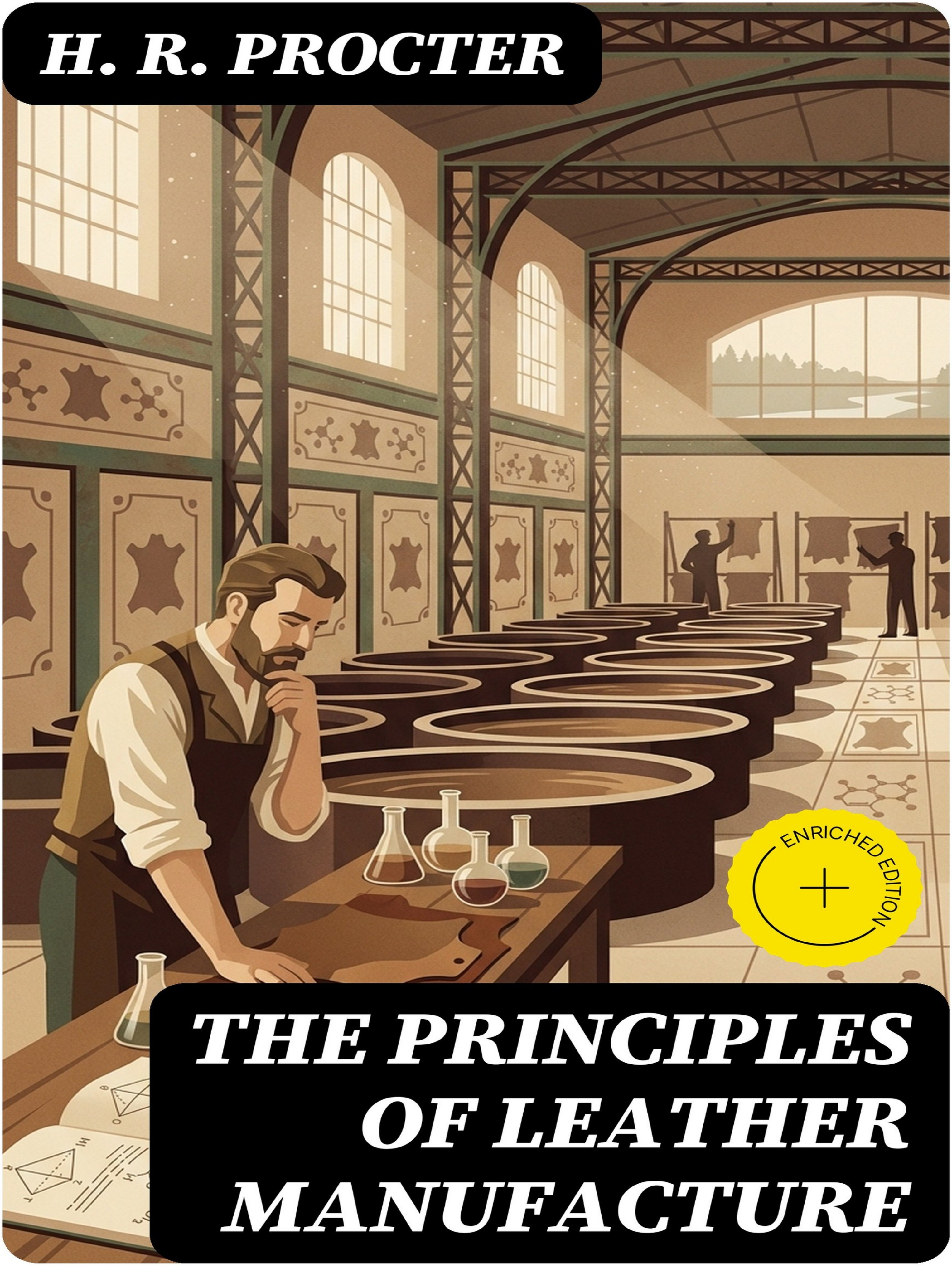
H. R. PROCTER



THE PRINCIPLES OF LEATHER MANUFACTURE

H. R. Procter

The Principles of Leather Manufacture

Enriched edition.

Introduction, Studies and Commentaries by Cooper Black

EAN 8596547251361

Edited and published by DigiCat, 2022

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PREFACE.

