XXXVII.—*Report of the Results of Researches in Physiological Botany made in the year* 1839. By F. J. Meyen, M.D., Professor of Botany in the University of Berlin*.

[Continued from p. 275.]

M. Mirbel† has given us some very interesting researches on the "Generative sap" of the roots of the Date-palm (*Phœnix dactylifera*); this sap he calls "Cambium." The cambium deposits itself in layers in the stems and boughs of the mono- and di-cotyledons, partly in the large interstices which remain between the utriculi or cells (schläuche), and partly in the cavities of the cells and tubes. From it proceeds the organization; and the principal object of this treatise is to follow, by a series of observations, the transition of the cambium from an amorphous state into that of continuous cellular tissue and of independent utriculi. The aim of the observations is no less than the profoundest study of the formation of all the tissues of which the different vegetative organs are composed. On examination of the roots of the date-tree, there are seen in transverse sections masses of cambium with a granular surface, at least it appears so, and this is seen with all possible distinctness. It is certain the appearance of the granulations (mamelons) precedes that of the cells; often in sections from a root of determinate age (viz. very young) in the centre of each granulation a dark spot is visible, and this is an unequivocal sign of the formation of the cavity of a cell; a larger spot shows the increase of the cell. In this latter case there was nothing granular to be seen, and the undivided partitions which bounded the neighbouring cells were thinner, in proportion as the cavities of the cells had increased in size. Frequent comparisons showed that this metamorphosis takes place without increase of substance. The cells do not remain long in this state; their sides extend, and become covered with minute papillæ, which are arranged like the squares of a chess-board, and which, although of firmer consistence than at first, still contain much moisture. Shortly afterwards these cells, which until then had had no determinate form, assume the shape of more or less regular hexagons (on transverse sections), their sides extend, become thin, dry, and stronger; the papillæ vanish, and there appear in their place horizontal, parallel, fine

* Translated from the German, under the direction of the Author, and communicated by Henry Croft, Esq.

† Nouvelles notes sur le Cambium, extraites d'un travail sur la Racine du Dattier.—Compt. Rend. 29 Avril, 1839. Ann. des Sci. Nat., Part. Bot. 1839, I. 321. Pl. 11—15. With larger plates in the Archive du Muséum d'Hist. Nat. I. p. 305.

close-pressed lines, like streaks. It is now thirty years, says M. Mirbel, since I first observed these streaks. On longitudinal sections these streaks appear vertical, and never cross each other at right angles. Some years ago M. Mirbel described an analogous case, namely, in the milk-vessels of *Nerium Oleander*—[these vessels are the cells of the liber, and in the *Apocyneæ* there is found in company with these another quite independent vascular system which constitutes the true milk-vessels!—Meyen], but the cause of the difference appeared to him to be evident. Very fine granules, placed like the squares on a chess-board, have the appearance of horizontal, vertical, or even diagonal lines, according to the point from which they are viewed.

In other vessels M. Mirbel could not see these points, but is inclined to believe, until a better explanation be given, that these horizontal, vertical, and diagonal lines on the cells and on the long and short utriculi, as well as in other vessels, are caused by a quantity of undistinguishable papillæ placed like chess-board squares. [This preferable explanation, I believe, was given by myself several years ago.—M.]

From the hollow granulations up to the cells with thin, dry, and striated sides, the vegetable matter forms one and the same completely continuous cellular tissue, the contents of which are modified by the advances of vegetation. The two states, one of which M. Mirbel designates as that of continuous cellular tissue, the other as a collection of distinct cells which are either separated or combined solely by juxtaposition, determine or fix two periods of utricular formation which may be exactly distinguished.

The root of the date-palm exhibits three clearly distinct organic regions, a peripherical, a medial, and a central.

In the above-mentioned early stages of vegetation there is a layer of cambium lying between the peripherical and the medial part, as also between the medial and the central; moreover, there are in each region certain parts destined for the formation of cells.

