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THESIS

A STUDY OF THE BEHAVIOR OF GRAINS OF CORN AND WHEAT AND THE SEEDS OF ONIONS IN AND OUT OF THE GROUND WHILE GERMINATING

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A STUDY OF THE BEHAVIOR OF GRAINS OF CORN AND WHEAT, AND THE SEEDS OF ONIONS, IN AND OUT OF THE GROUND, WHILE GERMINATING.

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A STUDY OF THE BEHAVIOR OF GRAINS OF CORN AND WHEAT, AND THE SEEDS OF ONIONS, IN AND OUT OF THE GROUND, WHILE GERMINATING.

The germination of seeds, and their progressive stages of growth, have been talked of, and illustrated, time and again, yet one cannot help feeling to a certain extent dissatisfied when he looks at the mere printed illustration before him, and reads the accompanying explanations. He must conduct experiments of his own, and make his own observations. Then, indeed, does the interest increase tenfold. That cold, plain, printed picture has been brushed out of his mind, and he sees only the strange reality. What an exhilarating satisfaction it is to him when he finds he is making his own observations and making his own drawings. Now the picture in his mind means something to him, and the explanation is a result of his own work.

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Part of the grains of corn and wheat, and the seeds of the onions, were grown in the ground, and the remainder on the surface of sand, in all cases covered by a glass jar to prevent too rapid evaporation. The temperature ranged between 64 and 68^{o} and the nearest source of light was a window about three feet above the place where the seeds were to germinate. Now the work of Nature proceeds.

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The second day after setting the seeds the wheat on the surface showed a marked progress in germinating. Upon examination under the stage microscope it was found in a few cases that only the plumule (b) Fig. 4, Plate I, and a single root (a) had made a start, but the majority appeared as Fig. 5, with the long root (a) and two short, lateral roots (c) (c). The plumule is hidden beneath the portion of the grain cover (d). By the next day this was pushed away, and Fig. 6 illustrates a three day's growth of the wheat, with the three roots (a) (b) (c) and the plumule (d).

Illustrations 1 and 2 are two views of the grain, and Fig. 3 a cross section. Fig. 7 shows an advanced stage in the germination of the wheat, with the complete set of roots (a) (b) (c) (d) and (e), and the plumule (f). The roots (d) and (e) are the last to appear, and are much weaker.

Thinking it was possible that an increase of temperature might bring out these roots together, a plate of sand was put on a radiator where the temperature averaged 85°, and upon this was germinated some wheat. Contrary to expectations the two last roots did not appear as soon as they did in a temperature of 64°. A low temperature, then, is favorable to the growth of wheat.

Figs. 8 and 9 are illustrations showing the internal structure of a grain of wheat as seen in a cross section through the compound microscope. Fig. 8 (a) is the pericarp, the extreme outer covering of the grain; (b) is a dark brown layer between the pericarp and the aleurone cells (c). These cells in section are usually square or oblong, and filled with aleurone. Lying next to this row of cells come the starch cells (d), somewhat elongated and tapering, filled with granules of starch (Fig. 12) and aleurone. In the illustration some of the cells are empty to show the structure better. The same structure continues clear around the cross section, as is indicated in Fig. 9, which illustrates the grooved portion of the grain.

Passing from this line of observation, let us now observe the effects of light.

On this same Plate, Figs. 10 and 11 may give one a fair idea of the effects of light upon the growth of wheat. Fig. 10 is an illustration of two plants of wheat, planted in the fall and taken up when the snow was flying. It represents the short, stout growth, and the arrangement of leaves. There should be a sheath partially enclosing the base of the plant, but it was probably torn off when removing the plant from the ground. As it is, we have the second blade (a) with the branch (b) coming up from its axil; (c) is the third blade, and (d) is the main stalk with its successive growth of blades.

Fig. 11 shows the effect of leaving the plants three feet below a small window. In their desire to reach the light they have grown rapidly into a long spindling growth, and eventually have become too weak to hold themselves up.

