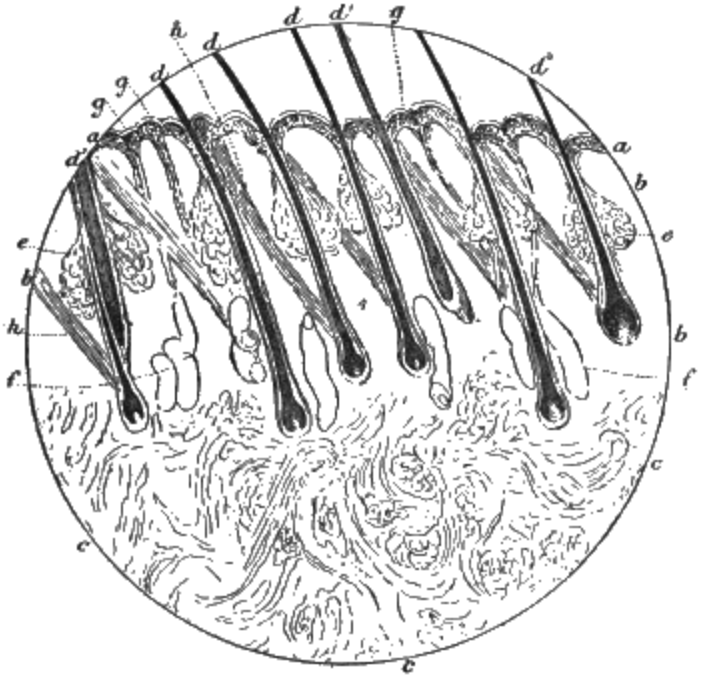

FIG. 1.

FIG. 2.

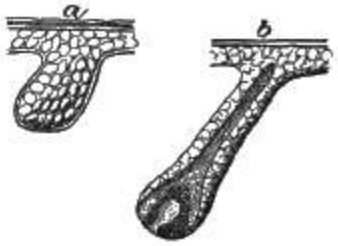

FIG. 3.

The hair itself is covered with a layer of overlapping scales, like the slates on a roof, but of irregular form. These give it a serrated outline at the sides, strongly developed in wool. Within these scales, which are sometimes called the "hair cuticle," is a fibrous substance, which forms the body of the hair; and sometimes, but not always, there is also a central and cellular pith, which is mostly transparent, though under the microscope it frequently appears black

and opaque, from the optical effect of imprisoned air. On boiling or long soaking in water, alcohol, or turpentine, these air-spaces become saturated with the liquid, and then appear transparent.

The fibrous part of the hair is made up of long spindle-shaped cells, and contains the pigment which gives the hair its colour. The hair of the deer differs from that of most other animals in being almost wholly formed of polygonal cells, which, in white hairs, are usually filled with air. At its base, the hair swells into a bulb, which is hollow, and rests on a sort of projecting knob of the *corium*, called the hair-papilla. This has blood-vessels and nerves, and supplies nourishment to the hair. The hair-bulb is composed of round, soft cells, which multiply rapidly; as they grow, they press upward through the hair-sheath, become elongated and hardened, and form the hair. In dark hairs, both the cells of the hair itself and those of its follicle or sheath are strongly pigmented, but the hair much the more so, and hence the bulb has usually a distinct dark form. The dark-haired portions of a hide from which the hair has been removed by liming still remain coloured, from the pigmented cells of the hair-sheaths, which can only be got out completely by bating and scudding. The cells outside the bulb, shown at *f*, in Fig. 4, pass upwards as they grow, and form a distinct coating around the hair, which is called the "inner root-sheath." This again consists of 2 separate layers, of which the inner is "Huxley's," the outer, "Henle's." They arise from the same cells in the base of the hair; but in the inner layer, these remain polygonal and nucleated, while in the outer, they become spindle-shaped and without nuclei. The inner root-sheath does not extend to the surface of the skin, but dies away below the sebaceous glands. This figure represents an ox-hair root, mag. 200 diam.: *a*, fibrous substance of hair; *b*, hair cuticle; *c*, inner root-sheath; *d*,

outer root-sheath; *e*, dermic coat of hair-sheath; *f*, origin of inner sheath; *g*, bulb; *h*, papilla.