The peripherical part being exposed to external injuries would soon be destroyed if new cells were not added from the neighbouring layer of cambium; this addition is the more necessary, as the above-mentioned spots destined for utricular formation are here wanting, and when the layer of cambium is wanting this part of the root is reduced to two or three layers of torn and lifeless cells. The medial region exhibits in its centre the oldest cells; the younger they are the nearer they lie to the cambium of the outer or inner region. Even if it should at first sight appear as if both streams, acting in opposition to each other, must necessarily pass into each other and, as it were, meet together; still closer observation shows that only one single centrifugal and irresistible force draws along with it the layers of cambium and all the utriculi or cells. Here, where the cells formed from the cambium have so much the upper hand, there are a quantity of peculiar smaller deposits of this substance, which are destined for very different purposes; some fill the cells, while others fill the intercellular passages.

The cambium in the interior of the cells is only visible when it has the form of a gummy tissue; frequently it disappears directly after its appearance, and leaves no trace of its ephemeral existence behind. At another time these cells separate into granular spheroids, which also only exist a short time; another time one of the cells alone increases, and appears destined to acquire double the size of that which contains it, but suddenly arrested in its development it sinks again, and mixing with the cambium forms an amorphous ferruginous mass, which exists some time and then vanishes.

The cambium in the intercellular passages is not less abundant; it either separates into small masses or else forms long threads. In the first case, the organizing substance passes so quickly into the utricular state, that it is often impossible to follow its changes. The new cells are easily distinguished from the old ones; they are smaller, and their walls appear as a gelatinous tender layer. Afterwards they become stronger, larger, press themselves between the others, and grow together with them. In the second case, when the cambium passes through the intercellular passages in the form of long threads, the changes can be clearly followed nearly from beginning to end. After a granular cambium appear—gelatinous cellular tissue; a cellular tissue whose sides are covered with papillæ; tissue with dry, thin, and finely striated walls; a tissue of long distinctly bounded utriculi, which are connected with each other; new cells press themselves in between these, which are thereby increased two, three, four, or five-fold; at last openings in the partitions establish an internal communication between the utriculi.

The outer layer of cambium exists only for a short time, and in roots which possess some consistency it is not to be found. Between the cells of the first and second region there appear here and there new ones, which, by increasing, combine with each other and inclose the central region as in a sheath. They are tubular, cylindrical, and their ends fit exactly on to each other. They are at first simple, but become compound by the addition of new tubes which are formed in the interior, and between which a communication is established by means of openings.

The central region of the root derives its utriculi from the inner layer of cambium, as do also the inner parts of the medial region. Here also the oldest cells lie in the middle, but are cylindrical, they are connected only in some points, and are in full vegetation. They soon, however, pass into the compound state. The youngest exterior cells are, as it were, only cellular cambium; at this age the central region can be clearly distinguished from the medial. Afterwards there is formed between them a plate or stratum of the thickness of a single layer, the cells of which assume a determinate form, either tetrahedral or in form of a parallelogram; they are equal and closely connected together in concentric rows, while the tubes of the medial part have no fixed form. At a later period the cells of this zone become filled with cambium, which soon forms irregular tissue. They increase in size, always retaining their concentric arrangement, and each is developed in the form of a semicircle whose diameter lies on the medial region. In the centre of each of these semicircles there is a small cell analogous to the large containing cell. From its external surface proceed vertical partitions in different directions like rays, which are attached to the inner surface of the large cell. The metamorphosis proceeds rapidly, and cannot be followed by the most attentive observation.

