XVIII.—*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*.

On the Nutrition and Growth of Plants.

M. Lampadius† has instituted some new experiments on the vegetation of wheat in different soils, and on the quantity of earthy matters contained in the wheat plants so cultivated; from which he arrives at the conclusion that the quantity of earthy matter in the plants produced on the different soils (viz. those rich in alumina, silicic acid, lime or magnesia) remains always the same, and that these substances are not taken up mechanically by the roots, but are selected by the *Vegetative Power* by means of the roots, and are then deposited in different combinations in the plants for the formation of their several parts.

The facts from which these conclusions were drawn were the following: A piece of field was divided into 5 beds, each 20 Prussian feet square. Each bed received first of all 5 lbs. of manure (a mixture of cow- and horse-dung), then on the 1st bed were strewn 5 lbs. of finely powdered quartz, on the 2nd the same quantity of alumina, on the 3rd the same of chalk, and on the 4th 5 lbs of carbonate of magnesia; the 5th was left without any mineral manure at all. On each bed were sown 2 Pruss. cubic inches of wheat, about 675 grains. The next summer the vegetation appeared most vigorous on the bed strewn with alumina, and the produce of grains of wheat on the 5 beds, was, according to weight, as follows:—

	Produce.	
Bed	oz.	dr.
1	24	2
2	28	6
3	26	2
4	21	4
5	20	0

After incineration it appeared that the grains which had been produced from the different beds contained almost equal

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

On commencing the publication of Professor Meyen's Report for 1839, it is with much concern that we have at the same time to record the death of the author, whereby Natural History sustains a heavy loss. Translations of his valuable Reports for the years 1835 and 1837, by Mr. W. Francis, have been published; the former in the Lond. and Edinb. Philosophical Magazine, vol. xi. pp. 381, 435, 524; xii. 53; the latter in a separate volume.—See Annals Nat. Hist. vol. v. p. 211, and Mag. Nat. Hist. vol. iv. p. 408.

† Erdmann's und Marchand's Journal für practische Chemie, Bd. xviii. p. 257—269.

quantities of inorganic matters, and the same result was obtained on incinerating the chaff, the straw, and the roots; and it moreover appeared that the roots and chaff were the richest in inorganic substances. The entire plants contained by weight from 3·7 to 4·08 per cent. The quantitative examination of the ashes showed that the quantities of silicic acid, lime, magnesia and alumina were nearly the same in the plants grown on all the different soils.

The conclusions which M. Lampadius has drawn from these analyses appear certainly quite evident; but at the same time I may be allowed to remark, that the results would have turned out quite differently if he had chosen some more easily soluble salts as manure, instead of chalk, silicic acid, &c., and that the above experiments would have been much more valuable if he had before given the analysis of the soil with the manure used; and therefore I believe that the question as to whether the roots are able to select this or that substance, remains completely unanswered by this in other respects highly interesting research.

M. Boussingault has continued his chemical researches on vegetation*, and has this time chosen as his subject the impoverishment of the soil and the study of the benefits of "alternation (wechselwirthschaft—assolemens†)." In the researches of M. Boussingault alluded to in last year's Report, it was shown that plants receive a part of their nourishment from the air; and in the present memoir M. B. endeavours to show that the most fruitful "alternation" (!) is that by which the greatest quantity of elementary bodies is absorbed from the atmosphere. Now it is highly important to know the exact quantities derived from the air, in order to be able to compare the merits of different methods of cultivation. On an estate, with the products of which M. B. was well acquainted, it was found, that the manure which was used for one hectare of land contained 2793 kilogrammes carbon. The produce from this piece of land contained on the other hand 8383 kilogr. carbon, and from this M. B. concludes, that the carbon derived by the plants from the air was at least 5400 kilogr. The given quantity of manure for one hectare of land contained 157 kilogr. nitrogen, while the produce contained 251, and therefore the atmosphere must have yielded the excess of 94

* "De la discussion de la valeur rélative des assolemens par l'analyse élémentaire."—Ann. des Sciences Naturelles, Part. Botan. 1839, t. xi. pp. 31—38."

