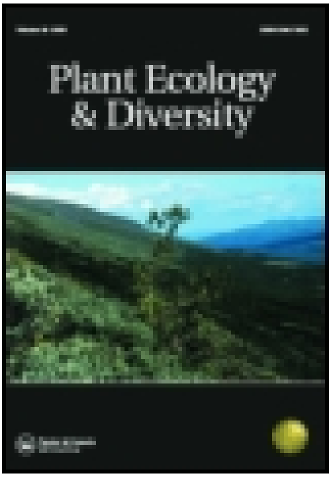

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II. On the Chemical and Natural History of Lupuline

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to one another as the two preceding; but, from the second generation, their hybrids cease to resemble them, and a certain number of individuals return to one or other of the two parent forms. Let us therefore conclude that these forms are specific, that they each have their autonomy and deserve, notwithstanding their affinity, to be distinguished from one another.

Nicotiana macrophylla and *N. angustifolia* combined in the "Prodromus" of De Candolle with *N. Tabacum*, give hybrids which, after the second generation, manifest a very appreciable commencement of return towards the producing forms. These last have therefore also their manner of growth proper to each of them. Why do we not admit them as distinct in our botanical catalogues?

But when the forms are so closely allied to one another that they are with difficulty distinguished, their hybrids must differ still less from one another than they differ between themselves. The data furnished by hybridisation, therefore, here lose their value; but then it becomes a matter of indifference, whether to separate the two forms as distinct species, or to combine them, by the title of simple varieties, under a common specific denomination.

It follows from all we have said, that the application of the terms hybrid and cross is determined by the rank which may be assigned to the individuals from the crossing of which the mixed forms requiring to be named have been produced—that is to say, it is entirely left to the judgment and tact of the nomenclator.

II. *On the Chemical and Natural History of Lupuline.* By M. J. PERSONNE. Translated by GEORGE LAWSON, LL.D., Professor of Chemistry in Dalhousie College, Halifax, Nova Scotia. (Plate II.)

Note by Translator.—Considering the great importance of the hop in an economical point of view, we might expect our scientific and manufacturing works to contain a somewhat satisfactory statement of the chemical products of the hop, and of the nature and development of the remarkable organ by which these products are secreted. This, however, is far from being the case; and intelligent brewers in Canada, puzzled by the contradictory statements that have been put forth, have frequently applied to me for information on this as on other scientific points connected with their art. I have therefore thought that a translation of M. Personne's Memoir, published some years ago in the "Annales des Sciences Naturelles," might not be without its use. In some of its bearings, the subject is of much interest in a strictly scientific point of view. It is obvious, likewise, that an acquaintance with the chemical properties of Lupuline is important, not only to the brewer, but to the hop-grower, the exporter, the manufacturer of hop-extract, and, indeed, to every one who has to handle an article so prone to change its character, and, consequently, its commercial value, from apparently trifling causes. The Canadian brewers having a favourable grain-market, and an unlimited supply of excellent water in the great lakes, almost entirely devoid of organic matter, have the means of manufacturing excellent beer. But much of the hops used requires to be imported from England. Canadian hops are grown to some slight extent at Kingston, more abundantly about Picton, and Belleville, C. W., and especially farther to the westward; but the best qualities of hops are always imported. The Canadian hop gives greater bitterness, but is deficient in delicacy of aroma. Were pains taken (and I have reason to believe that hitherto they have not been taken) to select suitable varieties from the Kentish hop-gardens, and to ascertain, more precisely than we as yet know, what are the special influences of certain soils and climates, no one can doubt but that a great improvement would result in the character of Canadian hops. All attempts in this direction must proceed upon a correct knowledge of the nature of the substances which give the hop its economical value; and although M. Personne's memoir is more complete and satisfactory than any other that has been published, yet it is to be hoped that by again calling attention to the subject, additional information may be obtained on points that are still imperfectly made out.

