In order to determine whether this substance was insoluble in presence of water, dry seeds were kept in cold alcohol for twenty-four hours, and during that time there was no change either in the color of the seeds or in the cell contents. The seeds were taken from the alcohol and placed in water, and within three hours they had turned black, and the blue was developed in the cells. Dry seeds were placed in glacial acetic acid, and within twenty-four hours they were turned a light yellow color and sections showed the cell contents to be colorless. These seeds were taken from the acid and kept in water for twelve hours, and during that time no further change took place. Dry seeds were placed in strong ammonia, and within twelve hours they had turned black on the surface and the cell contents were turned brown. After this treatment with ammonia, the seeds were kept in water for several hours, but no further change was perceptible. The dry seeds were kept in pure chloroform for three days, and during that time they retained their golden yellow color and the cell contents also remained colorless. Then they were taken from the chloroform and placed in water, and within three hours they had turned black, and the blue was developed in the cells.

After the color had been developed by water, sections were treated with nitric acid, and the blue color disappeared immediately, leaving the cell contents a yellowish brown color. The blue was turned green immediately upon being treated with sodic hydrate, but was changed to blue again within twelve hours after being placed in glycerine. On account of the small amount of material it was impossible to carry these experiments to a conclusion.

A blue substance is developed by water in the seeds of *P. Patagonica* also, but no chemical experiments were made upon these seeds.

P. Virginica and *P. Patagonica* were the only species examined in the genus *Plantago* which showed this peculiar development of color.

The test for this substance in the indigo plant itself was made upon an herbarium specimen and failed to produce it. The indigo plant must be taken at certain stages of its development in order to produce Indican, and such may be the case in *Plantago Virginica*.

Root System of Pogonia. By M. B. Thomas.

The genus Pogonia is a remarkably interesting group of orchids represented by five species in northeast North America out of a total of forty-three in the whole genus.

The species have a very wide distribution, being found throughout North America, Africa, eastern Asia, and, to a very limited extent, throughout Europe,

Notwithstanding the wide distribution, the species seem to have a remarkably similar habitat, and consequently the plants show a very striking resemblance in regard to their structure and adaptation to their rather peculiar surroundings. The plants of the genus are all found in low, damp places, with an extreme reached in *P. ophioglossoides*, which grows in sphagnum bogs throughout North America, Japan and Europe. With reference to the other North American species of Pogonia no marked variation from the regular terrestrial orchids has been observed which would indicate that the plants had undergone any special or irregular variations as a result of their peculiar environments.

In an examination of the roots of *P. ophioglossoides* it was found that a striking exception existed which might be a very suggestive one when considered from the standpoint of the adaptation of the plant in order to better fit it to withstand the peculiar difficulties of its surroundings.

The roots of all phanerogams are provided at the tip with a series of initial groups, from which differentiate the various parts of the root in the following order: From the calyptrogen comes the root cap, from the dermatogen the epidermis, from the periblem the cortex, and from the plerom the central cylinder. Sometimes one or more of these groups are combined and this is the condition ascribed by Trent to the orchidaceae, regarding which he holds that the calyptrogen is not present and the root cap and epidermis originate from a common initial group, the dermatogen. Janczewski holds that in these monocots we find a well marked calyptrogen, and in this he is supported by Flahault and others.

With reference to this arrangement, in the roots of *P. ophioglossoides*, was found what is believed to be a marked exception to all phanerogams, except possibly a few parasitic ones.

The roots of the plant are small, very long, much branched, and provided with a few root-hairs. At the tip we find an entire absence of a root-cap, and the cells of the dermatogen, with but slightly thickened walls, form the outside covering, which in the growing plant is quite green.

The cells of the dermatogen undergo a periclinal extension 2-8 mm. back from the tip, and at this point they quickly change into the more firm, brown epidermis which soon shows the differentiation of the root hairs. The dermatogen cells are very large, regular and with conspicuous nuclei showing great activity.

Another condition not seen in other roots is the very rapid development of the fibro-vascular bundles from the procambium which usually extends some distance back from the tip, and from it very gradually differentiate the elements of the fibro-vascular system, whereas in *Pogonia ophioglossoides*, the xylem shows reticulated tracheids often not more than ten cells back from the initial group of

the plerom. The arrangement of the parts of the central cylinder shows the regular differentiation of the radial bundle of roots.