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The origin of the present work was an attempt to prepare a second edition of the little Text-Book of Tanning which the Author published in 1885, and which has been long out of print. Though persevered in for years, the work was never brought to completion, partly owing to the constant pressure of other duties, but still more to the rapid advances which have been made in our knowledge of the subject, and in the scientific thought which has been devoted to it. For his share in the initiation of this work, much credit is due to Wilhelm Eitner[1], Director of the Imperial Royal Research Institute for Leather Industries in Vienna, but the advance he began has been energetically carried forward not only in Vienna, but in the Tanning Schools and Research Institutes of Freiberg, Leeds, London, Liège, Copenhagen, Berlin and elsewhere, and to a less extent in private laboratories.

Under the pressure of this rapid growth, as it was impossible to complete the work as a whole, the Author published an instalment dealing with the purely chemical side of the subject in 1898, under the title of the 'Leather Industries Laboratory Book'; which has been translated into German, French and Italian, and of which the English edition is rapidly approaching exhaustion.

The present work, which should by right have preceded the Laboratory Book (and which frequently refers to it as "L.I.L.B."), attempts to deal with the general scientific principles of the industry, without describing in detail its practical methods (though incidentally many practical points are discussed). To complete the subject, a third volume ought to be written, giving working details of the various methods of manufacture; but apart from the difficulty of the subject, and the weariness of "making many books," the methods of trade are so fluctuating, and dependent on temporary conditions that they have not the same permanent value as the record of scientific advance.

As the present volume is intended to appeal both to the chemist and to the practical tanner, it must to a certain extent fail in both, since many matters are included which are already familiar to the former, and it is to be feared, some, which may prove difficult to the latter. For these and other imperfections the Author claims the indulgence of his Readers.

The Author must here acknowledge his indebtedness to Dr. Tom Guthrie and to Mr. A. B. Searle for assistance in writing several of the chapters; to Dr. A. Turnbull and Mr. F. A. Blockey for much help in reading proofs and preparing the MS. for the press; and to the many gentlemen who have furnished or allowed him to use their blocks and drawings in illustration.

The Yorkshire College,
Leeds.

PRINCIPLES

OF

LEATHER MANUFACTURE.

CHAPTER I.

INTRODUCTORY AND HISTORICAL.

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The origin of leather manufacture dates far back in the prehistoric ages, and was probably one of the earliest arts practised by mankind. The relics which have come down to us from palæolithic times, and the experience of the modern explorer, alike tell us that agriculture is a later and a higher stage of development than the life of the hunter; and since, in the colder regions, clothing of some kind must always have been a necessity, we may conclude that it was first furnished by the skins of animals.[1]

[1] See also Gen. iii. 21.

While wet skins putrefy and decay, dry ones are hard and horny; and nothing could be more natural to the hunter than to try to remedy this by rubbing the drying skin with the fat of the animal, of which he must have noticed the softening effect on his own skin. By this means a soft and durable leather may be produced, and this process of rubbing and kneading with greasy and albuminous matters, such as fat, brains, milk, butter and egg-yolks, is in use to this day, alike by the Tartars on Asiatic steppes and the Indians on American prairies; and not only so, but we ourselves still use the same principle in the dressing of our finest furs, and in the manufacture of chamois, and many sorts of lace- and belt-leathers.

Such a process is described in the *Iliad* (xvii. 389–393) in the account of the struggle over the body of Patroclus:

> “As when a man
> A huge ox-hide drunken with slippery lard
> Gives to be stretched, his servants all around
> Disposed, just intervals between, the task
> Ply strenuous, and while many straining hard
> Extend it equal on all sides, it sweats
> The moisture out and drinks the unction in.”

It must also have been early noticed that wood smoke, which in those days was inseparable from the use of fire, had an antiseptic and preservative effect on skins which were dried in it, and smoked leathers are still made in America, both by the Indians and by more civilised leather manufacturers. To this method the Psalmist refers[2] when he says, “I am become like a bottle in the smoke;” and such bottles, made of the entire skin of the goat, are still familiar to travellers in the East.

[2] Ps. cxix. 83.

The use of vegetable tanning materials, though prehistoric, is probably less ancient than the methods I have described, and may possibly have been discovered in early attempts at dyeing; an art which perhaps had its origin even before the use of clothing! The tannins are very widely distributed in the vegetable kingdom, and most barks, and many fruits, are capable of making leather.