Plate II shows the weak condition they are in, some already having toppled over. In Plate I, Fig. 11 (a) represents the sheath, while (b) is the first blade with the sheath enclosed by (a), and (c) the third blade.

We will now turn our attention to the germination of the corn, illustrations of which will be found on Plate III. Fig. 1 represents a grain of Dent Corn.

Those grains of corn that were to germinate on the sand were very slow in making a start, and took two weeks to grow a single root 1/2 inch long. Fig. 2 represents about the extent of growth; (a) is the plumule, and (b) the single root. This was due to the temperature, 64^{o}, it being altogether too low. Corn requires a temperature between 80 and 90^{o}. The grains made but little further progress, and in a few days withered.

In order to accommodate the corn to its requisite temperature, some grains were placed on a plate of wet sand under a bell jar, and the whole placed on a radiator, where the temperature ranged between 85 and 95^{o}. It was soon noticed what a great influence the change had upon the corn. Inside of two days the plumule had broken through the covering, and the primary root was well under way. Fig. 3 represents a four-day's growth, showing the plumule (a), the primary root (b), with a few secondary roots (c). The growth continued strong and vigorous, and in ten days we find the second blade unfolding as in Fig. 4: (a) represents the primary root with the secondary roots on all sides; (b) the first blade of the plumule which forms the sheath. This stops its growth, and from its tip appears the second blade (c).

It will, perhaps, be observed that the roots in the illustrations referred to are branching off in most any direction. This is a marked characteristic of all grains germinated on top of the soil, under some vessel. So much moisture is held in the air as to cause the roots to reach out in all directions. In one instance it was noted that a root of one grain had grown up and over the root of another grain which was a little further advanced. The root hairs of the older root held a considerable amount of moisture, so the younger root went after it. In Fig. 5 we have the condition of the roots as grown in the ground, showing aggregate uniformity in their distribution.

The corn planted in the ground made better progress than that on the sand, but the conditions prevented a rapid growth. In Fig. 6 we have the progressive stages of growth up to the third blade; (a) is the first leaf of the plumule, consisting of the sheath merely as it first appears. It continues its growth for a short time, gradually opening at the top as in (b), allowing the second blade to protrude. The sheath of the first leaf has no blade. It soon ceases to grow, and the second blade (c) continues unfolding as in (d) until gradually it spreads open from the top towards the sheath as in (e), and the third blade (f) is exposed to view. In this way the plant continues to advance.

Fig. 7 is a group of starch granules, taken from the corn. (a) and (b) are taken from the grain before germination, (a) are the granules found in the flinty portion, and (b) from the starchy portion; (c) are granules taken from a grain of corn which has been growing until the nourishment is nearly used up. The perforated and broken condition of the granules show how their plant food has gradually been absorbed by the plant.

At a meeting of the Botany Club, one evening, the question was brought up in regard to the embryo of the corn; whether it would grow if deprived of all its endosperm, and, if so, to what. extent. The experiment was tried, with somewhat surprising results.

The starch was carefully separated from the embryo, and this, with a whole grain, were grown under the same conditions as described above. They both germinated in two days, the embryo as illustrated in Fig. 8, Plate III, (a) the first day, (b) the second day, after setting.

The growth continued vigorous, and on the fourth day it was surprising to note that the plumule of the embryo deprived of starch was nearly twice as long as that from the whole grain. Plate IV, Figs. 1 and 2, show the comparative growth. Fig. 1 (a) plumule, (b) second blade, of embryo. Fig. 2 (a) plumule of whole grain.

After taking this observation they each were planted in the ground, the plumule of the embryo being partially exposed above, while that of the complete grain was entirely buried.

The complete grain now began to show the effects of its additional supply of starch, and the next day after planting, it appeared above the surface, and the second blade began to unfold, while the embryo made but little headway. Figs. 3 and 4 on Plate IV represents the situation on the third day after planting in the ground. Fig. 3 is the embryo, with its few slender roots and general frail growth, the second blade (a) being still folded up. Fig. 4 represents the stout, healthy growth of the whole grain, showing the distribution of the roots in the ground, and the unfolding of the blades above.