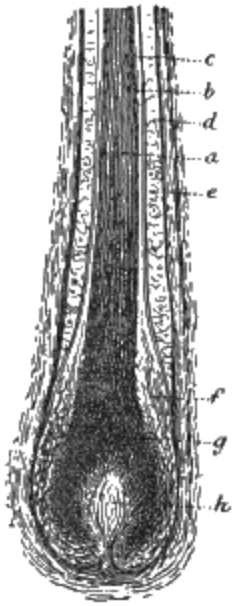

FIG. 4.

Outside the inner root-sheath is a layer of nucleated cells, continuous with those of the epidermis, and of the same character. This is the "outer root-sheath," and is shown at *d*, Fig. 4. This, together with the whole of the epidermis, is covered next the *corium* with an exceedingly fine membrane, called the "hyaline" or glassy layer. It is possible that this forms the very thin buff-coloured "grain" of tanned leather, which evidently is of different structure from the rest of the *corium*, since, if it gets scraped off before tanning, the exposed portion of the *pars papillaris* remains nearly white, instead of colouring. The whole of the hair-sheath is enclosed in a coating of elastic and connective-tissue fibres, which are supplied with nerves and blood-vessels, and form part of the *corium*. Near the opening of the hair-sheaths to the surface of the skin, the ducts of the sebaceous or fat-glands (*e*, Fig. 1), pass into them, and secrete a sort of oil to lubricate the hair. The glands themselves are formed of large nucleated cells, arranged somewhat like a bunch of grapes; one is shown

highly magnified in Fig. 5: *a*, sebaceous gland; *b*, hair-stem; *c*, part of *erector pili* muscle. The upper and more central cells are most highly charged with fat, which is shown by the darker shading.

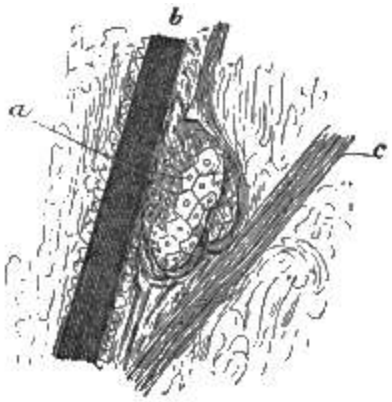

FIG. 5.

As already remarked, the sudoriferous or sweat-glands are also derived from the epidermis layer. They are shown at *f*, Fig. 1, and on a larger scale (200 diam.) in Fig. 6: *a*, windings laid open in making section; they consist, in the ox and sheep, of a large wide tube, sometimes slightly twisted. In this, they differ considerably from those of man, which form a spherical knot of extremely convoluted tube. The walls of these glands are formed of longitudinal fibres of connective tissue of the *corium*, lined with a single layer of large nucleated cells, which secrete the perspiration. The ducts, which are exceedingly narrow, and with walls of nucleated cells like those of the outer hair-sheaths, sometimes open directly through the epidermis, as shown at *g*, Fig. 1, but more frequently into the orifice of a hair-sheath, just at the surface of the skin. Each hair is provided with a slanting muscle (*h*, Fig. 1), called the *arrector* or *erector pili*, which is contracted by cold or fear, and causes the hair to "bristle," or stand on end; by forcing up the attached skin, it produces the effect known as "goose-skin." The muscle, which is of the unstriped or involuntary kind,

passes from near the hair-bulb to the epidermis, and just under the sebaceous glands, which it compresses.

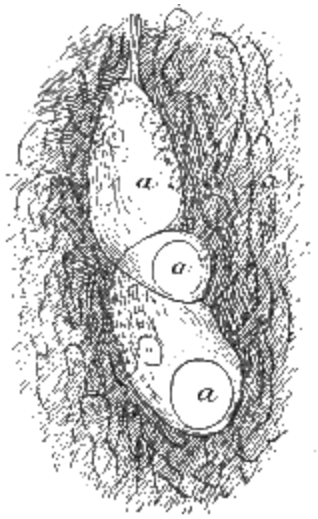

FIG. 6.