† *Wechselwirthschaft.* Different kinds of corn or other plants are cultivated on a piece of ground in a certain succession for three or more years; the land is then allowed to lie fallow for a certain time, and then the same succession or alternation is proceeded with.

kilogr. In another very productive alternation (?) which was however abandoned on account of the climate, the quantities of matters taken from the atmosphere appeared to be much greater. The produce contained 7600 kilogr. carbon, and 160 nitrogen more than the manure employed; by a three years' alternation, the fourth year the ground being manured and lying fallow, the quantity of carbon absorbed from the air was only 4358, and of nitrogen 17 kilogr.

According to M. B.'s researches, of all our common cultivated plants, *Helianthus tuberosus* takes up most from the atmosphere, and therefore this is the plant with which the smallest quantity of manure produces the largest quantity of nutritious matter. The chemical composition of the several products have been placed together in a table: in it we find the ultimate analyses of wheat, rye, barley, wheat-, rye-, and barley-straw, potatoes, beetroot, turnips, *Helianthus tuberosus* and of its stalks, yellow peas, pea-straw, red sorrel, and of manure. M. Boussingault remarks, that most of these nutritive substances have different tastes, but at the same time almost the same ultimate constitution. It cannot be said that these bodies consist of carbon and water, for in almost every instance there was a small excess of hydrogen; and from this it follows that during vegetation water is decomposed, as MM. Edwards and Colin (Report for 1838, p. 7) are said to have proved.

A very advantageous report of the above research was given to the Academy on the 14th of January, 1839, in the name of the Commission, by M. Dumas.

M. Unger, in a treatise, entitled 'Die Antritz quelle bei Gratz in Bezug auf ihre Vegetation*,' the contents of which are principally of a physical nature, has made known a number of observations, from which he arrives at the conclusion, that the free carbonic acid in springs has no influence in promoting vegetation, that it nevertheless causes the appearance of some plants, and must therefore be ranked among those causes which influence the *quality* of the vegetation.

M. Nietner, court-gardener in Schönhausen, near Berlin, has explained his views with regard to the necessity of varying plants, in order to arrive at successful results in their cultivation†. The theory, he states, is on the whole as follows: "The spongioles being the only parts of the subterraneous part of the plant which imbibe nourishment, give off certain substances, which for succeeding plants, if they be of the same

* Linnæa of 1839, pp. 339—356.

† Kurzer Umriss der Rotation oder des Wechsels der Pflanzen. Verhandlungen des Vereins zur Beförderung des Gartenbaues in den Preussischen Staaten, xiv. 1839, pp. 158—162.

species, are injurious; but if of a different genus, are, if not exactly favourable to their growth, still certainly not hurtful, as in the former case." This theory is to be found, it is true, in the most celebrated botanical works, but in the newer physiological ones it is circumstantially enough proved, that this theory is nothing better than an hypothesis, for the known experiments on which it has been founded have been shown to be incorrect; and therefore I cannot agree with those views according to which the advantageous influence of the changing plants is explained by M. Nietner. The several instances which are adduced as proving the correctness of the above theory, can be explained in a different manner; particularly the luxuriant growth of rye after three years' cultivation of sorrel, in which case the soil requires no manure. I do not suppose it is necessary to assume here an excretion from the sorrel roots which is beneficial to the rye, which moreover has by no means been proved; but one must look for this excellent manure in the roots and stubble of the sorrel plants.

Moreover, M. Nietner remarks, that carrots, parsnips? (weisse Rüben), and other bulbous plants acquire a bitter unpleasant taste, and become scarcely edible when cultivated on a soil which in the previous year has borne tobacco. This may however be explained by the great mass of the tobacco plants which always remains on such a field; these masses, abounding in alkaloids and still imperfectly decomposed extractive matters, pass over more or less into those plants which follow next.

