SOME OBSERVATIONS ON PLANT ENVIRONMENT.

By John M'Lean Thompson, M.A., B.Sc.

[Read 20th February, 1912.]

In dealing with any branch of plant environment one must have in mind those things which are necessary for plant life. For the life of a plant water is necessary, the temperature must be suitable, and light of a given intensity may be demanded. Air is usually necessary, and a supporting and nourishing substance is required. One must also regard as important the animals which may visit it, and the other plants which are its neighbours. These are determining things whose combined influences are brought to bear upon the plant, moulding and controlling it, and constituting its environment. Each determining thing is then an environmental factor. In nature, however, the factors are found to be for ever changing and oscillating, and this is accompanied not only by a change in the plant's attitude to an altered factor, but the plant also changes its attitude to all the other factors. The factors are more-over closely interdependent. Thus, water may be determined by temperature and temperature by water, and the degree and influence of each unit in the environment are directly dependent on the other factors. It is thus that each combination comes to be dependent on a pre-existing combination.

It should be further observed that each living thing for which one can define an environment is itself a factor in the environment of other living things, and may constitute, all unconsciously, a very determining influence.

For the welfare of a plant no one factor must have an influence so great as to render the organism unable to perform properly its vital functions, and only those plants whose environmental relationships are harmonious may be expected to be conservative in their general tendencies.

In one respect in particular do higher plants differ very markedly from animals. Whereas the latter can move from place to place should their surroundings prove distasteful, the former, as far as individuals are concerned, must face their surroundings as they are. The animal can at once seek an environment in harmony with its physique and its inclinations, but the plant must for the most part yield to the conditions under which it finds itself, if it is to survive. Only within very narrow limits can the individual plant determine for itself the degree of any factor. From this point of view the ideal plant would be one able to counter-balance the slightest tendency to strained relationships between its vital functions as a whole and its surroundings, and to render any environment harmonious. So plastic an organism as this has not yet been found, but there are no plants which do not possess to a greater or less degree the power of adapting themselves to their surroundings. Without this power no life would persist.

It must further be remembered that in plant life competition is inevitable, and so on the plant's power of adapting itself, on its plasticity, and on the harmonious relationships established between the plant's vital functions as a whole and its environment much depends.

A detailed examination of a single plant, and a determination of the ways in which its controlling factors exert their influences upon it would result in a definition of the plant in terms of its environment, and of the balance struck between the controlling factors.

It is proposed simply to illustrate a few aspects of this subject, and in the first place Plasticity of Form will be briefly discussed. As a type the Wild Mustard Plant will be chosen.

This plant is a troublesome and persistent weed on cultivated soil. It usually becomes conspicuous in our corn fields in May or June, displaying its bright yellow flowers on long spikes which rise above the rapidly growing crop. In potato and turnip fields it is also rampant; while by the road-side, on the waste heap, and on the most scanty and rocky soil, it is by no means uncommon. Three plant-types are distinguishable, and for convenience these may be named "The Corn Field," "The Potato Field," and "The Poorly Fed" plants.

The seed from which a corn field plant has sprung had lain in the soil during the winter, or had been sown with the grain in the spring, but no sooner is the seedling established than it finds itself faced with a great difficulty. It is surrounded by a rapidly growing corn crop which will soon attain a height of three or four feet. For the well-being of the mustard seedling an adequate supply of light must be maintained, but from the very outset there is the danger of over-topping and overshadowing. If the mustard plant is to survive it must find a means of overcoming its difficulties. The prevalence of mustard plants in our corn fields in early summer is good proof of the plant's ability to surmount those difficulties. It is not to be imagined that the plant as it were foresees that a factor essential for its well-being is threatened, and that it resolves to bestir itself to face the emergency, but the seedling's functions demand an environment in which light is ample, and immediately the rapid growth of the corn plants has commenced, the optimum supply of light is lost, and the harmony of the plant and its surroundings is destroyed by the disturbance of one essential factor. The food supply may be ample, the temperature suitable, and all the other factors may have remained unchanged, but the harmony for the factors as a whole has been destroyed. It is this loss of harmony which is perceived, and to strive to render itself harmonious to its new circumstances, or to regain the lost optimum illumination is but natural to the plant. This is a very critical point in the life of the mustard plant. To accept