The employment of alum and salt in tanning was probably of still later introduction, and must have originated in countries where alum is found as a natural product. The art was lost or unknown in Europe till introduced into Spain by the Moors.

Leather manufacture reached considerable perfection in ancient Egypt. A granite carving, probably at least 4000 years old, is preserved in the Berlin Museum, in which leather-dressers are represented. One is taking a tiger-skin from a tub or pit, a second is employed at another tub, while a third is working a skin upon a table. Embossed and gilt leather straps have been found on a mummy of the ninth century B.C., and an Egyptian boat-cover of embossed goat leather, as well as shoes of dyed and painted morocco, are still in comparatively good preservation. The art is of very early date in China, and was well understood by the Greeks and Romans. In the Grosvenor Museum at Chester is the sole of a Roman *caliga*, studded with bronze nails, which is yet pretty flexible. After the fall of the Roman empire many arts were lost to Europe, and it was not until the Moorish invasion of Spain that the art of dyeing and finishing the finer kinds of leather was reintroduced.

England was very backward in this manufacture up to the end of the last century, owing to the fossilising influence of much paternal legislation, and of certain excise-duties, which were only repealed in 1830. Since this time the art has made rapid strides, especially in the use of labour-saving machinery, and England may at the present moment be considered fairly abreast of any other country as a whole; though in some special manufactures we are surpassed by the Continent and by America. In making comparisons of this kind, it must, however, be remembered that, especially in sole-leather tannage, the most rapid progress has been made during the last few years in those countries which were more backward, and that therefore our superiority is much less pronounced than formerly, and in a few years will probably cease to exist unless marked improvements are introduced in the methods of production.

In the sketch of the development of leather manufacture which has just been given, it has been implied that its object is to convert the putrescible animal skin into a material which is permanent, and not readily subject to decay, while retaining sufficient softness or flexibility for the purposes for which it is intended. As these range from boot-soles to kid-gloves, there are wide divergences, not only in the processes employed, but also in the materials used and in the principles of their application.

The most important method of producing leather is by the use of vegetable tanning materials, and this is perhaps the only one which is really entitled to be called “tanning,” though the distinction is not very strictly adhered to. It includes the whole range—from sole leather, through strap, harness and dressing leather, to calf and goat skins, and the various sumach tannages which yield morocco and its imitations. All of these products but the first and the last undergo, after tanning, the further processes of “currying,” of which the most important operation consists in “stuffing” with oily and fatty matters, both to increase the flexibility and to confer a certain amount of resistance to water. Sumach-tanned skins are not strictly “curried” but usually receive a certain amount of oil in the process of “finishing.”

Next in importance to the vegetable tannages are the “tawed” leathers produced by the agency of alum and salt, including the “white leathers” for belt laces and aprons, and calf- and glove-kid. A connecting link between tanning and tawing is found in the “green leather,” “Dongola,” and “combination” tannages, in which alum and salt are employed in conjunction with vegetable tanning materials, and especially with gambier.

Salts of several of the metals, and particularly those of aluminium, iron, and chromium, have the power of converting skin into leather; and processes in which salts of chromium are used have recently attained very considerable commercial importance.

In the production of calf- and glove-kid, in addition to alum and salt, albuminous and fatty matters, such as egg-yolk, olive oil and the gluten of flour, play a considerable part, and are thus linked both to the primitive methods in use by the Indians and Kalmucks, and to those by which “crown” and “Helvetia” leather, and many other forms of belt- and lace-leathers are now produced by treatment with fats and albumens.

From these again the step is a short one to the “chamois” and “buff” leathers, and the German “*fettgar*” leathers, in which oils and fats only are used; and these are probably again related chemically to leather produced by the aid of formaldehyde and other aldehydes.

In an attempt to view all these complex processes from the scientific standpoint, the reader should constantly realise that the present methods of leather manufacture are the results of tens of centuries of experience, and of innumerable forgotten failures, and must not therefore expect that they can be easily superseded. Science must follow before it can lead, and its first duty is to try to understand the reasons and principles of our present practice, for we can only build the new on the foundation of what has been already learned. Another fact, which is scarcely understood by the practical man in his demands on science, is that in leather manufacture every question which is raised seems to rest on the most recondite problems of chemistry and physics; the chemistry of some of the most complex of organic compounds, and the physics of solution, of osmose, and of the structure of colloid bodies—problems which are yet far from completely conquered by the highest science of the day.