It might at first be supposed that *Pogonia ophioglossoides*, like many plants (*Azolla*, *Hydrocharis*, *Ranunculus*, *Ficaria*) having roots with a limited growth, throws off its root-cap, but such is not the case, since not even the rudiment of one is developed, and the secondary roots break through the cortex and epidermis without any covering to their tip. Neither is the absence of the root-cap in any way comparable to the condition found in some Aroids, *e. g.*, *Anthurium longifolium* (Bot. Zeitung, 1878, p. 645,), where the root-cap is torn away and the root, by the production of a bud at its tip, developes into a shoot, and in this way continues its growth.

Of the constancy of the peculiar condition in *Pogonia ophioglossoides*, there seems to be no doubt, since it is found to be true of plants collected in various parts of the United States, and growing under somewhat different circumstances. The condition is then something more than accidental. The structure of the root, so far as the apex is concerned, is then not unlike that of the stem of many water plants (*Hippuris vulgaris*), where a single layer of dermatogen covers the tip, and inside of this, 5-6 regular isodiametric cells of the periblem, which undergo periclinal division, give rise to the cortex. Inside of this, is a group of 4-5 initial cells of the same character giving rise to the fibro-vascular system.

The meaning of this variation and its value to the plant is not certain, but it is suggested that, since the plant grows in loose sphagnum and the roots are not in any immediate contact with the material from which they draw their food supply, the tip of the root pressing constantly against the decaying stems of the moss is a very important factor in the absorption of food. Protected, as it usually is in other plants, with a root-cap, the outer cells of which are not capable of becoming turgid, the efficiency of this part of the root is very seriously interfered with for the absorption of food. With most plants, where the whole length of the roots is in immediate contact with their source of food supply, the work done by the root hairs does not make necessary the use of the tip for absorptive purposes. Neither does *Pogonia ophioglossoides* have the advantages of a water plant, which, like *Pontederia crassipes* and many floating plants, take up their nourishment from the free water through the agency of the great mass of root hairs, often so strikingly developed. In *Pogonia ophioglossoides* only those parts of the root that are here and there in contact with the stems of the sphagnum are able to take up food. The necessity of a large absorptive surface to the root system is more apparent when we consider that, contrary to the general opinion, the bog soil is not rich in nitrogenous material.

Another and stronger proof that the tip of the root is so valuable an absorptive organ is the extraordinary development of the conductive tissue of the root to a proximity of the tip wholly unlike that found in other plants. This unusual development would indicate that the plant obtained through the vascular tissue from the tip a part of its food supply. Such a condition of unusual development of vessels at unexpected places is to be noted in various plants, and indicates the dependence on that part for supplies of moisture. This is true, for example, of those parts of pitcher plants that retain supplies of water, without which the plant would wilt. (King and Zimmerman, 1885.) On the other hand, aquatic and semi-aquatic plants often show poorly developed root-caps, or frequently the cap is attached only at the very tip, thus allowing the water free contact with the epidermis, but a few cells back from the initial group.

The need of the root cap as an organ of protection in *Pogonia ophioglossoides* can certainly not overbalance the increased efficiency of that part of the root due to its absence. The loose nature of the sphagnum does not offer any resistance to the growing root, while it at the same time affords an efficient protection. It is true that aërial and aquatic roots are not required to force their way through the medium in which they grow, but at the same time the air and water do not protect the roots as does the moss, and, further, in the case of aërial orchids the outer cells of the root cap do not drop away to any great extent, and the whole tip of the root may become turgid and capable of absorbing moisture, thereby accomplishing the same end in this respect as would be reached were the root cap not present. No doubt the increased activity of the tip would make it more sensitive, and, as the recent investigations of Pfeffer (Annals of Bot., Sept., 1894,) show the irritability of the root to be confined to that part, this would certainly be of great advantage to the plant.

It would seem, in view of what has been said, that the absence of this cap in *Pogonia ophioglossoides* is not the effect of degeneration, but rather the attainment of a greater stage of perfection, true to the principles of evolution, whereby a useless organ has degenerated and disappeared, and in so doing worked material advantage to the organism.

Salt-rising Bread. By Katherine E. Golden.