the condition of weak illumination means resignation to the corn plant's interference, but it is certain that very few plants are able to adjust their vital functions to suit this condition, and the general result of resignation is the destruction of the plant. It must, however, be remembered that if the plant could adopt the methods which it would adopt if it found itself growing quite apart from competing neighbours, it would do so. Experiment has shown that under such circumstances a broad and much branched stem, and large leaves are first provided, and that not until these have been secured is flowering attempted. In the present circumstances, however, this normal development is impossible, for, if the plant is to survive, it must first regain, and then continue to maintain its optimum illumination. To accomplish this it must adopt the methods of the corn plants around it; it must sacrifice its vegetative development, elongate rapidly, and hasten to flower. This second course is usually followed, and in the upward race which results the mustard plant is able, usually, at first to outstrip the corn plants, and it is during this period of temporary victory that it must seize its opportunity of flowering. At maturity then, the mustard plant of the corn field is tall and slender, its branches are few and its leaves comparatively small. The opportunity of flowering must be taken as soon as the plant-body will allow, and, as the time during which flowers can be displayed freely is short, as many terminal flowering spikes as possible are produced at once. By its early floweriug the mustard plant is simply evincing its inability to struggle further against the natural advantages possessed by its neighbours, and when the flowering is past the plant-body alters little in appearance and its remaining energies are directed to the nourishment of seed. In the behaviour of this type of plant one recognises adaptations, which have been made possible only by enormous plasticity of form, in a plant to which rapid upward growth is unnatural, to keep pace with the corn plants to which rapid upward growth is natural. For this type of plant the flowering period usually ranges from May to June, but it may not be arrived at till the middle of August in fields with short crops.

But in marked contrast to the foregoing is the condition of the mustard plant of potato and turnip fields. Many of the factors in its environment may be identical with the corresponding factors which govern the corn field plant. The neighbours of the two types of plant are, however, very different. At no point in the life of the potato field mustard plant is there the danger of loss of light due to the overtopping by its neighbours, and in fact, the mustard plant may often exceed its neighbours in height. It follows then, that since there is no danger of overshadowing, no modification is required by the mustard plant to meet such a danger. The fully developed mustard plant of potato and turnip fields is then short and slow growing, and seldom exceeds 2 feet 6 inches in height, but its stem is broad, its branches numerous, and its leaves large and well expanded. The interference of the corn plants necessitated both vegetative and reproductive adaptation on the part of the mustard plant, but here, however, neither vegetative modification nor early flowering is required, and each branch is provided with large leaves and secondary branches before the flowers are expanded. The vegetative period is a prolonged one, at any point in which a flowering axis may be produced, and one need not be surprised to find this type of plant steadily increasing its vegetative parts, and continuing the production of flowers during a considerable period. For it the flowering usually begins in July, and may be continued till the middle of October.

Of the third type—the poorly fed plant—little need be written, but it is referred to in order to illustrate how, under unfavourable conditions, a plant may attempt reproduction. The seed from which this plant sprang had found a resting place which has proved unsuitable for the production of a healthy plant, and scarcely has the seedling established itself and a few small leaves have been developed than the vegetative period is brought to an end, and in a usually vain endeavour at propagation it rushes to flower, producing at the end of its axis a few small flowers which it can seldom nourish and bring to seed. For this type of plant no definite flowering period can be given, for that must depend in each case on the

nature of the struggle through which the plant has come, but it seldom precedes the month of June, and may only be arrived at in September.

It is, however, not to be imagined that what has been stated above is in itself sufficient to explain the condition of any one type of plant mentioned, for a full explanation can only be based on a thorough knowledge of the physiological conditions of the organism at *every* stage in its development. It may, nevertheless, suffice to illustrate the variation in form in varying environment, and to mark out some things which are *determining*. That the variation is purely environmental has been proved experimentally. Seeds have been gathered from both corn field and potato field plants, and from these have been reared in pots, plants, all of which proved to be normal low-growing forms. Further, seeds of potato field plants have been sown in corn fields, and from these have been obtained only typical corn field mustard plants. At the same time, seeds of the corn field type of plant, sown in potato and turnip fields, have yielded only typical potato field plants.

It should be remembered, however, that the mustard plant on cultivated soil has proved itself troublesome to the farmer not so much as a competitor with his crops, as because it is very susceptible to the attacks of the Myxomycete Plasmodiophora which causes the disease known as "Finger and Toe." It is thus a host in whose roots are matured spores, which may render the soil unsuitable for years, for the production of a Cruciferous crop. The Myxomycete enters the mustard plant by the root hairs during the seedling stages, and having colonised the root system, stimulates its host to produce, and to store in the roots an abundant supply of Carbo-hydrate, which is employed in the nourishment of the spores. It is when one remembers how great is the drain on the resources of the mustard plant of the cornfield in which this disease has established itself, at the time when materials for rapid growth are urgently required, that a just estimate may be obtained of the vitality of those plants which survive in so hostile an environment.

