NOTE.

PRELIMINARY NOTE ON GASTRODIA ELATA AND ITS MYCORRHIZA.—A peculiar habit of *Gastrodia elata* and its highly reduced vegetative organ led me to undertake the present work. After careful observations in the field, cultivation-experiments, and cytological study, I have arrived at results, the chief points of which may be stated as follows :—

The vegetative organ of *Gastrodia elata* is represented simply by a tuberous rhizome. It forms mycorrhiza with the mycelium strand of *Armillaria mellea*, generally called *Rhizomorpha subterranea*. The cytological features tend to show the mycorrhiza to be an endotrophic form. However, the direct connexion of the endophyte with the *Rhizomorpha* strands vigorously vegetating in the surrounding medium indicates the physiological relationship between the two symbionts to be similar to that in a typical ectotrophic mycorrhiza.

The infection by the fungus is effected by a sucker-like branch of the *Rhizomorpha* strand, which penetrates into the cortical cell layers of the tuber, partly compressing the underlying cells and partly dissolving their walls. This process is essentially the same as that presented by the haustorium of *Cuscuta*. The infecting strand sends out separate hyphae which spread intracellularly in a definite zone under a few layers of subcortical cells. The extension of the endophyte is limited within a certain area around the infected spot.

The mycorrhizal cell-layers may be distinguished into three regions, according to the structure of the cells and the nature of the hyphae which compose them. The first region consists of the outer two or three layers, which contain a densely entangled mass of comparatively thick-walled hyphae. A similar convolution of hyphae is observed in the next one or two layers composing the second region. In this region the hyphae are generally thin-walled and of various breadths, and are often arranged in pseudo-parenchymatous form. The innermost layer constitutes the third region; these cells are the largest and contain each a few, slender, less curved hyphae.

The different hyphae of the endophyte have essentially the same structure as those composing the *Rhizomorpha* strand; the hyphae of the first, second, and third regions correspond respectively to the outer interwoven hyphal branches usually forming the gelatinous investment, the inner cortical hyphae, and the slender hyphae composing the secondary pith of the strand. The hyphae of each region show characteristic alterations. They are permanent in the first region, as may be seen in the so-called fungus host-cells, and undergo self-disorganization in the second, leaving their walls as irregular masses, while in the third region they are mostly consumed by the host-cells.

The walls of the mycorrhizal cells undergo certain chemical and physical changes. In the first region they become lignified, and in the second they are partly dissolved by the perforating hyphae. In the third region the walls become thickened, but do not undergo any chemical modification. Further, in both the first and second regions the wall develops a tubular sheath which always shows a distinct lignin reaction. Lignin reaction is also observed in the thick-walled hyphae of the first region.

In the mycorrhizal cells the amount of the cytoplasm and the size of the nucleus are increased previous to infection by the fungus. After infection the protoplast is soon consumed by the fungus in the second region, but in the first region the cytoplasm invests the hyphal clump and the nucleus is stretched, often so much as to cause fragmentation into two portions. When the clump becomes larger the protoplast disappears entirely. In the third region the cytoplasm increases further in amount and acquires a granular and dense consistence, while the nucleus undergoes hypertrophy, hyperchromatophily, and various deformations by constriction. The constricted portions may be often pulled apart in a stellate form.

In the mycorrhizal cells of the third region there appear prominent bodies which may be considered to comprise both secretion and excretion products of the endophyte. First, light yellowish, oil-drop-like globules (attaining to 0.08 mm. or more in diameter) and similar-sized vesicles with a hyaline membrane and containing yellowish granules become visible in the cytoplasm. They are both secretion-bodies, or, if not, their derivatives, to be consumed later by the host. While these are disappearing, there occur innumerable, small, hyaline, irregular masses, each in a vacuole of the cytoplasm. Afterwards they are thrown into a large common vacuole and by fusion form a mass, more or less resembling the so-called clump ('Klumpen') usually found in the digestive cells of many mycorrhizal plants. Probably they are derived partly from the remnants or ground-substances of the secretion-bodies and partly from the undigested wall of the hyphae, and judging from their resistant property they are certainly useless excreta.

The cell of the third region is a metabolic centre of the higher symbiont, where the food materials are elaborated. The remarkable alterations in the cytoplasm and nucleus are indications of the great activities that are going on in the cell during this process; so that, when the latter is over, the nucleus resumes its original form and structure, while the cytoplasm again becomes fibrous and vacuolate.

The *Rhizomorpha*, besides forming mycorrhiza, behaves towards *Gastrodia* as a true parasite, and under certain circumstances the strand penetrates deeply into the tissue of the tuber, then developing as *Rhizomorpha subcorticalis*. The infected tissue collapses and is apparently injured, as may be seen in potato tubers attacked by the same fungus.

Gastrodia multiplies usually by a tuber. It produces long rhizomes from its apex or node, upon which are developed stalked offsets. Sometimes the latter are produced directly on the node of the mother-body. At the end of autumn, the mother-body and the pedicel of the offset undergo degeneration, so that the daughter tubercles are all set free separately.

The association of the tuber with the *Rhizomorpha* takes place quite occasionally.

If the mother-tuber forms mycorrhiza, it can produce a full-grown offset which remains dormant during the winter and develops the inflorescence axis in the spring of the next year. Otherwise, the offsets cannot grow larger than the mother-tuber, and under this condition the offsets become smaller and smaller in successive generations, until they are so much reduced in size and deficient in food materials as to be incapable of further multiplication.

The tubercles cultivated in the pot with sand, loam, or humus soil produce, as in the field, numerous offsets, but none of them can reach the flowering stage. This shows that they have no ability to provide themselves with nutriment from the surrounding medium.

The usually saprophytic development of *Armillaria mellea*, the extremely reduced vegetative organ of *Gastrodia*, and the cytological features involved in the symbiosis lead us to the view that the reciprocal exchange of nutritive substances between the two organisms is not equal, i. e. the fungus becomes the victim of the Orchid, perhaps receiving from the latter but little benefit for its whole organization. Therefore, it appears probable that physiologically the relation of *Gastrodia* to the fungus is similar to that of subterranean holoparasites to their host roots—*Gastrodia* is parasitic on the fungus.

The chief reserve material stored in an adult tuber is starch. The amyloplast contains a heavily staining body of nuclear nature, whose structure changes at successive stages.

A full account of this subject, with illustrations and references to the literature, will appear in the 'Journal of the College of Agriculture, Imperial University of Tokyo'.

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