The cones of the hop (*Humulus Lupulus*) employed in therapeutics, and especially in the manufacture of beer, owe their properties to a multitude of yellow corpuscles, resinous and odorous, which are separated very freely in bruising the ripe and dry cones. These small bodies have been successively called by the names of Lupulin, Lupuline, and Lupulite. It is to these that the hop owes its bitter and aromatic flavour; for if the scales and the fruit are deprived of this yellow powder, the cones lose those properties on account of which they are sought after.

The importance of this substance has been known for a sufficiently long time. In 1821, Dr Ives of New York attempted to determine its principal constituents, and endeavoured to introduce it into therapeutics under the name of Lupulin. In France, almost about the same time, Planche likewise concluded that it was a proximate substance, and named it Lupuline, because, said he, "This substance is to the hop what quinine is to cinchona or strychnine to nux-vomica."

In 1822, MM. Payen and Chevallier made the most complete chemical analysis which we have of this substance. They thereby demonstrated the complex nature of lupuline, and, consequently, the error of Planche; but the small quantity of substance upon which these chemists worked, did not permit them to study sufficiently well the bodies which they had obtained from it.

Lastly, in 1827, M. Raspail published, on the organisation of lupuline, the unique work which exists on this subject. That author sought to demonstrate the analogy of this body with the pollen, as much by the investigation of its structure as by that of the action which the various solvents and chemical reagents exercised upon it. He designated it under the name of *pollen of the foliaceous organs*, "because its office," said he, "is to fecundate the bud, just as that of the pollen of flowers is to fecundate the ovary." I review farther on the observations of M. Raspail.

Structure and Development of Lupuline.

The lupuline obtained from cones that have arrived at maturity presents itself in the form of a yellow powder, whose tint varies according to the length of time which has elapsed since it was gathered. In the fresh state, it has a greenish-yellow colour, which afterwards passes into a golden yellow, deepening more and more the longer it is kept, especially when exposed to contact with air. The form of the lupuline, when it has arrived at its complete development, may be compared to that of an acorn with its cup. Just as some acorns are more or less lengthened at the base, so also some of the grains of lupuline are more or less elongated. The length of these grains varies between $\frac{16}{100}$ths and $\frac{30}{100}$ths of a millimetre, and their thickness between $\frac{14}{100}$ths and $\frac{25}{100}$ths; but in general the two parts of the lupuline, the superior and inferior, are strictly proportional. We shall later see the reason.

In comparing the lupuline with an acorn, I do not mean to say that it is, like it, composed of two solid parts, one of which encloses the base of the other. The comparison can only be applied to the external form, for they differ in all other respects. In fact, the surface of the two parts, superior and inferior, of the lupuline, is perfectly continuous, only the superior, at its point of insertion on the inferior, is bent a little inwards towards the centre, and it is the slight curve which it makes that gives it the acorn form.

These two parts present on the exterior, even under a magnifying power of from 200 to 300 diameters, a structure apparently similar. Both appear to be composed of cellules more or less irregular, which, however, are frequently disposed with a certain regularity from the centre to the circumference; they are sometimes ranged in radiating series from the summit of the superior part, and from the base of the inferior to the circumference or median line, which unites them. The cells, therefore, increase in size from the two extreme points to the (median line) point of junction. But as I said just now, this structure is only *apparent* in the upper half; because if we succeed in making a longitudinal section in the direction of the axis of the grain of lupuline, and adjust the same, when placed under the microscope, in such a manner that the plane parallel with its axis shall be in the focus of the instrument, it will be seen that the lower half of the grain is a sort of cupule, composed of a single layer of cells. It is by the base of this cupule that the grain is attached to the epidermis of the bracts, calycine leaves, &c. It is observed, besides, that the upper half consists only of a very thin continuous membrane, and that the cells, which are depicted upon its surface, are nothing more than the imprints of utricles, the origin of which we give further on in describing the formation of this organ, this singular gland. The space embraced between this membrane and the interior of the cupule is occupied by a yellow liquid, the nature of which we shall examine fully farther on. The cellules which compose the cupule are also filled ; it is these that secrete it, as we shall presently see.