It may seem bold to attempt the scientific treatment of such a subject at all; and, indeed, it must be admitted that our knowledge is still far from adequate for its complete accomplishment, but enough has been done to lay a foundation for future work, and this can at least be summarised and arranged in an available form. The subject falls naturally into two sections, in the first of which the processes of manufacture would only be described in general terms, and with sufficient fulness to enable the reader to understand the scientific considerations on which they are based, and the methods of investigation which can be applied to them; while in the second an effort should be made to give working details of the various processes sufficient to enable those with a general knowledge of the trade to experiment successfully in its various branches. It was at first intended that these two sections should be published in one book as a second edition to the Author's 'Text-book of Tanning,' but owing to the long delay in its publication, it was decided to publish the first section under the present title 'Principles of Leather Manufacture,' leaving the latter section 'Processes of Leather Manufacture' to a later, and I fear, somewhat uncertain date; while the strictly chemical portion has already appeared in the 'Leather Industries Laboratory Book,' frequently referred to in the following pages under the abbreviation "L.I.L.B." Where quantities and details are given, they must not be taken as recipes to be blindly followed; or even, in every case, as the best known methods; but rather as mere guides to experiment, which must be modified to suit varying conditions and requirements. It is the special virtue of the scientific, as opposed to the merely traditional way of looking at such questions, that knowing the cause and effect of each part of the process, it can so adjust them as to get over difficulties, and to suit novel conditions. It is needless to add that many methods are jealously preserved as trade secrets, and full details are frequently unattainable.

After what has just been said, it may be well to emphasise the great importance of practical knowledge and experience to the leather manufacturer. Even in trades which have reached the highest scientific development, such, for instance, as the manufacture of the coal-tar colours, the small experiments of the laboratory are not transformed into manufacturing operations without experience and sometimes even failure; and this must still more often be the case in a trade like that of leather-making, where our knowledge of the actual changes involved is still so incomplete. On the other hand, the cost of experiments on a manufacturing scale is usually so heavy that the least scientific must admit the advantage of learning all which the laboratory can teach before venturing on anything more; while even our present imperfect knowledge of the chemical changes involved will often warn us off hopeless experiments, and give us hints of the directions in which success may be attained. A knowledge of chemistry will probably prove at least as important to the future of our trade as that of mechanics has been in the past.

CHAPTER II.

INTRODUCTORY SKETCH OF LEATHER MANUFACTURE.

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The object of tanning has been stated to be the rendering of animal skin imputrescible and pliable, but as we now rarely require leather with the hair on, preliminary processes are needed to remove it, and to fit the skin for tanning, and the nature of these processes has great influence on the subsequent character of the leather produced.

The first step is usually a washing of the skin to remove blood and dirt; while, where it has been salted or dried, a more thorough soaking is needed to remove the salt, and to restore the skin to its original soft and permeable condition.

The hair is then loosened by softening and partial solution of the epidermis structures (see p. 47) in which it is rooted. This is most generally accomplished by soaking for some days in milk of lime, which is occasionally assisted by the addition of caustic alkalies or of sulphides. When the latter are used in concentrated solution, the hair itself, as well as the epidermis tissues, is softened and destroyed in the course of a few hours. The lime not only serves to loosen the hair, but swells and splits up the fibre-bundles of which the hide tissue is composed, and so fits it to receive the tannage (cp. p. 125).

For some purposes a regulated putrefactive process is substituted for the liming; the hides or skins being hung in a moist and warm chamber (see p. 119), when the soft mucous layer which forms the inner part of the epidermis is disintegrated, partly by direct putrefaction, partly by the action of the ammonia evolved, so that the hair can be scraped off. In this case the hide-fibre is not swollen, and the necessary swelling has to be obtained by subsequent processes.

In whatever way the hair has been loosened, it is scraped off with a blunt and somewhat curved two-handled knife on a sloping rounded “beam” of wood or metal; this operation being termed “unhairing” (see p. 144).