The *corium* or true skin is principally composed of interlacing bundles of white fibres, of the kind known as "connective tissue"; these are composed of fibrils of extreme fineness, cemented together by a substance of different composition from the fibres themselves. This may be demonstrated by steeping a small piece of hide for some days in a stoppered bottle in lime-, or baryta-water, in which the inter-fibrillar substance is soluble, and then teasing a small fragment of the fibre with needles on a glass microscope-slide, and examining with a power of at least 200–300 diam. In the middle portion of the skin, these bundles of fibre are closely interwoven; but next the body, they gradually become looser and more open, forming the *pars reticularis* (or netted part); and the innermost layer is a mere network of loose membrane, generally loaded with masses of fat-cells, and hence called adipose tissue.

It is this adipose tissue which is removed in the "fleshing" process. On the other hand, the outermost layer, just beneath the epidermis, is exceedingly close and compact, the fibre-bundles that run into it being separated into their

elementary fibrils, which are so interlaced that they can scarcely be recognised. This is the *pars papillaris*, and forms the lighter-coloured layer, called (together with its very fine outer coating) the "grain" of leather. It is in this part that the fat-glands are embedded, while the hair-roots and sweat-glands pass through it into the looser tissue beneath.

Besides the connective-tissue fibres, the skin contains a small proportion of fine yellow fibres, called "elastic" fibres. If a thin section of hide be soaked for a few minutes in strong acetic acid, and then examined under the microscope, the white connective-tissue fibres become swollen and transparent, and the yellow fibres may then be seen, as they are scarcely affected by the acid. The hair-bulbs and sweat- and fat-glands are also rendered distinctly visible.

The nerves of the skin are very numerous, each hair being supplied with fibres passing into both the papilla and sheath. They also pass into the skin papillæ. They cannot readily be seen, without special preparation, and, so far as is known, exercise no influence on the tanning process. "Breaking the nerve" is a technical term, which signifies a thorough stretching and softening of the skin, but has nothing to do with nerves properly so called. The blood- and lymph-vessels are, from the present point of view, somewhat more important. They may often be seen in sections, and are lined with nucleated cells, similar to those of the glands. These are surrounded by coatings of unstriped muscular fibre, running both around and lengthways, and also by connective-tissue fibres. In the arteries, the muscular coating is much stronger than in the veins.

It may be thought that the space devoted to a discussion of the anatomical structure of the skin is disproportionately large; but there can be no doubt that, in order to make

improvements, nothing is of more importance than a clear conception, even to the smallest details, of the materials and causes to be dealt with. The illustrations are from actual specimens, and enable the various parts of the hide to be identified under the microscope.

As this instrument is a most useful means of investigation in the tanning industry, and one likely to be of increasing importance, it will be well, before proceeding further, to say a few words, both on the selection of a suitable instrument, and on its manipulation in general.

To do useful work, it is not necessary to possess a very elaborate or expensive instrument, but it is essential that the microscope be well made and good of its kind. As high powers are often required in the examination, both of hide sections and of ferments, which are the principal objects of investigation in a tannery, it is of the first importance that the fine adjustment should be perfectly steady, without vibration or backlash. This, in the writer's experience, is never the case with cheap microscopes, in which the fine adjustment is made by a screw at the side of the tube moving the nose by means of a lever. A much more satisfactory arrangement is that in which the whole body of the microscope is raised or lowered by a screw in a pillar at the back of the stand on which it slides. A rack for the coarse adjustment is useful, but not essential. If a sliding tube only is provided, it must be tight enough not to slip, but must move easily up and down with a sort of screwing movement. A mechanical stage is not at all necessary, and for most purposes one of black glass is better as well as cheaper. The diaphragm for regulating the light should be as near level with the surface of the stage as possible, and when examined with a low power should appear in the centre of the field. For research work on the minuter ferments, an achromatic condenser and the finest oil- or

water-immersion lenses are necessary, but directions for this are beyond the scope of the present work. It may, however, be mentioned that Prof. Flügge,[A] a first-class authority on the subject, especially recommends Abbé's illuminating apparatus as made by Zeiss.