We will pass the remainder of the illustrations on Plate IV, for a few moments, and turn our attention to Plate V, upon which we find illustrations of the germination of the onion.

The onions germinated just about in the same time as required for corn, but were more durable, and continued their growth. The first thing we notice is the appearance of a single small, white root, which makes a straight growth for a short distance, then forms a loop, as in Fig. 1 (a). When the seed is planted in the ground this loop comes to the surface, as will be seen later on, and the portion (b) makes but little further progress.

As the plant continues its growth, the whip portion gradually rises, and, in most cases, depending on the soil, it carries the seed-coat with it, as in Fig. 2, (a) is the whip, and (b) the seed-coat. After further growth the seed-coat gradually dries up and drops off, leaving a thin shrivelled tip to the whip-lash, as in Fig. 3 (a).

Those onions that were planted in the ground had the same trouble in regard to light as did the wheat. The successive stages of growth are illustrated in Fig. 4; (a) represents the loop as it appeared above ground, (b) the same a little further advanced, the seed-coat appearing at (c). Later this seed-coat is pulled from the ground, as in (d), and the whip-lash gradually takes an erect position, as in (e). Owing to the lack of light nothing further could be developed. The onions made a long, spindling growth, meeting with the same fate as did the wheat under the same conditions.

To get more definite results, some onion seeds were planted and allowed to grow where they could get sufficient light. In Fig. 5 we have the successive growth illustrated. It starts with the loop, as before, but it is stouter. As we follow the successive growth through (a) (b) (c) we come to (d), and here we notice that the seed-coat is not attached. This is due, probably, to the compact nature of the ground, which has held the seed-coat down, while the whip, being unable to stand the strain, has broken its connections, and is now taking the upright position. In (e) of the same Fig. 5 we find something we did not see in the previous experiments, and that is the branch (f). This, in reality, is the the plumule, while the remaining portion is the cotyledons. As the growth continues, the cotyledons gradually wither away, and the plumule continues its growth, itself forming a sheath for another blade.

In Fig. 6 we have the onion plant a little further advanced, showing the roots at (a) as they appear below the ground; the cotyledons (b) with the seed-coat still attached at (c), and the plumule (d).

Fig 7 seems rather out of place on this Plate, it being merely an experiment with oats: (a) represents the germination of an oat grain, with the husk still attached, showing how the plumule (b) has been forced to come out at the opposite end from the roots. In (c) is the grain with the husk removed, thus allowing the plumule (d) to grow in any direction. Leaving the husk on did not delay the germination of the plant to any great extent.

Before leaving this matter of germination, the attention is called to an experiment in nipping corn shortly after germinating. Referring to Plate III, Fig. 4, one plant was nipped off below the point (x), and one just above it. In the former case it was thought possible that the plant might send out a branch, but Nature ceased operations, and eventually the plant withered. In the latter case, Nature continued operations, and commenced re-building the lost structure, but the resulting blades came out with their tips cut off.

We will now leave the subject of the germination of seeds, and turn our attention to the illustrations on the lower half of Plate IV. Here we have illustrated the change in structure of a grain of Pop-corn while undergoing the process of "popping"

In Fig. 1 we have the grain under natural conditions, (a) representing the grain, (b) representing the normal size and shape of the starch cells in section, as seen under the micro-scope, (c) is a cell partially filled with starch granules, (d) represents the starch granules in the cell taken from the flinty portion.

The grain of corn is now put over the fire. Soon the intense heat causes the grain to swell, and the outer coverings break apart as in Fig. 2 (a), the ruptured portion at (b). In (c) we notice the increased size of the cells over those in Fig. 1 (b), both are drawn to the same scale.

In Fig. 2 (d) we find the granules of starch have lost their natural form, and have become markedly swollen. Their texture seems to be like that of flour paste.

A grain of corn well popped is next examined. The form is irregular as (a) or (b), Fig. 3, the white portion being the starch; (c) shows how the cell walls have been ruptured in many places by the force of the explosion, and under a higher power we find that the starch granules have flattened out more or less, rupturing their own coverings: (d) shows two views of the starch granules (x) and (y) as obscured by slight change of focus, (x) out of focus, (y) in focus.