This is generally followed by “fleshing,” which is performed on the same beam with a somewhat similar knife, which, however, is two-edged and sharp. In this operation, portions of flesh, and the fat and loose tissue which underlie the true skin (see p. 147) are removed by scraping and cutting. Machines for fleshing are also largely in use for certain purposes (see p. 148).

For sole leather, the hide, after some washing in soft water to cleanse from lime, is then ready for the actual tanning process; but for the softer leathers more thorough treatment is needed to remove the lime, and to still further soften the skin by solution and removal of a portion of the cementing substance of the fibres.

This treatment is generally of a fermentive or putrefactive nature, and the most common form is that known as “bating,” which consists in steeping in a fermenting infusion of pigeon- or hen-dung. The theory of its action is not yet thoroughly understood, but the effect is largely due to the unorganised hydrolysing ferments produced by the *bacteria* present; while at the same time the lime is neutralised and removed by the weak organic acids and salts of ammonia which are produced; and the fibre which had been plump and swollen with lime, becomes extremely relaxed and flaccid.

In the lightest leathers, such as kid- and lamb-skins for gloves, and goat and sheep for moroccos and the like, dog-dung is substituted for that of fowls, and the process is then called “puering[2]” (see p. 170).

These processes are often followed by “drenching,” which sometimes indeed takes their place, the skins being soaked in a fermenting bran infusion. In this, the small quantities of acetic and lactic acid formed by fermentation are the active agents, neutralising and dissolving the lime, and cleansing and slightly plumping the pelt (see p. 166).

The tanning process which follows consists in soaking the pelt in infusions of various vegetable products containing bodies of the class known as “tannins,” which have the power of combining with skin-fibre and converting it into leather.

If at first strong infusions were used, they would act too violently on the surface of the skin, hardening and contracting it so that the subsequent tannage of the interior would be impeded, and the “grain” or outer surface would be “drawn” and wrinkled. This is avoided by the use at first of very weak infusions which have already been used on goods in a more advanced stage. In the later part of the process much stronger solutions are employed, and the hides are frequently “dusted” in them with ground tanning material.

In the case of sole leather, these processes may require from two to twelve months for completion; after which the leather is dried, smoothed, and compressed by mechanical means, and is then ready for use.

Dressing-leathers, ranging from calf-skins to harness-hides, receive a much shorter tannage, and the subsequent treatment with fats and oils, which, together with mechanical manipulations, constitute “currying.” The thin film of grease distributed over the surface of the fibres renders them supple, and to some extent waterproof.

The lighter fancy leathers, such as morocco, are dyed, and undergo many complex processes to fit them for their required purposes and improve their appearance.

Many skins such as calf, glove, and glacé kid, are not tanned, but “tawed” by a solution of alum and salt, which is often supplemented with mixtures of flour and egg-yolk to fill and soften the leather.

Salts of chromium are also employed in place of alum and salt, and produce an equally soft, but more permanent and enduring leather.

Lastly, wash-leather, or so-called “chamois,” and buff-leather are produced by fulling the prepared pelt with fish or whale oil, which converts the skin into leather by subsequent oxidation, during which aldehydes are evolved.

CHAPTER III.

THE LIVING CELL.

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The larger part of the materials employed in leather manufacture are organic in their origin, and the skin itself is an organised structure, while the life-processes of putrefaction and fermentation play a large part in the tannery. Some knowledge, therefore, of biological structures and processes is necessary to a full understanding of much which follows, and a few words are not out of place with regard to the foundations of life itself.

The bricks of which all living structures are built are the living "cells" and their products, and these first elements differ little, if at all, whether the life is animal or vegetable, the distinction being produced rather by the way in which they are put together, than by differences in the cells themselves. This is so much the case that it is often difficult to decide in which of the two classes to place the simplest organisms, since most of these forms are capable of active movement, and their modes of nutrition and reproduction are common to both kingdoms.