It has at length been acknowledged in France that the results of the experiments of Macaire on the excretions of the apices of the roots of plants, on which so important theories have been founded, cannot be correct. M. H. Braconnot of Nancy has opposed the conclusion drawn by Macaire from his experiments. M. Braconnot* planted a large specimen of *Nerium grandiflorum* in a pot which had no opening at the bottom, and let it grow therein for three years, and when the earth was examined at the expiration of that time, it was found that there was nothing therein beyond the usual salts, and none of that peculiar poisonous sharp principle peculiar to *Nerium.* In the same manner the root-excretions of *Inula Helenium, Scabiosa arvensis, Carduus arvensis,* and of several *Euphorbiaceæ* and *Cichoriaceæ* were examined, but without satisfactory results. Hereupon some of Macaire's own experiments were repeated; but instead of *Chondrilla muralis*

* "Recherches sur l'Influence des Plantes sur le Sol."—Annales de Chemie et de Physique, Septembre, 1839, pp. 27—40.

common lettuce was taken and placed with its roots in water. The result of this experiment agreed with Macaire's, i. e. a portion of the lacteous sap was found in the water, the appearance of which however M. Braconnot correctly refers to the tearing of the fine rootlets. Some plants of *Euphorbia Peplus* which grew in water, imparted to it no taste, and it remained colourless: moreover the soluble substances in moulds in which *Euphorbia Brioni, Asclepias incarnata,* and *Papaver somniferum* had been grown, were examined, but the results were not favourable to Macaire's conclusions. Finally, Macaire's experiment with "*Mercurialis annua*" was repeated. One half of the roots of this plant was placed in a weak solution of acetate of lead, and the other half in pure water. In the end, the water contained some of the lead salt which had been given to the roots in the other vessel. This is, however, explained by Braconnot as the simple effect of capillary attraction in the roots, an explanation to which I cannot assent; it is by no means necessary to seek for such a one, for we can explain the phenomenon much more simply without having recourse to Macaire's views, according to which plants have the power of excreting substances injurious to them by means of their roots.

In last year's Report notice was taken of M. Payen's researches on the chemical composition of the woody substances; but they were only published with additions in the beginning of the present year*. M. Dumas gave an excessively favourable report of this research to the Academy†; however, many of the discoveries contained therein had already been published in Germany, &c., as was shown in the former Report.

It is now several years since the newer microscopes have shown that the original stratum or layer of cellular membrane exhibits characters different from those of the secondary layers: indeed the chemical difference of these parts was proved by the observations of Schleiden, and this fact has been confirmed and extended by M. Payen. The first series of ultimate analyses was made with quite tender cellular tissue, which was viewed as the primitive layers of the woody cells; for this purpose were used the ova of almonds, cucumber sap, the tender cellular tissue of cucumbers, pith of elder, pith of *Æschynomene paludosa,* cotton and "root-spongioles," (*Wurzelschwämmchen*): by this is probably meant the small extremities of roots; for I have long since proved that these "spon-

* Annales des Sciences Naturelles, 1839. Part. Botan. i. pp. 21—31.
† *Ibid.* pp. 28—31.

gioles" do not exist. All the analyses show that one may assume the proportion of oxygen to hydrogen to be as in water, and that these substances are isomeric (perhaps polymeric, H. C.) with starch, for the small differences found may be considered as faults in the analyses. With regard to these analyses it may be remarked, that however correct they may be, they by no means show us the correct composition of the primitive membrane; for in the cells of the youngest ova, as well as in those of the cucumber, elder pith, and principally of the root-extremities, indeed, even in the fibres of cotton, there is contained a great quantity of organic substances which cannot be separated without destroying the tender tissue, and the presence of these matters renders the analyses of the membrane unsatisfactory. However, we may assume, that by far the greater portion of these substances have an isomeric constitution with starch. Moreover several kinds of wood were analysed in order to show the difference of composition of the primitive membranes of their cells.

	Oak.		Box.		Aspen.	
	In its natural state.	Treated with carb. of soda.	Natural state.	Treated with carb. soda.	Treated once with carb. sod.	Treated twice with carb. sod.
C	54·44	49·68	54·35	49·40	48·00	47·71
H	6·24	6·02	6·25	6·13	6·40	6·42
O	39·32	44·30	39·50	44·47	45·56	45·87

From these analyses it certainly appears that in the ligneous substance, besides carbon and water, moreover free hydrogen must be present; but here it must also be remarked, that it is almost impossible to separate the membrane of the woody cells from their contents, and the microscope shows that various and perhaps resinous substances are contained in them.