Turning from purely vegetative to reproductive parts one is faced by the enormous variety of flower form and mechanism. There is good reason to believe that prior to the Jurassic period there did not exist any plant possessing the attractive appendages and intricate mechanisms which one associates with Angiospermic reproduction alone. The geological evidence proves further that the Jurassic period saw the evoluion of the pollinating insect. In late Jurassic and early Cretaceous times there was a simultaneous outburst of true flowering plants and of pollinating insects in the vegetable and animal kingdoms respectively, and there can be little doubt that the "Flower" and the "Visiting Insect" have had a symbiotic development. A few points will be discussed from the environmental standpoint. For many years it was held that flowers were altered vegetative parts, and suitable cases were by no means lacking which were believed to demonstrate that a flower was a "shoot" whose axis had become shortened, and whose appendages, terminally aggregated, were leaves, transformed and set aside for reproductive purposes. Sepals and petals were held to show clear proofs of their *leafy* origin, while stamens and carpels—which alone produce the sexual elements—were believed to have arisen in like manner, but to have departed most from their ancestral forms. According to this theory, the true sexual organs were merely altered vegetative leaves, and the fact that a purely vegetative phase invariably precedes sexual reproduction in the *individual life history* was looked on as a further proof of the priority of the vegetative parts *in descent.*

Such a theory was based almost entirely on *external form*, but with accurate knowledge of the structural and developmental details of stamens and carpels, and by comparison on an evolutionary basis with the sexual processes in "lower plants," has come the belief that sexual organ are *sui generis*, that they have existed throughout descent, and that much which is now purely vegetative tissue has been evolved by the *sterilisation* of *potentially spore producing tissue*, to meet the physiological necessities of plant life on land. From the modern standpoint, accordingly, only the Perianth—consisting

of sepals and petals—and the advantageous modifications in external form and internal details of stamens and carpels, need be regarded as having accompanied the adoption of the pollination methods of Angiosperms. Within certain affinities such as the Anemones—there seems little doubt that the calyx has been evolved by the promotion of bracts, but on the other hand, there is abundant proof that in the Nymphiaceae and many Ranunculaceae the petals have arisen by degeneration of stamens. The grounds on which these statements are based cannot be dealt with here, but the position which one is inclined to take is, that a structure which has arisen in one way within anyone group, may have been produced within another affinity in quite a different manner. A thorough knowledge not only of the individual and its conditions, but also of its relatives is necessary before any evolutionary line can be marked out. Much discussion has arisen over the question of acquired characters, and unfortunately, many supporters of one theory have failed to see good in the views of those who have advanced another theory. Thus the devotees of the theory of acquired characters due to inherent tendencies have often refused to believe that, because certain environmental characters have been shown to play no *apparent* part in character transmission, as far as the experience of the individual observer has gone, any environmental characters can be *permanently* acquired. The truth seems to be, however, that no one theory can explain all the facts, and that there is no single way in which characters are acquired, but that each theory may explain something. It is almost impossible to define strictly the conscious or unconscious modifications in any organism as due only to inherent tendencies to accept the advantages which may arise in its surroundings. Evolution is not synonymous with advance in specialisation, but while one recognises much which is specialised, there is also much which has degenerated. In this evolution of degeneration the organism cannot be assumed to be retracing the steps by which it came to be what it was, and so if one is to accept the theory of acquired characters due to inherent tendencies a explaining all, one must at the same time believe that an organism which at one point in its evolution has tended to specialise in one part, has at a later period tended to degenerate in the same part. To indicate accomplished features of advance or of degeneration is all that one can do with assurance at present. For the performance of any *apparent* structural modification there must have been an earlier *unseen* constitutional alteration. It seems then impossible to lay the finger on any one character, and to prove that because it has been manifested in the tissue of an organism, that the whole initiation of the character has depended on the organism. And thus one is inclined to regard the responses and tendencies of any organism as being directly dependent upon environment, and to believe that such responses and tendencies cannot be viewed from the organism's standpoint alone, but that the environmental attitude is dictatorial. Turning then to the follicular group of Ranunculaceae one can trace the flower condition with special reference to the visiting insect. In this group, while the follicle—which is held to be a relatively primitive carpel form—has been retained throughout, the changes have been rung in floral mechanism. It is, however, not to be supposed that any one genus has been derived from any other genus of this existing group. In Caltha conspicuousness is secured by a perianth composed entirely of petaloid sepals, and from two shallow pits on the side of each carpel abundant nectar is secreted. Both self and cross-pollination take place, but by the outward dehiscence of the anthers, the latter is favoured. In Trollius both sepal and petals are present, the former being numerous, large, and conspicuous, the latter small, clawed, linear, with a nectariferous pit at the base. Both self and cross-pollination are accomplished. Helleborus shows most clearly the development of the honey petals by the diverting of stamen primordia from spore production to a nectar-secreting function. The secretary function in Nigella is performed by bifid blades carrying nectaries covered by movable lids, and here, pollination is accomplished by bees. Garidella shows similar modifications, but its sepals are smaller than those of Nigella, while its petals are more conspicuous. The honey petal in this actinomorphic group reaches its highest state of perfection in Aquilegis, (Columbine) and in its flowers, one finds for the