One sees already that this description of lupuline differs essentially from that given by M. Raspail in his " New System of Organic Chemistry," 1833, page 175. Here, in effect, is what he says :—" Examined by the microscope, this yellow powder (the lupuline) is seen to be composed of vesicular organs, rich in cellules, varying in size about the $\frac{1}{8}$th of a millimetre, and of about the form of that represented in figure 6 of plate v. (of his work.) Each of these grains, when dried, is of a beautiful golden yellow, somewhat diaphanous, flattened, presenting on some part of one of its two surfaces the mark of its point of attachment, by which the grain has been originally attached to the organ which produced it, which mark I usually designate by the name of hilum. . . . When these grains are examined, as recently obtained from the still living female cone, they are found to be pyriform, with a peduncle terminated by a hilum," &c.

And farther on, § 387, pp. 176, 177, M. Raspail attempts to prove that the grains of lupuline emit pollen tubes, and that these are produced in contact with water. The conclusion of this paper will show the cause of the error of this observer.

Let us now study the origin of lupuline.

It commences like a hair, by one cellule *l* (fig. 3, Plate II.), which is developed between cells of the epidermis *e*. This cellule, projecting to the exterior, is divided by a transverse partition at the level of the external surface of the epidermis. The utricle *a*, ovoid or elliptical, which results from this division, is in its turn divided transversely (fig. 4, *a*). The two new utricles enlarge ; the superior *a* (fig. 5) is more dilated than the other, and is filled with somewhat granular matter; the inferior *p* forms a short pedicel, which unites the former to the epidermis *e*, by means of the primitive cell *l*. Thus far the multiplication goes on by transverse division; it now proceeds vertically. The terminal cellule *a* divides longitudinally into two, as shown by figure 6 at *a*. Each of the two utricles which thus originate produces in its turn, either one after the other (figs. 7 and 9), or simultaneously (figs. 8 and 10), two cellules, so that by this time the pedicel *p* is terminated by three cells (fig. 7), or by four, as in figure 8. The figures 11 and 12 show more advanced stages of this subdivision. There now appear some new utricular elements in the interior of the terminal cells. Figure 13 presents a degree of multiplication still more advanced; in it may be clearly observed, in *a a a a*, the four terminal cells of figure 8, and that they have divided in a radial manner and parallel to the circumference. In figure 14, which indicates a later phase, may also be observed the four original divisions; but the cells of each of these are still more numerous than in the preceding figure. It not unfrequently happens that the utricular multiplication parallel to the rays is more marked than that which occurs in the other direction, in which case the section appears as in figure 15. It is at this stage of development of the lupuline that its edges become raised; then from the discoid state it becomes cup-shaped. Figure 16 represents some of these cupules which are almost arrived at the perfect state. They have longitudinal striæ, interiorly and exteriorly; that is to say, in the direction of the utricular multiplication parallel to the rays. These elegant cupules appear sessile in consequence of the pedicel not being elongated.

When the enlargement of the cups has ceased, other phenomena take place in the interior of their tissues. Each cupule consists, at this time, of a layer of cells, which is covered with a cuticle on its two faces, the interior and exterior; then commences the secretion of the yellow liquid before mentioned. It is poured out on the whole internal surface of the cupule between the secreting cells and the cuticle which covers them. The latter, detached from the cells by this flowing, is gradually raised completely from the whole extent of the internal surface (fig. 17 *d*), and finally pushed up like the finger of a glove ; it is now that the lupuline takes the form of an acorn (figs. 18 and 19), to which I have compared it ; it is then arrived at its most perfect stage of development.

It is curious to observe under the microscope the rising of the cuticle. It may be caused artificially, by placing the cupules in water slightly alkalised, which penetrates their walls better than pure water. They may be seen successively passing through all the intermediate stages between the form *l* of figure 16 and that of figure 18.