The increase of the central region by the insinuation of new cells begins at a slight distance from the centre, and becomes continually greater till it reaches the above-mentioned zone. This phænomenon (one of the most curious in the whole formation of vegetable organs) takes place in every cell by means of successive deposits of cambium, which exists but a short time itself, but before it disappears produces a quantity of small cells which are often destined to live for centuries. Vessels of all sizes pass lengthwise through the central region; the larger lie towards the centre, the smaller near the periphery; all are polyhedral tubes, whose sides are penetrated by transverse clefts (or at least apparently so), and have more or less the appearance of small ladders, and hence the name "Vasa scalariformia" (Treppengefässe). In a note M. Mirbel adds, that he has found in the root of the date-palm that that which appears to be an opening is probably in most cases only a spot where the side of the cell is thin; but a thinning of the membrane is not very far from an opening, and every opening in a tube commences by it*.

* The opinions concerning the pores which occur so frequently on the sides of cells have been very various. Their discoverers, Moldenhawer the elder, and

Between the vessels there are compact masses of cells, which also reach as far as the zone; these separate, and a new cellular tissue, whose sides are covered with papillæ, insinuates itself between them. It extends itself in the form of an irregular layer, in the same direction as the compound vessels, viz. towards the centre.

M. Mirbel does not agree with those physiologists who hold these cellular layers to consist of laticiferous vessels, but considers them as lengthened cells destitute of coloured sap; and he thinks he has observed the gradual metamorphosis of the utriculi into variously sized scalariform vessels. Each new layer, in lengthening, separates the mass of tubes in the centre.

In the mean time a new layer of cambium is formed in each half, which is soon converted into a layer of cells and then into vessels. These formations continue so long as cambium is produced.

The metamorphosis of cells and vessels from simple ones into compound, takes place in the same manner as was stated above, by means of the development of other cells in their interior.

I have given the contents of this very excellent work without any remarks; but I must add that I by no means agree with all the results contained in it; for on an examination of the young roots of the date-palm I took quite a different view of several of the above observations. I cannot, however, here enter further into the subject.

M. Mirbel, considered them as small holes, and the latter seemed to assume the presence of such holes in the membrane of cells as a general occurrence. The Germans, in general, disputed the existence of these holes, but afterwards acknowledged their error, and held these formations as true holes. At a later period it was found that these pores were only thinner portions of the membrane, which could be clearly seen with a good instrument. M. Mohl described them as such. These differences of opinion arose solely from the imperfections of microscopes; but now we can always determine whether at any spot there are holes or only thinner parts, and we must therefore modify our opinions on this subject. The small pores appear very generally as transparent dots; but we may easily convince ourselves that actual holes do occur in the membrane of the parenchymatous cells of most herbaceous and succulent plants when they are old, for then the original or primitive membrane which closed the transparent spot is absorbed; this may easily be seen in autumn, when succulent plants are killed by the first frost. Even in the membrane of the parenchymatous cells of the *Tradescantia* I found holes at this season, although in summer not even transparent spots were to be seen. It is just the same with the large transparent spots on the sides of the parenchymatous cells in the leaves and leaf-stalks of the *Cycadeæ*; in the ferns, the palms, in short, in every case, where at an earlier period there are only transparent spots, these pores may make their appearance, but one is soon convinced that in the interior of such porous cells no circulation of the sap and no new production can take place. These formations might therefore reassume their old name of pores, if, indeed, it were any improvement.

The delineations which accompany this treatise, are among the most beautiful and correct which have ever been published; especially those in the 'Annales des Sciences Naturelles.' They are not so good in the 'Archives du Muséum.'

By new observations I have confirmed the statement, that the bark of trees is not reproduced*; in a series of cases I had covered barked twigs and young stems with glass tubes which fitted air-tight, and thereby prevented the injurious influence caused by evaporation and the consequent desiccation of the wounded surface. The substance which, under certain circumstances, is formed on the decorticated wood, and which has been considered as bark, consists simply of a loose parenchymatous tissue, and is formed out of a gum-like sap exuded from the medullary rays which open upon the decorticated surface. This sap exudes in the form of transparent drops, which, when protected from evaporation, metamorphose themselves into a colourless cellular tissue, which increases more or less according to the quantity of forming sap exuded by the medullary rays; sometimes a surface of a square inch or more is covered with this bark-like tissue, which proceeds from one point; and if this formation commences at several neighbouring spots at the same time, the masses at length join together and cover the decorticated wood for a considerable space. This new tissue is, however, not bark, and produces no new wood, and therefore cannot prevent the final death of a tree when it has been barked all round; but in case of partial decortication only its rapid production is much to be desired.