[A] "Fermente und Mikroparasiten," Leipzig, 1883.

A frequent defect in cheap English microscopes is that the mirror for substage illumination does not bring the rays of a lamp to a focus exactly on the slide, but frequently some inches above it. This may be to a great extent overcome by the use of a bulls'-eye condenser between the lamp and the microscope. Another defect is that sometimes the centre of the mirror is not in a line with that of the microscope body.

The objectives (or lenses at the lower end of the microscope) are the most important part of the instrument, and however good it may be in all other respects, if these are defective the whole is useless. The most useful lenses for our purpose, if only two are to be selected, are a 1-in., magnifying about 50 diam., and a $^1/_4$-in., magnifying about 200 to 400, according to the eye-piece; a $^1/_8$-in. giving, say, twice this magnification will be needed to see the smaller bacteria distinctly, but it is possible just to see even the small putrefaction bacteria with a really fine $^1/_4$-in. In any case, the highest power should be as perfect and of as large an angle as attainable. A good $^1/_4$-in. should resolve *Pleurosigma angulatum* with direct light, and should show the movement of the granules of protoplasm in the round corpuscles which are present in saliva. In using the latter test, it must be remembered that the motion only lasts a very short time on a cold slide.

About 5*l.* is the very least for which a microscope can be obtained which is suitable for tanners' use; where it can be

afforded, a better one is advisable.

Without disparaging other makers, it may be mentioned that the writer has generally used both the eye-pieces and objectives of Dr. Hartnack of Potsdam; and that they are moderate in price, at least for the dry combinations, and perfectly satisfactory for all technical purposes. Numbers 2, 5, and 8 objectives with No. 3 eye-piece, are sufficient for all ordinary work. If only 2 objectives are to be obtained, Nos. 3 and 7 would be perhaps the best selection. It is always better to use objectives on the stand, and with the eye-pieces for which they are intended, but in case Hartnack's objectives are used on an English stand (which is easily done by means of an adaptor ring), it is important to remember that they are constructed to work with a shorter tube than that customary on English microscopes, and that they will not perform well if its length is much more than 6 in.; these objectives are not provided with a movable adjustment for thickness of cover-glasses, which for technical purposes is not required, and in inexperienced hands is apt to prove troublesome. Extra-thin covers must therefore always be used. Where this adjustment is provided, the object must be accurately focused, and then, maintaining this focus with the fine focusing-screw, the collar must be cautiously turned till the best definition is obtained. Practically it will be best to make this adjustment accurately once for all, and to take care to use covers selected of a uniform thickness.

High-power objectives of wide angle (which condition is essential to good defining power) necessarily work extremely close to the object, and it is always best to use the thinnest cover-glasses which can be got. Even then, with such glasses as Hartnack's No. 8, unless the sections are very thin, it will be impossible to examine their lower parts; and one of the greatest difficulties of microscopic research

is to obtain them thin enough. It will be obvious, from what has been said, that the greatest care is needed to avoid screwing the objective down on the cover, and so breaking one or both of them. One way to avoid this is to screw down as close as possible to begin with, and then focus upwards. Another plan, when the object on the slide is small, is to keep continuously moving the slide gently with the fingers, while looking into the tube. It is then easy to notice when the dust and small particles on the slide come into focus, and if the point should happen to be overstepped the contact will generally be felt before serious damage is done.

Illumination is one of the most important points in practical microscopy. With powers of not less than $^{1}/_{2}$-in. focus, objects may generally be examined by light thrown upon them from above by a bulls'-eye condenser, or by good daylight. In this case they need not be transparent; and the plan is often convenient for a mere surface examination. In examining bodies illuminated in this way, prominences often appear as hollows and *vice versâ*, by a sort of optical illusion, which, once established, is very difficult to overcome. By remembering the direction of the light, and that this appears reversed in the microscope, it is easy to decide the truth.

For all finer work and higher powers, and most generally with the low powers also, it is necessary to render the object transparent, and to examine it by light transmitted from the mirror below the stage.