If we examine the fresh but perfectly developed lupuline in water, it is seen to swell gradually, becoming turgid by endosmose, then all the cells of the cupule appear as a perfect network, and it is then evident that the imprints marked upon the cuticle disappear almost completely. The enlargement increases to the point of bursting of the grain, and it then emits a perfect cloud, formed by a multitude of small globules of essential oil ; it frequently happens that these globules, by uniting, form a globule somewhat large, which is very well seen on the summit of the grain in front of the rent.

This rent is generally made at the junction of the cuticle with the edge of the cupule. The cuticle is raised, as a cover, and, as the cupules open, the cuticle is detached, and swims away in the surrounding liquid. Occasionally during this action it occurs as much in the wall of the cuticle as in that of the cupule, according to their greater or less resistance.

An alkaline solution and alcohol act more rapidly than water, because, by dissolving more readily the resinous matter which impregnates the walls of the grains, they render the penetration more easy.

It has never been possible for me to observe the pretended pollen tubes seen by M. Raspail, in examining the fresh lupuline. But if we examine lupuline that has been kept for some time, we observe a very few grains which are with difficulty impregnated with liquid in this or that place, and which, breaking a long time after most of the others, permit the exudation of a viscid matter. This matter, moulding itself in the aperture which gives it passage, slightly resembles, to a certain extent, a pollen tube, and it was this most probably that was seen by M. Raspail; but it requires only a slight examination to account for the appearance, which is most certainly due to the interior matter of the grains having been dried dissolving with difficulty.

The lupuline is produced on the ovaries, on the inferior surface of the bracts and on that of the leaves. It is equally met with on the stem and on the stipules; but it is only on the ovary and on the scales of the cone that the lupuline arrives at its complete development. On the leaves, on the stipules, and on the stem, it is never met with except in the state of cupules more or less advanced, or all simply of discs, which readily wither up and are shed.

The lupuline is then a gland, which contains a complex liquid, of which we now proceed to investigate the nature.

Chemical History of Lupuline.

The matter contained in the gland, which I designate by the name of *Lupuline*, has a very complex composition; its constituent principles may be classed into two groups: the one embracing those that are volatile, and are obtained by distillation with water; the other those that are fixed, or at least not volatile with steam.

Examination of the Volatile Principles.

The product of distillation consisted of a solution decidedly acid, which reddened tournesol paper, and upon which floated an essential oil, coloured occasionally of a most beautiful green.

The proportion between the quantity of essential oil and of acid of the liquor distilled varied according to the quality of lupuline employed in the operation. Besides, the lupuline when as fresh as possible, furnished at once a less acid liquor and a greater quantity of essential oil than the older lupuline, which gave, on the contrary, more acid and less essential oil; the latter is likewise drier and more resinous than that obtained with the freshest lupuline.

The quantities of essential oil which I obtained with the lupulines of different ages, have given me the following proportions:—With recent lupuline I obtained as much as

1 from 100 of the essence, while with older lupuline I have had not more than 0·61 from 100, that is near my proportion.

Volatile Acid of Lupuline.

If we next separate the essential oil from the acid liquid obtained, as I have described, by distillation of lupuline with water, and saturate the liquid with some carbonate of soda, and then evaporate to dryness, it yields as residue a mass of a soapy nature, which liquefies by heat and becomes very solid on cooling, it is with difficulty permeable by water, which, however, ultimately dissolves it completely; it, in short, comports itself like the compounds of fatty acids with alkalies.

This mass, dissolved in a small quantity of water and then treated with sulphuric acid diluted with its weight of water or with gelatinous phosphoric acid, yields some sulphate or phosphate of soda which remains in solution in the aqueous liquid, to the surface of which is seen to float a brown oily liquid, diffusing a strong and disagreeable odour of butyric and valerianic acids.