The starch in popcorn takes the form of cells, and these are within the true cell walls, thus appearing as though there existed a lot of small cells inside of each large cell.

The theory of the explosion of pop-corn is that the grain contains a large amount of oil, and when overheated forms gas, and being so tightly enclosed results in an explosion.

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Plate I.

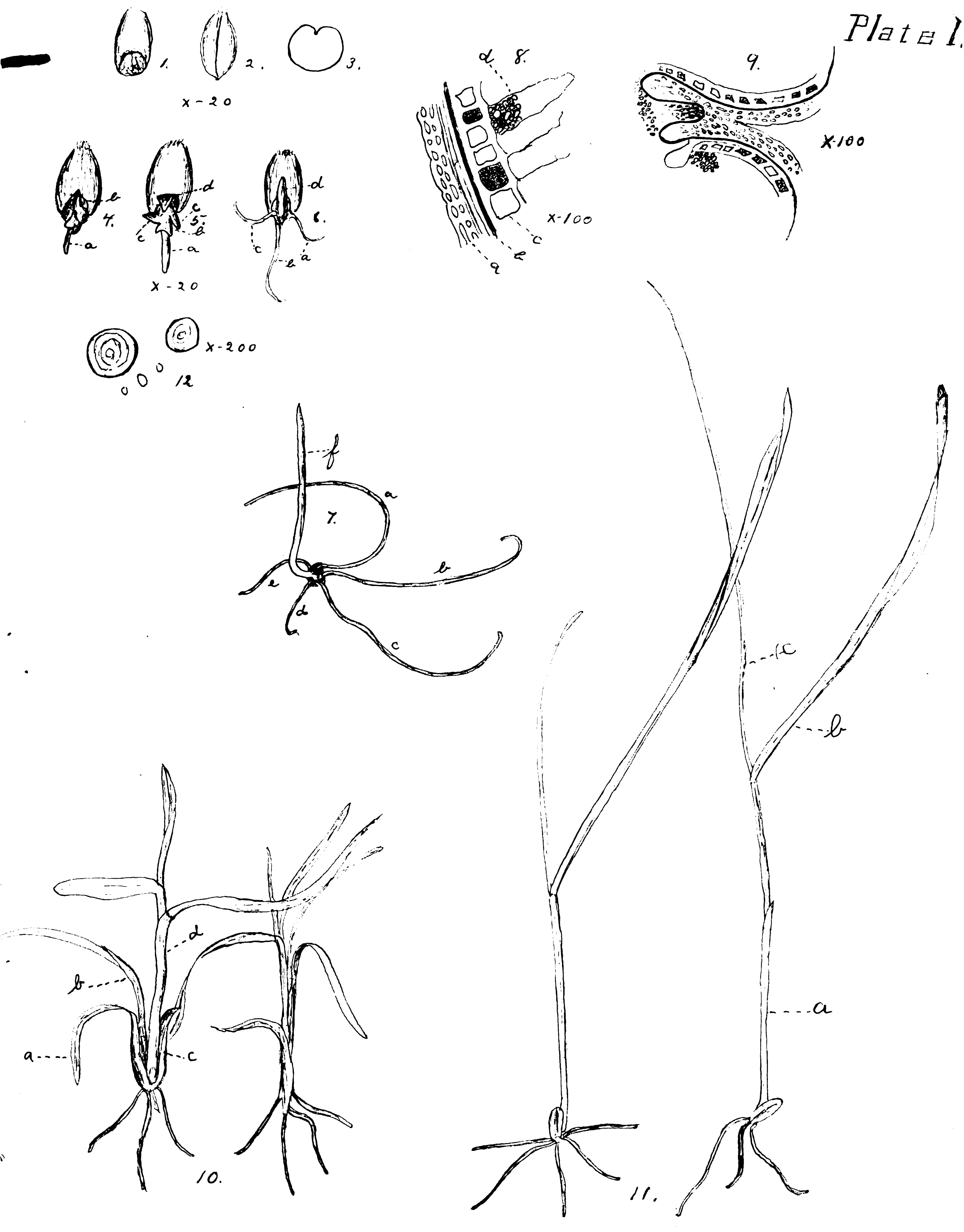


Plate II.