On some specimens I could see that the new layer of wood, with its medullary rays, &c. was formed only on the inner surface of the bark, for the bark which had been separated from the wood before the formation of ligneous matter produced a new ring; in some places, indeed, a quantity of this bark-like tissue had been deposited between the new-formed ring and the surface of the wood.

Moreover, I remarked that in eight cases the thick glass tubes which were fastened over the decorticated surfaces were three times broken, and indeed suddenly, and into small pieces, which cannot well be explained by an evolution of vapour.

Dr. Becks† has published a treatise 'On some Phænomena in the growth of Dicotyledonous Trees,' in which he explains the formation of those raised signs and figures which one sometimes finds on the stems of trees, when in a former period they had been imprinted on the wood, as, for instance, in

* Berichte über die Setzung des Vereins zur Beförderung des Gartenbaues in der Preussischen Staaten, vom 27 October, 1839.

† Linnæa, von 1889, 544.

the case of marks made on those trees in forests which are destined to be sold.

M. C. van Hall* has laid before the Academy of Sciences of Amsterdam a series of observations on the increase of trees in thickness, by which it is clearly shown which trees thicken slower or faster, and what is the proportion of increase in different ages, different years, and even in the several months. An oak stem which in 1826 had a circumference of 140 millimetres†, during ten years increased yearly on the average 37 mill. in circumference; an oak of 555 mill. increased during ten years 307 mill., or yearly $30\frac{7}{10}$ mill.; and another of 1792 mill. in circumference increased yearly only $12\frac{1}{2}$ mill. An elm of 170 mill. increased yearly on the average $36\frac{3}{10}$ mill.; another of 190 mill. $32\frac{1}{2}$; and one of 1155 mill. only $20\frac{5}{8}$ mill. A willow (*Salix alba*) of a circumference of 191 mill. increased $47\frac{1}{2}$ mill., and one of 1130 nearly as much. The Canadian poplar (*Populus monilifera*), in circumference 620 mill., increased yearly as much as 81 mill.; and one of 1645 mill. even $91\frac{1}{7}$ mill. Birch and maple, on the contrary, increased even when young only about 10 or 12 mill. *Pinus Abies, Tilia europæa, Juglans regia,* and *Æsculus Hippocastanum* were measured in the same manner. Moreover, seven different kinds of trees were measured for five years during the summer monthly, and these measurements in particular have given good results. It appears, first of all, that the increase in the five years was not always the same, and that no determinate increase or decrease therein, according to the age, could be observed. The increase of the circumference varied very much in the different months of the several years, which is evidently to be referred to the weather. We will here give only one of the tables in order to prove the above statements. A stem of *Ulmus campestris* measured in February 1834 265 millimetres, and increased in millimetres

	May.	June.	July.	Aug.	Sept.	Oct.	Total.
1834	13	21	17	15	2	$1\frac{1}{2}$	$69\frac{1}{2}$
1835	10	12	10	16	1	1	50
1836	8	17	6	15	7	0	53
1837	5	7	17	15	2	0	46
1838	6	15	16	12	$4\frac{1}{2}$	1	$54\frac{1}{2}$

M. van Hall remarks, that by the observations, the opinion of Agardh, that trees increase in length in the first part of the summer and in breadth in the latter part, is proved to be unfounded; and that they also show that the circumference of stems is not altered during the six winter months.

[To be continued.]

* Waarnemingen over de Toeneming der Boomen in Dikte.—Tijdschrift voor Natuurl. Geschied. en Phys. 1839, vi. p. 207.

† The millimetre is ·03937 of an English inch.