Subjected to distillation this liquid furnished, by many successive rectifications, a product which boiled at + 175 degrees (=347° Fahr.), and distilled without alteration at this temperature; the first portions carried over water in excess, which was thus separated with sufficient ease.

This acid, obtained in a state of purity, is a liquid, slightly oleaginous, very fluid, colourless, with a strong and persistent odour of valerianic acid; its flavour is acid and piquant; it produces a white stain on the tongue in the manner of energetic fatty acids; it is not solidified by a cold of −16 degrees (= +3°· 2 Fahr.), and remains perfectly limpid; it burns readily with a smoky flame. The specific gravity of this acid is found to be 0·9403 at + 15 degrees (=59° Fahr.). It corresponds to that of valerianic acid, which has been found to be 0·937 at + 16·5 (=61°·7 Fahr.)

I omit here the description of all the analyses which I have made for ascertaining the composition of this acid. All lead to the formula of valerianic acid. I have purposely multiplied its combinations with oxide of copper, oxide of silver and baryta, in order to be well satisfied of its true constitution. But the odour alone of lupuline, especially of that which has been kept for some time, does not admit of doubt of the existence of this acid among the bodies which this substance contains.

Volatile Oil of Lupuline.

This crude essential oil—that is to say, such as has been given by distillation of lupuline with water—is an oleaginous liquid, more or less fluid according to the state of the lupuline which furnished it, and of a specific gravity less than that of water. It has at the same time a somewhat intense colour of yellowish green, more frequently of a beautiful green ; its odour recalls slightly that of the hop ; but this odour does not resemble that of valerianic acid when the oil has not undergone oxidation or contact with air.

Subjected to distillation, it enters into ebullition at + 140 degrees (=284° Fahr.), and distils for some time at + 150° (=302° Fahr.) to 160 degrees (=320° Fahr.), but the temperature rises gradually, and when the process is finished, is + 300 degrees (=572° Fahr.)

The portion of this essence obtained between 150° (=302° Fahr.) and 160° (=320° Fahr.) is a sufficiently thin liquid, slightly amber-coloured, of an odour which does not resemble that of the hop, and of a specific gravity of 0·8887. It has not an acid reaction, but, on exposure to air, it acidifies and becomes resinous ; it is slightly soluble in water, to which it communicates its odour, and the solution exposed to the air acidifies rather readily ; it is soluble in alcohol and in ether. With a cold of −17 degrees (+1°·4 Fahr.) it lost a little of its fluidity, but its transparency was not altered, even after four or five hours' exposure to that temperature. It deviates to the right the rays of polarized light. Its rotatory power (Dextrogyrate) has been found by the red glass to be + 2·7⋗ for the length of $0^{m}·080$; it is then of

$$\frac{+\,{}^{6}2{\cdot}7}{80 \times D}$$

Nitric acid gives at first a beautiful purple colour ; afterwards, if heated a little, the reaction becomes more lively, and the products furnished are a resinous matter and valerianic acid.

Potash in solution fails to attack it at a boiling temperature; but if we form an emulsion with a concentrated solution of potash, and expose the mixture for some time to contact with air, we find that there are produced valerianate of potash and a resinous matter.

Fused potassa transforms it into carbonate and valerianate of potassa, with disengagement of hydrogen and of a hydrocarbon liquid.

This reaction of potassa is very important, because, after some useless trials, and a great number of analyses, it rendered clear the true nature of this essence, placing it by the side of the essential oil of valerian.

In fact, the composition obtained by analysis of the crude essence, may be represented by the formula $C_{56}H_{46}O_6$; that of the essence distilled between +150 and 160 degrees (302° and 320° Fahr.) by the formula $C_{22}H_{18}O_2$.

In submitting these essences to the action of fused potassa, there were obtained products in which the quantity of carbon and of hydrogen increased each time that they were submitted to a renewed action of potassa, while the proportion of oxygen decreased. Finally, after many successive treatments, we finished by having a perfectly pure hydro-carbon.