In a note sent into the Academy on the 24th of December, 1838, M. Payen states, that by means of nitric acid he has extracted the incrusting matter of the ligneous cells from the primitive membranes: for this purpose finely rasped oak and box wood were used. The incrusting substance (by which is meant the inner layers of the cellular membrane) dissolved in nitric acid, and was thus separated from the residual tissue, which, after repeated purification, was dried and analysed. The composition was found to be

C	43·85
H	5·86
O	50·28

whilst the above analyses gave quite a different result. According to this then the secondary layers of the cellular membrane must exhibit a striking difference in constitution; but this is very improbable; for it was shown at length in the former Report, that it is exactly these secondary layers, which by boiling with an alkali, &c., are converted into a starch-like substance; besides, the microscope should have been used before those analyses were made, but such observations are not mentioned.

In the meeting of the Parisian Academy on the 14th of January, M. Payen read a paper, entitled "Mémoire sur les applications théoretiques et pratiques des propriétés du tissu élémentaire des Végétaux*," the contents of which are of considerable interest, but would here lead us too far into the province of Chemistry.

On the 4th of February, 1839, new researches were made public by M. Payen; he gave the composition of the incrusting matter of wood as $C^{35} H^{24} O^{10}$, while the formula for the primitive cellular membrane is $C^{24} H^{20} O^{10}$ or $C^{24} H^{18} O^{9} + H^{2} O$. In the sitting of the Academy of the 30th of July, a new treatise by M. Payen was read, "On the tissue of Plants and on the incrusting substance of Wood†," an extract from which has been published by the author. M. Payen remarks, that he had already made known to the Academy his researches, according to which all young parts of plants contain a considerable portion of substances containing nitrogen; that moreover the peculiar substance of the membranes in different plants has always the same composition; and that in those parts which are grown woody by age, there are contained two chemically different substances, viz. the primitive membrane and the hard incrustation.

"Many tissues," observes M. Payen, "acquire a high degree of hardness without possessing large quantities of incrusting matter." (In the same manner we may bring forward cases where many cells with thickened sides have no hardness, and it is evident from this that the hardness of the vegetable substance does not depend solely on the thickening of the walls of the cells, but on the chemical change in the layers of cellular membrane, M.) The latest analyses and microscopical observations of M. Payen have led him to conclude that wood consists of not less than four different substances, viz. the primitive cellular membrane, and the sclérogène, which again is said to consist of three peculiar matters; the one insoluble in water, alcohol, and æther, the other soluble in alcohol, and the third in all three solvents. The ultimate composition of these four substances in the above order is as follows:—

* Comptes Rendus de 14 Janv. 1839, p. 59.

† *Ibid.* 20 Juill. 1839, p. 149.

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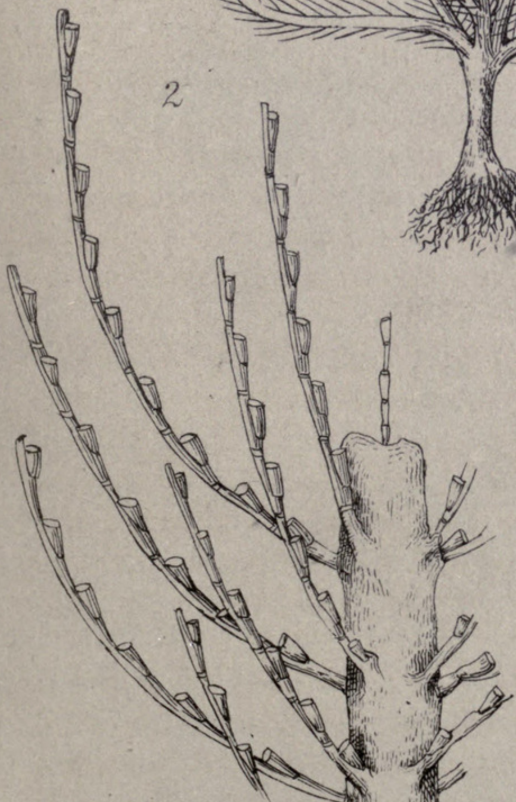

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A. Cremer, fecit.

J. Basire, lith.