In its simplest form, the cell, whether animal or vegetable, is strictly speaking not a cell at all, but consists merely of a minute mass of living jelly or protoplasm. Such is the amœba found in water and damp soil, such are the lymph-cells and white blood-corpuscles of our bodies, and such also some stages at least of the lowest forms of fungi, like the *Æthalium septicum* which is sometimes found on old tan-heaps as a crawling mass of yellow slime. If a drop of saliva be examined with the microscope under a cover-glass, with one-sixth objective and small opening of diaphragm,[3] a few scattered semi-transparent objects will be found, of the apparent size of a lentil or small pea, and of rounded form. These are lymph-corpuscles (Fig. 1). Their contents are full of small granules, and if they be observed quickly, or if the slide be kept at about the warmth of the body, it will be noticed that these are in constant streaming motion. If the warmth can be kept constant, which is difficult without special apparatus, and the cells can be observed from time to time, it may be seen that they lose their circular form, and put out protuberances (pseudopodia, “false feet”) one of which will gradually increase in bulk, till it absorbs the whole cell, which thus crawls about. It will now readily be understood how these cells wander through all the tissues of the body, passing through the smallest pores like the fairy who put her finger through a keyhole, and grew on the other side till she was all through! This independent vitality, in a warm and suitable nutrient liquid, may continue for more than a week, and, in the case of amœba, quite indefinitely.

[3] For details of microscopic manipulation in this and the following chapter see L.I.L.B., p. 234 *et seq.*

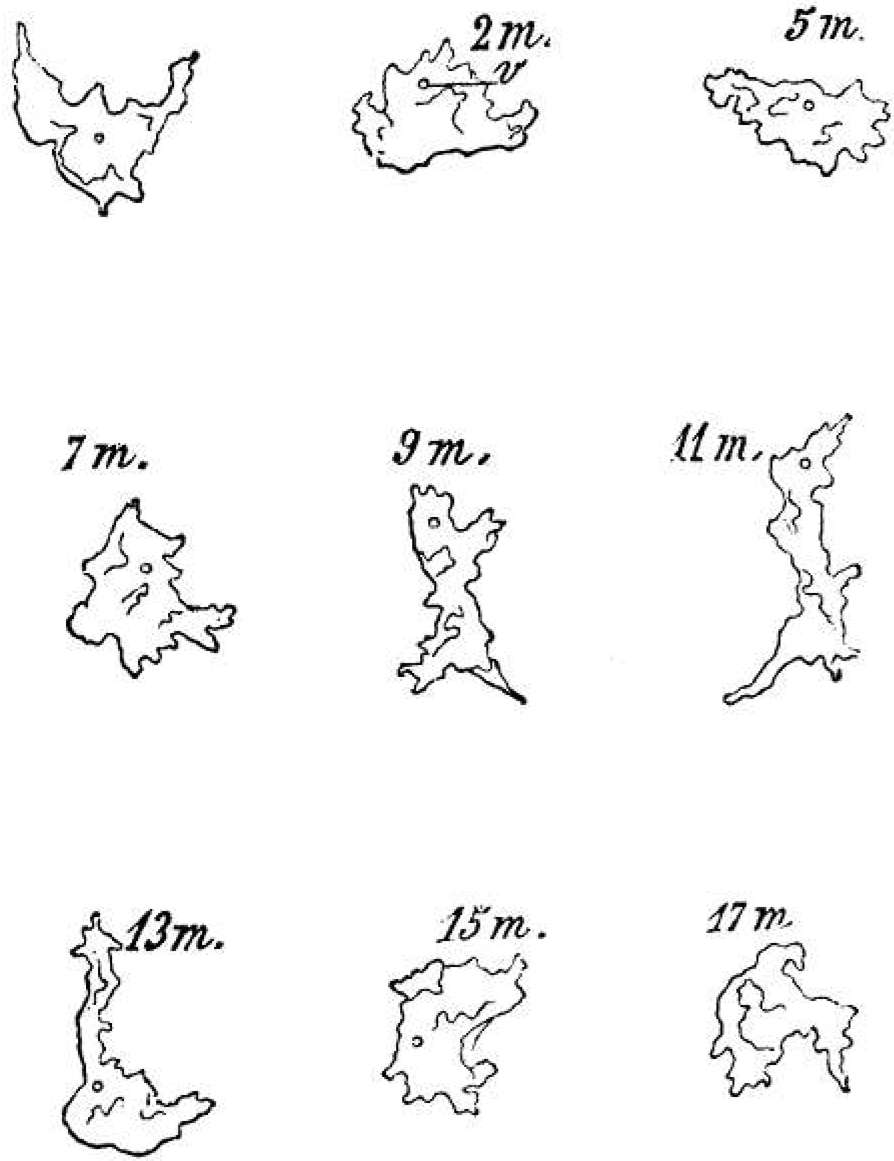

FIG. 1.—Lymph-corpuscle of frog, showing gradual change of form. (Ranvier[3].)