This hydro-carbon is a colourless liquid, which boils at +160 degrees (320° Fahr.) It does not acidify by contact with air; it is as difficult to be altered by contact, for a score of days, with pure oxygen. Its composition, deduced from analysis, is represented by the formula $C_{10}H_8$; it is consequently the same as that of the oil of turpentine and of *bornéène,* which M. Gerhardt has found in the essential oil of Valerian. But this body, although possessing the composition of oil of turpentine and of bornéène, is not the same, but isomerous with these last; for I have not transformed them into solid camphor of Borneo, neither by the action of nitric acid nor by that of potassa. Kept for some time on a solution of potassa, it acquired the odour of thyme, sufficiently to show an approach to thymol.

We see that the action of fused potassa upon the essential oil of hop, consists in setting free a hydro-carbon liquid $C_{10}H_8$, and in retaining an oxygenated body, which it transforms into valerianic acid and carbonic acid; results absolutely similar to what M. Gerhardt has obtained with the essence of valerian.

It is not easy to separate the oxygenised principle of this essential oil, because it is found to be retained in the thickish resinous matter, which does not permit the separation without great difficulty.

The essential oil of lupuline is clearly, then, to be considered as a complex oil, constituted by a hydro-carbon $C_{10}H_8$, and a body containing oxygen of the formula $C_{12}H_{10}O_2$ analogous to *valerol* of the essential oil of valerian. The formula of the crude oil $C_{56}H_{46}O_6$, may be represented by $3\ (C_{12}H_{10}O_2) + 2\ (C_{10}H_8)$; that of the oil rectified between $+150$ and 160 degrees (302° and 320° Fahr.) by $C_{12}H_{10}O_2 + C_{10}H_8 = C_{22}H_{18}O_2$.

The process by which it may be obtained as free as possible from extraneous matter, consists in preparing a tincture of lupuline with alcohol, of 36 degrees; to treat this liquid with an alcoholic solution of tartaric acid, which forms a precipitate somewhat abundant, of bitartrate of ammonia. The liquid separated from the precipitate, is added to a little water, and submitted to gentle heat in a capsule exposed to the air; the alcohol, in evaporating, leaves separate, at the end of two or three days, the resinous matter of the solution, acid and bitter. This bitter liquid is then deprived of the excess of tartaric acid which it contains, and then made to digest with some carbonate of lead recently precipitated; the mass, evaporated at the lowest possible temperature, is treated by boiling alcohol, which dissolves only the bitter matter.

Resinous Matter.

The resinous matter is very abundant in lupuline; it forms itself alone nearly two-thirds of its weight; it retains always a certain quantity of the volatile oily products, which gives to it a variable consistence, and preserves at the same time the peculiar odour of lupuline. It is oxidized by contact with air, especially in presence of water, and its colour then passes from a golden yellow to a deep brown tint, at the same time that it hardens. It is largely soluble in water, to which it communicates the property of lather by agitation. This solution presents an acid reaction, and is completely altered by evaporation in contact with air.

The alkalies dissolve it in the cold, and separate an insoluble part. This resin, insoluble in the alkalies and in water, is soluble in alcohol; it is dry, friable and inodorous. The alkaline solution, saturated by an acid, sets free the resinous matter with its original properties, and retaining some valerianic acid which is got by distillation. Lastly, nitric acid with heat attacks this resin with energy, but without producing special reaction which would serve to characterise it.

To obtain this resin as pure as possible, the lupuline must be exhausted by long boiling in water, which drives off the volatile products, and dissolves the bitter matter. The insoluble residue, composed of resin and of disintegrated tissue of the lupuline grains, well washed and dried, is then treated by boiling alcohol, which sets free, when cooled, a certain quantity of *waxy matter*; the alcoholic liquor, filtered after cooling, furnishes the resin by evaporation of the alcohol.