Good daylight is least trying to the eyes. Where artificial light must be used, that of a small paraffin lamp is best; and a blue chimney, or blue glass interposed between the stage and mirror, or lamp and microscope, spares the sight, and makes it easier to distinguish colours. The light should be sufficient, but not too dazzling. Work should never be prolonged after the least strain is felt, nor should the

microscope be used for some little time after a meal. It is well to accustom oneself to keep both the eyes open while observing.

If it be required to see how far the cellular structures of the hide, such as hair-sheaths and fat-glands, are affected or destroyed in any stage of liming or bating, the following ready method may be employed. If a strip of hide be cut $^{2}/_{3}$ through from the grain side, as shown at *a* in Fig. 7, and the flap be turned down, and held between the finger and thumb, the fibrous tissue will be put on the stretch, and will then allow a moderately thin shaving (including the grain and parts immediately below it) to be cut by a sharp razor. The hide should be held in the positions shown, and a steady drawing cut be made from flesh to grain, the razor being steadied on the tip of the forefinger, and its hollow surface flooded with water. If the thin section be now placed on a glass slide, moistened with a drop of water, and examined on the microscope under a strong light from above, with a 1-in. objective, the fat-glands will be seen as yellow masses, embedded in the white fibrous tissue. If a drop of a mixture of equal vols. of strong acetic acid, glycerin, and water be used to moisten the section, the fibrous tissue will become quite transparent, and whatever remains of the cellular tissue will be easily visible, and may even be studied under tolerably high powers if covered with a thin glass, and lighted by the mirror from below. (The cover-glass must be carefully cleaned by rubbing with a linen handkerchief, and placed in position with a pair of tweezers, one side being supported by a needle, which is gradually withdrawn, so as to avoid air-bubbles.) Care must be taken that this mixture does not touch the brass-work of the microscope; even the vapour is apt to tarnish, so that the preparation must not remain longer than necessary on the microscope. The same method is applicable for ascertaining the completeness of the tannage of leather,

and to decide whether the hide fibre is really tanned, or only dyed. Actually tanned leather is unaffected by the acetic acid, but raw or only stained hide swells and becomes transparent.

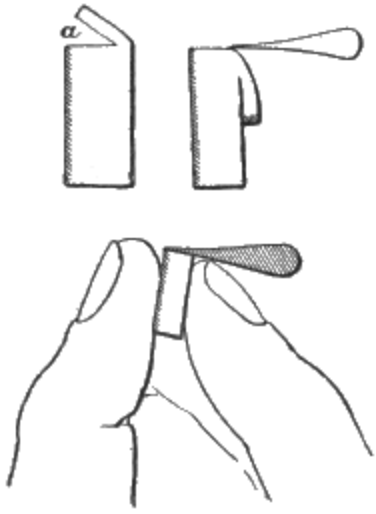

FIG. 7.

To prepare the very thin sections necessary for detailed study of the hide, more complicated methods are required. Small slips of hide, not exceeding $^{1}/_{4}$ in. wide, and cut exactly across the lie of the hair, are placed first in weak alcohol (equal parts methylated spirit and water), and, after a few hours, are removed into strong methylated spirit. It is then kept for some days in absolute alcohol, which must be repeatedly changed, until the hide is hard enough to give fine shavings, and may be cut either when held as above described, between cork or pith, or when embedded in paraffin wax. This is accomplished by placing the piece of hide in a little paper-box and covering it with melted paraffin (candle), which is just beginning to stiffen. The piece of hide may be fixed in position with a needle, which must of course be withdrawn before cutting. When hard, the paraffin is shaved away till the object is exposed, when it may be cut. The razor must be wet with alcohol, and the section be made exactly in the plane of the hair-roots, which may be

seen with a hand-lens. (The use of a microtome for hide-sections is rarely successful, as it is almost impossible to fix the fragment of hide so that it is cut exactly with the hairs.) The slices may now be stained by placing them in a watch-glass with water and a few drops of the logwood or picrocarmine staining-mixtures sold by opticians, and afterwards either examined in glycerin, or, after soaking some hours in absolute alcohol, may be transferred to clove-oil, and afterwards to a slide, and covered with a drop of dammar varnish or Canada balsam dissolved in chloroform. The sections moistened with glycerin may also be mounted in Farrant's solution or glycerin jelly, under a cover-glass for permanent preservation. If picrocarmine be used, the connective-tissue fibres (gelatinous fibres) and the nuclei of the cells will be coloured red, and the cells themselves of both epidermis and glands, together with the muscles and elastic fibres, will be yellow.

