In the Mackay herbarium *Spergula* was not represented, nor were Irish specimens contained either in the herbarium of Mr. A. G. More, or in the British collection at Trinity College, Dublin; but in the general collection in the latter herbarium was a specimen with darker wings to the seed, which I should, with some doubt, refer to *S. pentandra*, and which was simply labelled '*S. pentandra*, Dublin,' without date or collector's name, and in a writing not familiar to Professor Wright, who kindly showed me the specimens referred to.

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ON THE CHANGES IN THE ENDOSPERM OF RICINUS COMMUNIS DURING GERMINATION[1].—The seeds of *Ricinus communis*, the castor-oil plant, consist of a central embryo which has two large foliaceous cotyledons embedded closely in a mass of endosperm to which, pending germination, they closely adhere. The cells of the endosperm which are in immediate contact with the cotyledons are empty and their walls pressed closely together, forming a layer which, though occupying but little space, really consists of several ranks of cells. Beyond this layer the mass of endosperm-cells lies, and each cell contains a matrix or network of protoplasm saturated with the oil. This does not exist in the condition of globules or drops, though it can be extracted by pressing the tissue. In the interspaces of the protoplasmic network the proteid reserve materials are found. They are the well-known aleurone-grains, each consisting of an ovoid mass of proteid matter in which are contained a crystalloid, also proteid, and a globoid composed of a double phosphate of calcium and magnesium. The cell-walls are thin, so that there is but little cellulose present. Of other carbohydrates there is a trace of sugar, but no starch. No glucoside exists in the cells.

Under favourable conditions germination is completed in five to seven days. At its onset the mass of the endosperm begins to swell, and speedily the radicle emerges from the testa; soon the testa ruptures, and the endosperm, still increasing in bulk, is pressed outwards, the testa falling off at the apex of the seed. The endosperm then forms a white caky covering to the cotyledons, which adhere to it less and less completely. The mass of endosperm, now much

[1] Read before the Royal Society, Jan. 30, 1890.

flattened and extended laterally, cracks along the edges, and half of it continues to lie adpressed to each cotyledon. The surface of contact between the two is at this stage slimy, as if the material of the endosperm had become deliquescent. Later gradually the two pieces of endosperm dry up.

During these changes of form intricate chemical changes take place inside the cells. The aleurone-grains gradually dissolve; the proteids of which they are composed, viz. globulins and albumoses, becoming transformed into peptone and later into asparagin. The cotyledons are the organs of absorption, and they take up the latter body, which can be extracted from them in crystalline form. The oil disappears during the germination, but does not enter the cotyledons unchanged. It consists chiefly of ricinoleic acid in combination with glycerine, and the first decomposition that is observed is the separation of the fatty acid from the other constituent. During the early days of the germination the free fatty acid that can be extracted from the endosperm increases considerably in quantity. Later on it diminishes, and its place is taken by another acid which differs from the greasy ricinoleic acid by being soluble in water, capable of dialysis, and crystalline in appearance when separated out. Ricinoleic acid has been proved by several observers to be capable of such a decomposition as this in the laboratory when treated with oxidising agents, such as nitric acid or permanganate of potash. This crystalline acid makes its appearance a little later in the process than the fatty acid, and though absorption of it goes on continuously by the cotyledons, the endosperm contains about the same percentage during the rest of the germination, while the fatty acid is continually getting less in quantity.

Besides this acid the cotyledons are continually absorbing sugar from the endosperm. This arises during germination, only a trace being found in the resting seed. There is hardly any doubt that its immediate antecedent is the glycerine that comes from the splitting up of the oil. Glycerine has been proved to be easily convertible into sugar, and though there is sufficient liberated in the decomposition of the oil to account for all the sugar formed in germination, none of it can be found in the free state either in the endosperm or in the cotyledons.

In the last stage of the germination the thin shell of endosperm left only contains a little sugar and a little crystallisable acid.

The processes in the endosperm which lead to the changes thus briefly described are two-fold. There is first *ferment action.* From the germinating seeds can be extracted two ferments, which in the laboratory are found capable, the one of transforming the proteids into (ultimately) asparagin, and the other of splitting up the oil into ricinoleic acid and glycerine. The latter body can be detected in the process in the laboratory, though it escapes careful search in the plant. This probably indicates a change into sugar almost immediately it is formed.

The ferments in question are not in the active condition in the resting seed. There they exist in the antecedent form of zymogen, and can be rendered active by warming their solutions with a little dilute acid.

The ferment which liberates the fatty acid cannot transform the latter into the crystalline acid. This change appears to be brought about by the oxidative activity of the protoplasm of the cells. The endosperm retains a certain amount of vitality, for if it be detached from the embryo and put in suitable conditions it undergoes changes just as the normal seed does in germination, though more slowly. The mass swells, the oil is decomposed; fatty acid, crystalline acid, and sugar appear. The cells cannot therefore be regarded as mere storehouses for the food of the young plant placed near it in readiness to supply its wants when it begins to draw upon them. They are this, but they are more than this. The parent plant has not completed the provision for its offspring when its seed assumes the quiescent form; it takes it further and completes it when conditions call the embryo into renewed activity. In the castor-oil plant germination is at once the final effort of the parent and the first effort of the offspring in the task of the propagation of the species.

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