The wax is contained in the cells which compose the cupule of the lupuline grain; it exists also in the scales which constitute the cone of the hop, and by treating these scales with boiling alcohol, it is procured in sufficient quantity. It is dry and pulverulent, inodorous and tasteless; it begins to soften at +80 degrees (176° Fahr.), and is fully melted at +100 degrees (212° Fahr.) Strongly heated, it gives two volatile products, which diffuse an odour of wax; it burns without residue, producing a white shining flame; this matter resembles, as we see by its properties, the wax of the sugar cane.

[The paper was illustrated by drawings of Lupuline, and a series of specimens from the Industrial Museum, exhibited by Professor Archer.]

Explanation of Plate II.

Fig. 1. Cone of Hop.

Fig. 2. Terminal bud enveloped by the stipules, *s s*, on which are marked the granulations, which represent the cupules and the discs indicated by the figures 14, 15, 16, &c.

Fig. 3. Lupuline originating; *e e*, epidermis; *l*, primordial cellule of lupuline, by which it is attached to the epidermis; *a*, cellule produced

by the preceding, and which gives rise to the following modifications :—

Fig. 4. *e*, epidermis ; *l*, primordial cellule ; *a*, cellule divided transversely into two ; the inferior division constitutes the pedicel of the lupuline, the superior forms the gland of the same.

Fig. 5. *e e*, epidermis ; *l*, primordial cellule ; *p*, pedicel ; *a*, cellule containing grey matter with granules.

Fig. 6. *p*, pedicel : *a*, cellule divided into two longitudinally.

Fig. 7. *p*, pedicel ; *a*, represents one of the two cells of the preceding figure, subdivided longitudinally into two ; *a'*, is another cellule, not so parted.

Fig. 8. *e*, epidermis ; *p*, pedicel ; *a*, gland formed of four cellules.

Fig. 9. Gland, represented in figure 7, front view ; *a*, is the cell not divided ; *a'*, the cell which is parted into two longitudinally.

Fig. 10. Gland *a* of the figure 8, front view.

Fig. 11. The same gland more advanced, in which are seen many cells originating by the intra-utricular mode of multiplication.

Fig. 12. The same gland, seen on the face, and a little farther advanced.

Fig. 13. Gland more advanced, in which the four cellules of figures 10, 11, and 12, are subdivided parallelly to the ray, and parallelly to the circumference; each of the cells is indicated by *a a a a*.

Fig. 14. Gland in which the utricular multiplication is still more advanced. The four mother cells of fig. 10 are still visible, and indicated by *a a a a*.

Fig. 15. Shows the aspect which the glands present when they have acquired a somewhat considerable size ; *e*, epidermis ; *l*, the gland.

Fig. 16. Glands more advanced. The edges of the discoid glands, as seen in preceding figures, are here raised, forming cupules, *l*, *l* ; *e*, epidermis.

Fig. 17. Cupule from the internal (or upper) surface of which the cuticle *d* is detached, and elevated by the secretory products.

Fig. 18. Lupuline, which has acquired its complete development ; *c i*, secreting cupule or proper gland, surmounted by the cuticle *c s*, raised up by the products of secretion.

Fig. 19. Grain of lupuline enlarged ; *c i*, cupule or gland proper; *i*, point of attachment; *c s*, elevated cuticle. There is seen on this last the impression or trace of the cellules of the cupule, on the cavity of which this cuticle was applied.

Fig. 20. Longitudinal section of a grain of lupuline ; *c i*, cupule composed of a single layer, which secretes the contained liquid ; *c s*, cuticle detached from the internal surface of the cupule by the secreted liquid.

The figures are from the pencil of M. Trecul.

III. *Remarks on the Sexuality of the Higher Cryptogams, with a Notice of a Hybrid Selaginella.* By Mr John Scott, Royal Botanic Garden, Edinburgh.

Modern researches, on the reproductive phenomena of Cryptogams, have induced a number of botanists to accept the doctrine of their sexuality, this function being attri-

PLATE II.