Franz Kathreiner, who has made very elaborate researches on skin, and the changes which take place in it during the processes of tanning, employs a mixture of osmic and chromic acids for hardening, and at the same time staining the tissue. This mixture was first used by a German histologist with whose name I am not acquainted, in a research on the internal organs of hearing, and was applied by Kathreiner in 1879 to the investigation of skin, and communicated by him to the writer in the autumn of that year. His method is briefly as follows. The pieces of hide to be examined must, if salted, be well washed, or if dry, be thoroughly softened. For the study of hide in its unaltered and natural condition, it is essential that it be quite fresh, and taken from the animal as soon as possible after death. In any case the *Panniculus adiposus* or fatty layer is, as far as possible, removed with scissors, the hair cut short, and the skin cut up into little pieces of 3–4 millimetres wide by

10–12 millimetres long (about $^1/_8$ in. by $^1/_2$ in.); the hair must lie exactly across these pieces.

They are then placed for 4–8 days, according to the thickness of the hide, in about 12 times their volume of a solution consisting of

0·2	parts	osmic acid.[B]
0·5	"	chromic acid.
200·0	"	water.

[B] Solution of osmic acid is best preserved in sealed tubes in the dark. If obtained in solution it is rarely of full strength, for which allowance may have to be made. Care must be taken to avoid inhaling its fumes, which are very irritating to the eyes and to the respiratory organs, producing severe catarrh.

This solution must be kept from dust and light, in a glass stoppered bottle, and in a cool place. On removing the hide-pieces from this solution, they are placed in about 12 times their volume of absolute alcohol for 4–8 days, during which time the spirit must be at least 3 times renewed. The sections are cut with a razor flooded with absolute alcohol, so that the thin shavings float without friction upon it. The hide-pieces may be held either between soft cork, or, as is generally preferable, simply between the forefinger and thumb as shown in Fig. 7. The cut must be made exactly parallel with the direction of the hair roots, and from the grain towards the flesh; and the sections cannot possibly be too thin. After lying for $^1/_2$−1 hour in absolute alcohol, the sections are soaked till quite clear in clove oil (which must be pale and of the purest kind), and may then be mounted in dammar varnish, or solution of Canada balsam.

In these sections, fat and the oily contents of the fat glands are stained black, and the limits of the cells both of these glands and of other elements of the hide (*rete malpighi*, hair-bulb, &c.) are made very distinct, so as to be

capable of the most delicate investigation under the highest powers; but the beginner will learn most easily to recognise the different tissues by studying at first some sections stained with picrocarmine as before described. The method is admirably adapted for the study of hide as affected by the limes and bates.

CHAPTER II.

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CHEMICAL COMPOSITION OF HIDE.

The chemical composition of skin is very imperfectly understood. The bulk of the skin is, as has long been known, converted by boiling into gelatin or glue. The yellow fibres and cellular tissue remain undissolved. Müntz, who made some interesting researches on the subject, found that completely dried hide contained—3·086 per cent. of cellular tissue insoluble in hot water, 1·058 of fat, 0·467 of mineral matter, and 95·395 of matters soluble in hot water. Müntz counts the whole of the tissue soluble in hot water as converted into glue; but this is not strictly the case. Gelatin is not identical with the fibre of the hide, which is only converted into it by boiling. The nature of the change is not well understood; but it is either simply molecular, or depends on the addition of one or more molecules of water. The gelatin of bones seems identical with that of skin and connective tissue, but that of cartilage differs slightly from it, and is called chondrin. Raw hide, unhaired and purified, contains, according to Müntz—carbon, 51·43 per cent.; hydrogen, 6·64; nitrogen, 18·16; oxygen, 23·06; ash, 0·71; while gelatin has—carbon, 50·1 per cent.; hydrogen, 6·6; nitrogen, 18·3 (Mulder); carbon, 50 per cent.; hydrogen, 6·5; nitrogen, 17·5 (Fremy). Probably, however, neither substance was quite pure.

