ELEMENTARY INTRODUCTION TO THE SUBJECT OF VEGETABLE PHYSIOLOGY, PART II

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VEGETABLE PHYSIOLOGY.

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PART II.

THE principal object of our former Paper (Journal of the Royal Agricultural Society, vol. xvii., page 62) was to expound, in as simple a manner as possible, the fundamental fact of vegetable organisation, namely, the transformation of fluid substances into solid structures forming parts of a living being, in the development of new cells, the microscopic elements of organic bodies, from formless substances, through the agency of the organising force residing in existing tissues. The general principles there laid down apply to all plants without exception, since the phenomena from which these principles are deduced constitute the first step both in the development of every member of the vegetable kingdom, and in every new part or organ produced by any individual plant. The primary element of vegetable structure, the cell, was described in its most general characteristics—those which are met with in all cells at certain stages of their existence.

In the following pages we propose to furnish such an account as may be intelligible to ordinary readers, of the subsequent history of vegetable cells, and to describe the most important kinds of structure or tissue which enter into the formation of plants. Since, however, the cellular textures constitute only the framework or shell enclosing the matters in which the vitality of plants appears especially to reside, the nature of the fluids and solids contained in the cells and tissues must form a no less essential object of investigation; and indeed, as will be seen from the sequel, the study of the *cell-contents* constitutes, as regards the physiologist, by far the most important branch of the subject. In a practical point of view, above all, such questions as the history of starch and chlorophyll are of far greater importance than investigations of the forms of cells, the mark-

ings of the spiral structures, and the like, interesting as these are in other respects to the philosophic botanist. Admitting, however, the paramount importance of the contents of the cells in reference to the functions of vegetable life, it must not be forgotten that these are limited and defined in their manifestations by the laws which rule over the forms and the arrangement of the tissues, and the organs of which these constitute part. The diversity of character in the life of different plants is principally dependent upon certain fundamental differences in the plan of combination of the elements (the cells). Hence it is necessary at the outset of our inquiry to devote a few paragraphs to the consideration of the general characters of the organization of plants, before entering upon the description of the tissues and cell-contents. This will enable the reader to form juster ideas of the relative importance of the facts which will be afterwards placed before him, by setting the whole upon a more comprehensive basis.

The differences which we perceive in the outward characters of plants are accompanied to a certain extent by differences and gradations of structure in the internal parts, upon which the life of the whole essentially depends. The diversities in the internal anatomy of plants are far less striking than those which exist in the animal kingdom, as may be naturally conceived when we remember how few of the more remarkable vital functions of animals are represented in plants. Moreover, the vast variety existing in the vegetable world is rather dependent upon variations of forms and plans of arrangement (*morphological types*) than upon *physiological* differences. Hence the vegetable physiologist need not concern himself, except as to the great primary groups, with the laws and "patterns" regulating the configuration of the members of the different classes of plants. Leaving these to the botanist *par excellence*, he must especially direct his attention to the modifications of the tissues which are found combined or distributed to a great extent irrelatively, or, at all events, occur in numerous gradations within the limits of the classes whose rank is defined by the plan of arrangement of their larger organs. Let us endeavour to explain this a little more fully. The rank which is given to a plant or animal in classification depends upon the degree to which the principle of specialization, or division of labour, is carried out in it. As the organization becomes more complicated, its parts more mutually dependent, we say it is higher; and while, in regard to physiological functions, the more the different actions are confined to distinct organs, the more exalted becomes the character of the life; so the greater diversity that presents itself in the outward form, and in the

modes of combination of the organs, the higher becomes the morphological character. Now the vital functions of plants are so few in kind, and so simple, that their distribution among distinct organs only leads to a comparatively small amount of variation. The chief distinctions between the subordinate classes of plants depend upon differences of form and arrangement of organs which physiologically correspond, and are only unlike in minor particulars, to which it is difficult to assign any physiological value. Then again the structural conditions may vary almost indefinitely in complexity in the same organ within the limits of a single class in both the lower and the higher types. In the Algæ the *thallus*, or vegetative mass, presents gradations from the simple cell, or string of simple membranous cells, to the enormous frond of *Macrocystis* 500 feet in length, where the cells of which different regions of the thallus are composed, exhibit considerable differences both in their forms and functions. Among flowering-plants we find, in the same monocotyledonous class, the palms with their magnificent organization, and the duckweed of our pools, in which the physiological functions are performed by organs constructed on an analogous type, but in the latter case almost rudimentary in their internal organization.

From these considerations it becomes evident that there can be no serial arrangement of vegetable forms in a single graduated scale. We do indeed find a progressive complexity or perfection in the types or plans which characterise the great classes; yet these do not run into one another, but rather stand side by side, exhibiting corresponding gradations, or running out from a common centre into radii of different length.