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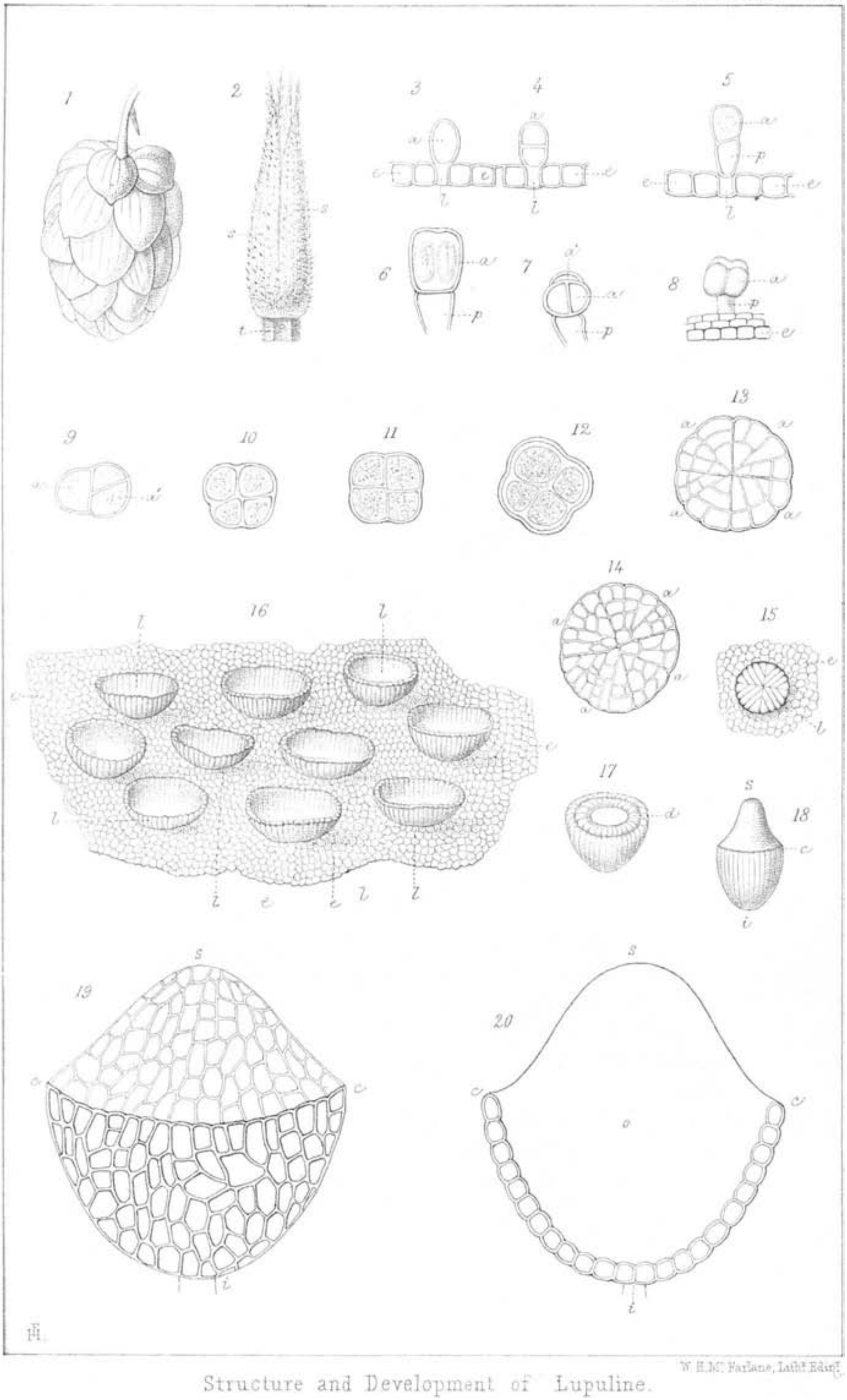

W. H. McFarlane, Lith. Edin.

Structure and Development of Lupuline.