Gelatin is insoluble in alcohol, ether, and cold water, but swells in the last, absorbing about 40 per cent. It is soluble in hot water, but is reprecipitated on the addition of a sufficient quantity of alcohol, resembling in this respect

gum, dextrin, and many other substances. It is soluble in glycerin, with the aid of heat, and in concentrated sulphuric acid in the cold. Moist gelatin exposed to the air rapidly putrefies. It first becomes very acid, from formation of butyric (and perhaps other) acids, but afterwards alkaline, from evolution of ammonia. Boiled with concentrated potash, it yields leucin (amidocaproic acid, $C_6H_{15}NO_2$), glycocin (sugar of gelatin), and other substances. The same products are obtained by boiling with sulphuric acid, and probably also more gradually, and in greater or less proportions, by the prolonged action of lime or barium hydrate, by putrefaction, and by any other influence which tends to resolve the gelatin molecule into its simpler parts. Gelatin is precipitated by all tannins, even from very dilute solution. A solution containing $^{2}/_{10000}$ parts is rendered turbid by infusion of gall-nuts or gallotannic acid. The precipitate is soluble in excess of gelatin. Solution of gelatin dissolves considerable quantities of lime phosphate, hence this is always largely present in common glue. Gelatin is precipitated by mercuric chloride, in this respect resembling peptones; but not by potassium ferrocyanide, by which it is distinguished from albuminoids; and it differs from albumen in not being coagulated by heat. On the contrary, by prolonged boiling glue loses the property of gelatinising, and becomes soluble in cold water, being split up into two peptones; semi-glutin, which is insoluble in alcohol, and precipitated by platinic chloride; and hemicollin, which is soluble in alcohol, and not precipitated by platinic chloride. Both are precipitated by mercuric chloride (see Hofmeister, abst. Chem. Soc. Jour. 1881, p. 294). Gelatin or glue with about 3 per cent. of potassium dichromate becomes insoluble when exposed to the light, from the formation of a chromium compound. This reaction is the base of several modern photographic processes, and has been used for waterproofing and for cementing glass, &c.

The connective-tissue fibres are partially converted into gelatin by the action of strong acids and alkalies, as well as by heat. By weak acids, they are swollen and gradually dissolved, and Reimer[C] has found that the material may be reprecipitated by lime-water. It forms an irregular fibrous mass, which has not the sticky feel of gelatin, but is at once converted into that body by boiling. Rollet has demonstrated that when hide and other forms of connective tissue are soaked in lime- or baryta-water, the fibres become split up into finer fibrils, and as the action proceeds, these again separate into still finer, till the ultimate fibrils are as fine as can be distinguished under a powerful microscope. At the same time, the alkaline solution dissolves the substance which cemented the fibres together, and this may be recovered by neutralising the solution with acetic acid, when it comes down as a flocculent precipitate. This was considered by Rollet to be an albuminoid substance; but Reimer has shown that it is much more closely allied to the gelatigenous fibres, if indeed it is not actually produced from them by the action of the alkaline solution. Reimer used limed calf-skin for his experiments, and subjected it to prolonged cleansing with distilled water, so that all soluble parts must have been pretty thoroughly removed beforehand. He then digested it in closed glasses with lime-water for 7–8 days, and precipitated the clear solution with dilute acetic acid. He found that the same portion of hide might be used again and again, without becoming exhausted, which strongly supports the supposition that it is merely a product of the partial decomposition of the hide fibre. The substance, which he called "coriin," was purified by repeated solution in lime-water, and reprecipitation by acetic acid. It was readily soluble by alkalies, but insoluble in dilute acids, though in some cases it became so swollen and finely divided as to appear almost as if dissolved. It was, however, very soluble