The vegetable kingdom falls very naturally into two great sub-kingdoms or regions, characterised at once by the outward form (morphologically), by an essential diversity in the internal structure, and by the different degree of specialization of the functions (physiologically). In the lower group we can find no physiological distinctions in the structures devoted to the vegetative life, the general mass of cellular tissue carrying on in common the processes of absorption, digestion, respiration, and development. In the higher group there exists, well-defined in almost every case, a distinction between the absorbing organs (roots), the digestive and respiratory organs (the leaves), and the organ which at once serves to connect these together, and constitutes the focus of development (the stem). This distribution of labour is accompanied, from the lowest forms in which it appears, upwards, by the coincident occurrence of a kind of tissue absent in the lower group; the fibrous and fibro-

vascular cords which, connected together and arranged in various ways in the stems, form a bond of union between the organs, and, in the more highly developed plants, constitute a skeleton or framework to support the almost indefinite products of the vital activity of the properly cellular tissues.

The first group are called Thallophytes, from *thallos*, a Greek word signifying a vegetating shoot, and *phyton* a plant. The vegetative structure consists of a homogeneous mass, such as we see in the fronds of Sea-weeds or the scaly patches of the Lichens; and as this vegetative mass or layer is exclusively composed of cells comparatively little changed from their primary conditions, these plants are sometimes distinguished as Cellular plants. The cellular tissue does indeed exhibit very considerable diversities and a considerable range in the degree of alteration from the original form of a membranous sac, as is evident when we compare the simple confervoid filament with the larger Sea-weeds, in which there is a distinction into cortical and medullary tissues, evident both from the form and texture of the cells. But the thallus never presents any trace of those specially metamorphosed and regularly arranged masses of elementary tissue which constitute the fibro-vascular cords of the higher groups.

A most important kind of gradation does, however, present itself within the limits of the Thallophytes, dependent on a matter which we have not yet touched, namely, the specialization of cells in reference to the reproductive functions. In the very lowest forms, as in the fresh-water Algæ, the same cells form in the early part of their existence the organs of vegetation and growth, and at a later period give up these functions and undertake the production of the *spores*, the germs of new individuals for the reproduction of the species. Step by step, in more complex forms of Algæ, the reproductive functions become more localised, at first in certain selected cells of the vegetative mass; afterwards the reproductive cells are found marked for their special function from their very first origin; and in the highest forms, portions of the thallus are developed into peculiar *fruits* or *receptacles*, enclosing and protecting the reproductive cells. These distinctions in the reproductive structures are of great importance in the eyes of the botanist and of the physiologist; but their interest is almost exclusively scientific, and they bear upon practice chiefly through affording instructive illustrations of phenomena of reproduction occurring in an analogous manner in the higher plants, where they are less accessible to direct observation.

The higher of the two groups founded on the characters of the vegetative system comprehends all plants possessing a stem

or *axis*, bearing leaves above and roots below, presenting therefore two diametrically opposite directions of growth. The distinctive name of *Cormophytes* has been applied to these, from the Greek word *kormos* a trunk or stem, and *phyton* a plant; the term *Vascular plants*, as contrasted with *Cellular plants*, is likewise applicable to all but the lowest orders. In the simplest members of this sub-kingdom the fibro-vascular structures are present, but represented by elementary organs presenting little variety of conformation; thus in the Mosses they constitute a simple fibrous cord running through the centre of the stem, giving off branches which sometimes run into the blades of the little leaves, but more frequently are confined to the stem, so that the leaves are mere cellular plates like the fronds of the stemless plants. In the Ferns and allied plants there is a great advance, the general characters of the stems and leaves approaching those of the flowering plants; but the inferiority of organization indicated by the absence of flowers, and the intimate connexion of the reproductive structures with vegetative system (evident in the formation of the *spores* on the ordinary leaves of Ferns), correspond to a much slighter diversity and complexity in the conditions and arrangement of the fibro-vascular elementary tissues.

In the Flowering-plants, in the two large classes called the Monocotyledons and Dicotyledons, the different plans of arrangement of the fibro-vascular structures cause a totally different mode of growth of the stems, forming perhaps the most strongly-marked of the characteristics by which these classes are distinguished.

As in the Thallophytes, however, the most important diversities of the sub-kingdom of Cormophytes lie in the mode of development and arrangement of the reproductive organs. In the progressively higher orders these become step by step extricated from their connection with the vegetative system, until in the Flowering-plants we find the organs which produce the reproductive bodies (*seeds*) associated with a complicated collection of specially-metamorphosed organs (sepals, petals, stamens, &c.), while the germs produced are no longer thrown off as simple cellular bodies, but remain dependent upon and nourished by the parent plant until they have acquired their own stem, leaves, and root—that organization, in fact, which distinguishes the vascular stem-forming from the cellular or stemless plants.

The great number of distinct parts, the manifold difference of texture, provision for long duration, &c., involved in the existence of flowers, seeds, and fruits of almost endless variety of character, give occasion, as must be evident, to very great multiformity in the conditions of the fully-developed tissues in the highest class