It is possible that by close attention, a rounded or elongated body, somewhat like an oil-globule, may be seen within the cell, though it is generally more obvious when the latter has been killed and stained with a weak solution of iodine. This is the nucleus, and within it is a still smaller speck called the nucleolus, which bears an important, and as yet little understood, part in the life-history of the cell. After a period, it undergoes certain somewhat complicated changes, and divides into two, the nucleus elongates, and also divides, each half carrying with it a portion of the living protoplasmic jelly, and thus forming two complete and independent cells. This is the life-history, not only of the lymph-cell, but with more or less modification, of every living cell or tissue.

Fig. 2.—Yeast-cells, much magnified.

These cells, like all living things, feed on the nutriment which surrounds them, and even enclose small particles of solid food, which are gradually dissolved and disappear. In this way the white blood-corpuscles are said to feed upon and destroy the still smaller organisms which gain access to the blood, and which might otherwise cause disease. The matter which cells consume is not, of course, destroyed, but simply converted into other forms, some of which are useless, or even poisonous to the cells, and which, like the secretions of higher animals, are discharged into the surrounding fluids; while others are retained, and contribute to the growth of the cell. Thus most vegetable cells secrete cellulose, or plant-tissue, which forms a wall enclosing the protoplasm, and so justifies the name of cell. If to warm water and a little sugar we add enough yeast to render it slightly milky, and examine it like the saliva, we shall have before us typical vegetable cells of the simplest form (Fig. 2). There is the same granular protoplasm, and there is the nucleus, though it cannot be seen without special preparation, the rounded spaces which look like one, being simply filled with transparent fluid, and called vacuoles. There is, however, no motion, as in the case of amœba, for the cells are enclosed in a tough skin of cellulose, which will be evident if they are crushed by putting some folds of blotting paper on the cover-glass, and pressing it with the handle of a needle or a rounded glass rod, when the protoplasm will be forced out and the skin remain like a burst bladder. This will be more obvious if the cells are previously stained with iodine or magenta, which will stain the protoplasm, but not the membrane. It is easy to observe the multiplication of the yeast-cells, which is somewhat different to that of the corpuscles. Instead of enlarging as a whole, and dividing into two equal cells, a small bud appears on the side of the parent-cell, and enlarges till it becomes itself a parent-cell with buds of its own. These do not break away at once, and hence chains and groups of attached cells are formed which are easily noticed in growing yeast if a microscope be employed. The principal nutriment of yeast is grape-sugar or glucose; and much more of this is consumed than is needed to produce the cellulose wall and the substance of new cells; just as in the animal, sugar, starch and fat are consumed to give heat and energy. In the yeast, this extra sugar is split up into carbon dioxide, which escapes as gas, and to which yeast owes its power of raising bread; and into alcohol, which in too large proportion is poisonous to the yeast itself.

HTML does not give a full forename or title, so the exact work must be identified from the book's bibliography or external catalogues.

67 A traditional currying oil recovered from skins after chamois-dressing; it is produced by partial oxidation of marine oils on skins and contains emulsified, oxidised fatty products used as a leather fat-liquor.

68 A French term used in the chamois process for the liquid oil obtained by pressing oiled and oxidised skins (the 'first pressing' or première torse), which is then blended and sometimes further processed into commercial dégras.

69 A low-molecular-weight aldehyde formed by dehydration of glycerine during heating or oxidation of fats; it is a pungent, eye-irritating volatile compound mentioned here as produced in chamoising.

70 In traditional hand-stuffing, 'dubbing' is a pasty mixture of fats (commonly cod-oil and tallow) brushed onto the flesh side of leather to help deposit grease during drying; harder fat crystals in the dubbing are later scraped off as 'table-grease.'

71 A German stuffing method (literally 'to burn in') in which leather is first thoroughly dried and then saturated with hot melted tallow or dipped in a tallow bath, used historically for heavy belting and similar goods.