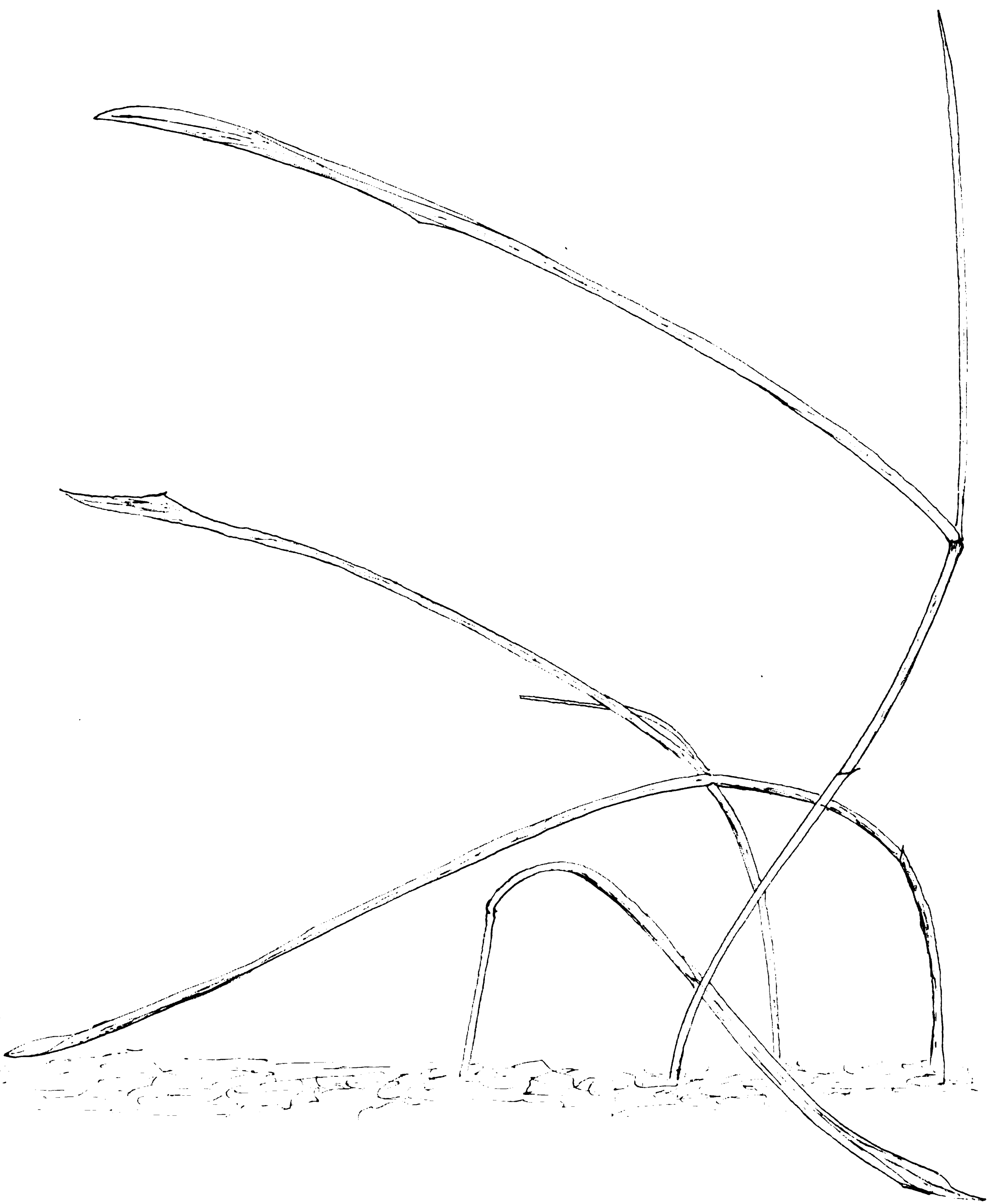


Plate III

Plate IV.