first time in the group, a very noticeable device by which it is assured that cross-pollination will be performed. The honey petal is long, hooded, and spurred, and the nectar is secreted by a glandular swelling at the end of the spur. Access to this nectar can be gained only by an insect whose proboscis can be inserted into the comparatively long distance from the lip of the petal to its base. The bee is the visiting insect, and while the flowers of Columbine have thus a selected visitor, they possess also stamen and carpel movements by which the pollen is exposed on a conical surface, and is all removed before the stigmas are exposed. But while these advantages have been gained, a danger has arisen, for not only might the honey petals become flooded during wet weather, but further, once they were flooded, days might elapse before all the water could be removed. In the bud then the flowers remain erect, but as they expand, by a curving of the flower stalks the flowers become inverted, and the danger of petal flooding and pollen wetting is averted. The inverted position is maintained until all the pollen has been removed, and an opportunity of cross-pollination has been offered, but immediately this has been accomplished the flower stalk becomes straight, and the erect position is regained in the later stages. That the flower inversion is in this case a *permanently* acquired "environmental" character seems indisputable.

The intimacy of the relationships existing between visiting insects and flowers might be illustrated in many ways, but it will suffice to refer to only a few points. Of the many insects which visit the flowers of the wild mustard probably the most conspicuous is a small black beetle known as Meligethes. This beetle spends much of its time crawling among the flowers. When sections of the flower stalks are examined tiny insect eggs are often found in small flash shaped smooth walled cavities. From these eggs develop minute grub-like larvae which make their way into the hearts of the flowers, and there do considerable damage, aborting and destroying stamens and ovules. The pupa or chrysalis stage is passed in cavities in the tissue of the sepals, and from these emerge the fully developed insects. That the early stages are also passed in a variety of situations seems probable, and the list of plants on which the fully developed beetle is to be found is very varied. On such a plant as the mustard one may often observe this beetle greedily devouring pollen from the dehisced anthers, or tearing apart sepals and petals in order to reach the stamens, while as often one may find it sipping the nectar from the glands. The beetle thus receives from the host plant a safe resting place for its eggs, a home for the larva and pupa, and in the later stages both pollen and nectar as food and drink respectively. In return for those things the insect gives to the host plant its services as a pollinator. Beetles possess two pairs of wings, and of these the upper pair is usually modified so as to form cases, useless in flight, but used to protect the delicate membranous lower wings by which the insect flies. One may often observe Meligethes on the wing, but as often it may be found crawling among the flowers, and unable to raise its wings. In this condition it wanders from flower to flower, and at times one finds it with its back thickly coated with pollen which has adhered to its scale wings which have been rendered sticky with nectar in which, while over-indulging, it has stumbled. That the insect at times becomes intoxicated with nectar has been proved experimentally, and while in this condition it loses full control of its limbs and accomplishes during its wanderings a very extensive cross-pollination.

It has been found impossible to deal in detail with any of the points referred to above, and the sole object in view has been brief illustration.

FRENCH GARDENING.

By J. Rennie.

[Read 12th December, 1911.]

It seems to me that your honoured president keeps a sharp lookout over all stray visitors to Rothesay. In June last I happened to pass through this central spot for changing steamers, met your president, said something about gardening in general, and intensive culture in particular, and well, here I am with the intention of trying to explain to you what that branch of intensive culture called French Gardening in this country *is*.

As to what it is, let me read to you an extract from Prince Kropotkin's "Fields, Factories and Workshops" as it stands in a book called French Gardening, by Th. Smith.

"While science devotes its chief attention to industrial pursuits, a limited number of lovers of nature and a legion of workers whose very names will remain uuknown to posterity have created of late an entirely new agriculture, as superior to modern farming as modern farming is superior to the old three fields system of our ancestors. . . They smile when we boast about the rotation system having permitted us to take from the field one crop every year, or four crops each three years, because their ambition is to have six and nine crops from the very same plot of land during the twelve months. They do not understand our talk about good and bad soils because they make the soil themselves."