72 A defect of stuffed leather described in two forms: a white, powdery efflorescence from crystallised hard fats or fatty acids, and a more serious resinous exudation from oxidised oils; the former is chiefly cosmetic while the latter can form sticky coatings.

73 William Henry Perkin (1838–1907) is the chemist who discovered the first synthetic organic dye (mauve or mauveine) from coal-tar in 1856, an event that launched the modern coal-tar dye industry referenced in the text.

74 The Society of Arts refers to the Society for the Encouragement of Arts, Manufactures and Commerce, a British organisation founded in the 18th century to promote technical and industrial improvement; it is commonly known today as the Royal Society of Arts (RSA).

75 In dyeing terminology, 'basic colours' are basic (cationic) dyes developed in the 19th century that bind strongly to acidic sites in fibres; they often fix rapidly, can give uneven penetration in tannin-tanned leathers, and may have poorer lightfastness than some acid dyes.

76 Tartar emetic is the historical name for antimony potassium tartrate, a metallic salt formerly used in tanning and dyeing to 'fix' tannins; it is a toxic compound and was also used medicinally in the past.

77 Logwood (Caesalpinia campechiana) is a tropical hardwood used as a dye-wood whose principal colouring substance is hæmatoxylin, which oxidises to hæmatin and forms coloured complexes with mordants such as iron or tin.

78 A specific type of evaporator described in the text in which the boiling liquid is sprayed through coil-tubes to expose a very large surface, enabling rapid concentration (4–5 minutes) at relatively low temperatures (about 60–70 °C); the book does not give an inventor’s biography, so its origin and date are not specified here.

79 An evaporator that uses steam-heated rotating copper discs with buckets on their rims to lift and pour liquid as a thin film over heated surfaces, promoting rapid evaporation;

it is cited as a form of surface evaporator used when vacuum-pans are unsuitable.

80 A make of screw (axial) industrial fan shown and discussed in the chapter, used to move large volumes of air at low velocities for drying; the illustrations and text attribute the supply to the James Keith and Blackman Co., Ltd.

81 A simple hygrometric instrument comprising two thermometers—one with its bulb kept moist—where the temperature difference (wet minus dry bulb) is used to estimate the air's drying power and relative humidity.

82 An early automatic fire-suppression system consisting of a network of water pipes and spray jets held closed by fusible metal links that melt at high temperature; such systems were developed and adopted in industry in the late 19th century to arrest fires at their inception.

83 A person or firm operating cotton-spinning machinery in textile mills; in the 19th and early 20th centuries cotton spinners were considered a high fire-risk trade and were among the first to adopt industrial sprinkler systems.

84 Dried fruits (commonly from Terminalia species) used as a tannin-rich tanning material in leather manufacture, traditionally imported from South Asia and used to produce or modify tanning liquors.

85 A reference to machinery of the 'Priestman' type, i.e., equipment designed or manufactured by the Priestman engineering firms active in Britain in the late 19th/early 20th century; the name denotes a known maker or design of industrial striking or handling machines rather than a generic process.

86 A practical handbook published in New York in 1876 by Jackson Schultz that surveyed tanning and leather-making practices in the United States; cited here as a contemporary technical reference for furnace designs and particulars.

87 Two common 19th-century stationary steam boiler designs used in industry: the Cornish boiler typically has a single large fire-tube, while the Lancashire has two parallel fire-tubes; both enclose water that limits the maximum furnace-temperature at their crowns.

88 A mechanical roller arrangement used to crush valonia (the cups of certain oak acorns used as a tanning material) or similar solid tanning extracts; the term denotes the crusher type modelled on equipment used for valonia processing.

89 Paper treated with the chemical indicator phenolphthalein that turns pink in the presence of moderate alkalinity (typically above pH ≈8–9), used here as a quick test to show a solution is faintly alkaline.

90 A tannin (gallotannic acid) obtained from oak galls and used as a standard tanning agent and analytical reagent; the text specifies a purified, highly soluble form used to evaluate hide-powder absorption and tannin content.

91 A commercial or prepared gelatin reagent referenced for analytical work — here a 1% solution is used to detect tannins by producing a precipitate or cloudiness when tannin is present; the precise manufacturer or formulation is not specified in the chapter.

92 Indicates the place of publication or printing; London was a major centre for publishing and printing in the 19th and early 20th centuries.