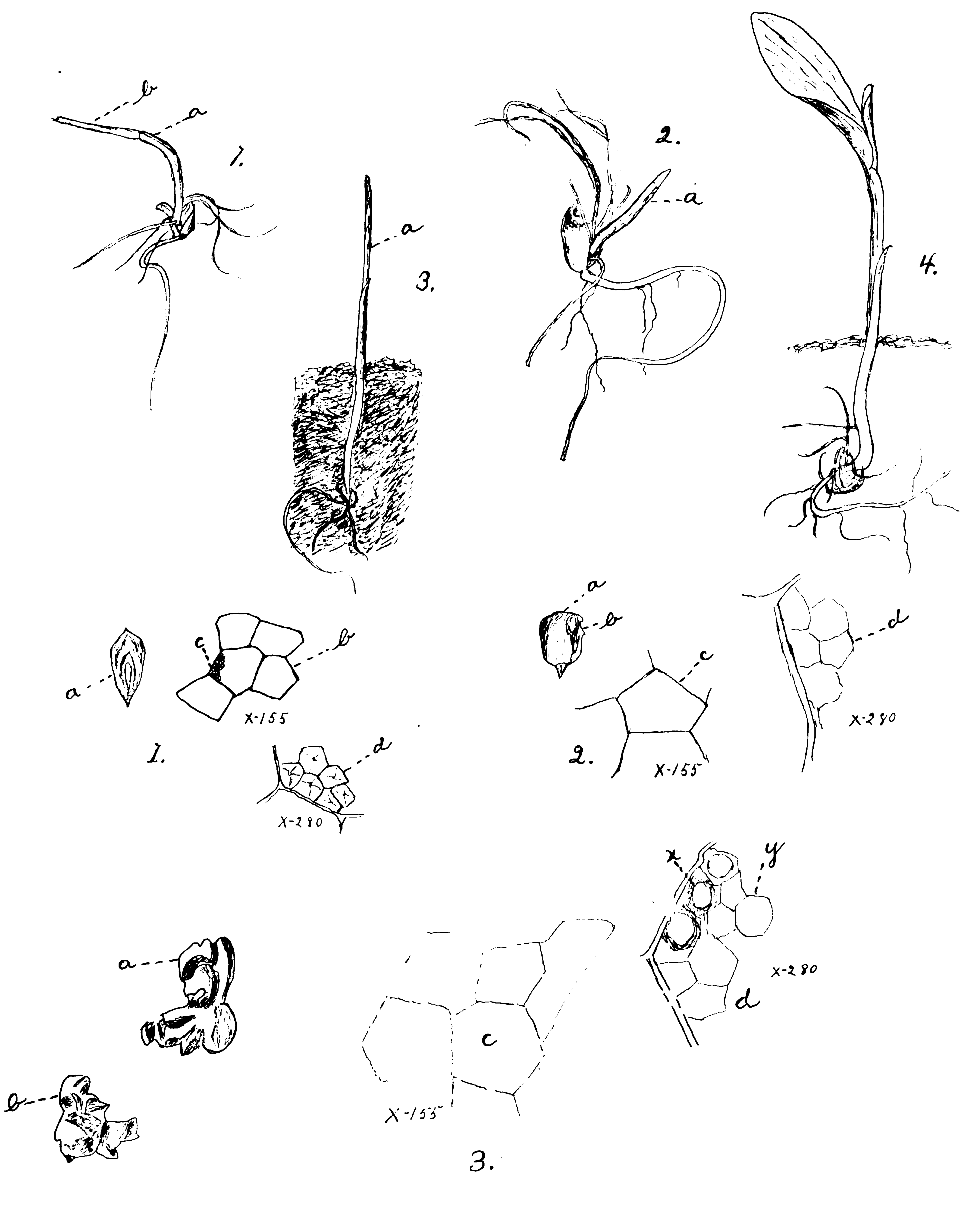
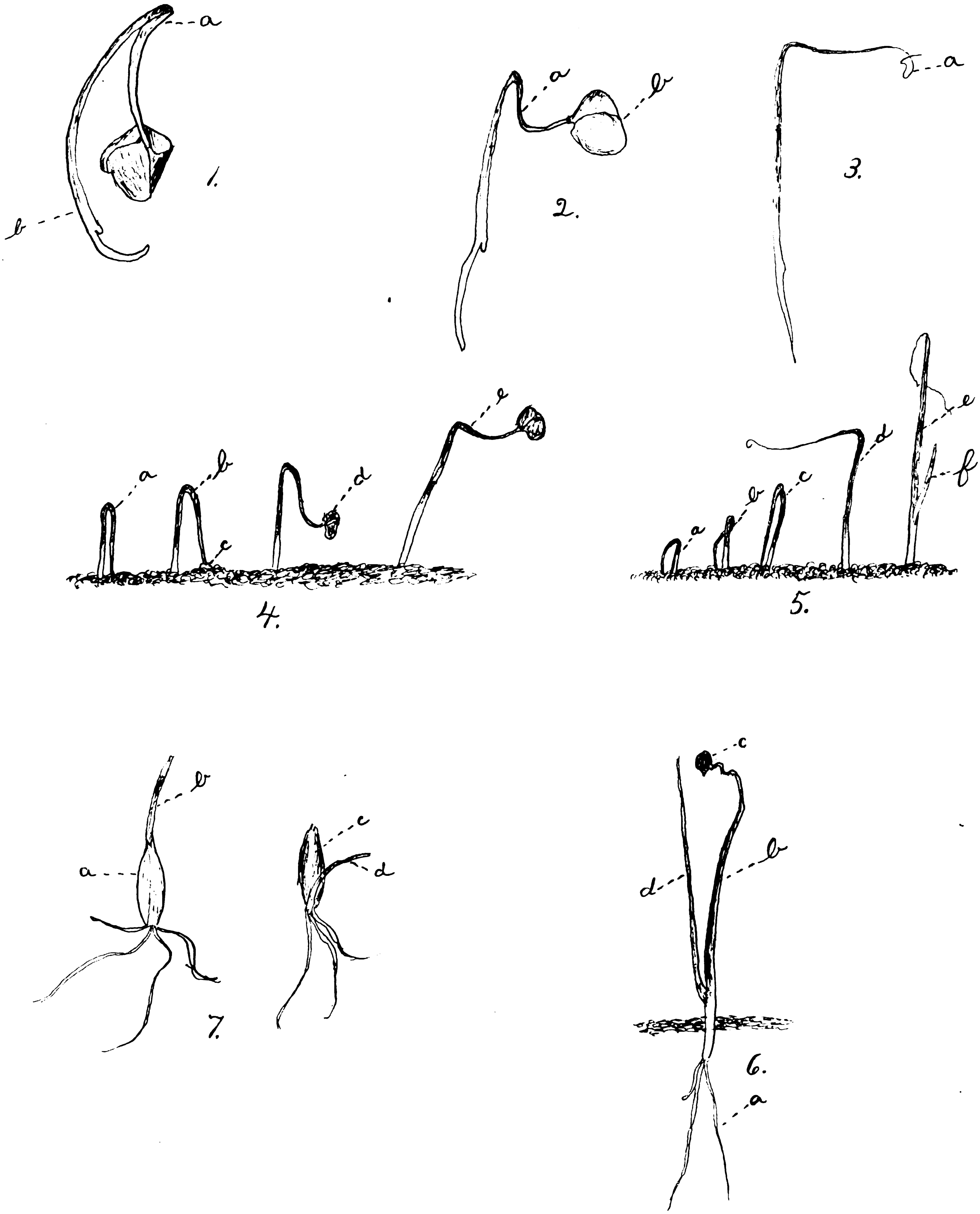


Plate I



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