freight-train ahead, may be regarded as of great importance to the American railroad system, in a manner crowning the edifice, and enabling roads to be operated with greater speed, safety, and regularity.

(To be continued.)

THE INFLUENCE OF GRAVITATION, MOISTURE, AND LIGHT UPON THE DIRECTION OF GROWTH IN THE ROOT AND STEM OF PLANTS.

MEMBERS of my present botany class have performed some experiments this spring, bearing upon the above caption, which, although not developing any thing new in the interest of the extension of experimental methods in the lower schools, it seems to me may be found worthy of a record in the columns of SCIENCE.

Seven balls of moss, about four inches in diameter, were prepared, in the centre of which were planted from fifty to a hundred grains of oats, barley, or corn; in some cases a mixture of two of these grains.

No. 1 was suspended in free air, lighted on all sides. No. 2 was placed on a glass tumbler, in the bottom of which some water was kept, but not enough to rise within two inches of the lowest part of the ball. No. 3 was fitted into the mouth of an inverted bell-glass in such a manner that one half of the ball was within the jar and one half without it. No. 4 was placed one half within and one half without a bell-glass placed in a horizontal attitude. No. 5 was in a tight tin can, the ball fitting it like a stopper, so as to exclude the light and to prevent a circulation of air. One-half of the ball protruded from the can, and the can was inverted. No. 6 was placed in a can similar to that of no. 5; but this was placed in a horizontal attitude, as in no. 4. No. 7 was mounted upon a spindle running through its centre. The spindle was attached to the stem of the minute-hand of an eight-day clock in such a manner that the axis of the spindle was a continuation of the axis bearing the minute-hand of the clock. The spindle was a piece of one-eighth inch brass wire having a strip of tin soldered to one end of it. The tin was perforated with a square hole, exactly fitting the shaft of the minute-hand of the clock. The other end of the wire was filed down to form a small journal, which worked in a hole bored in a lump of solder secured to the end of a wire which acted as a support to the distant end of the spindle. This supporting wire was first bent double, forming a narrow V, and the solder, which served as a box for the journal, dropped in the vertex. The two arms of the V were then bent upon themselves in the same direction so as to form a right angle with the plane of the V. Two holes were bored in the frame of the clock above the dial, but close to it, and the arms of the bent V inserted. The minute-hand was then removed from the clock, and also the washer behind it. The tin shoulder of the spindle was then placed upon the shaft, and the minute-hand replaced; the shoulder serving in the place of the washer, which had not been replaced. It was only necessary to shorten the pendulum a little to enable the clock to record time with its usual regularity.

The results observed after germination were as follows: —

In no. 1 the stems all came out in a clump at the top of the ball, and the roots in a cluster from the under side. The roots, however, after protruding from half an inch to an inch, curved upon themselves, and re-entered the ball, or else withered. In no. 2 the stems all came out at the top, and the roots at the bottom; but the roots in this case continued straight downward into the water, no one of them turning back into the ball. In no. 3 the plants deported themselves in all respects as those did in no. 1, except that the growth was very much more rapid. In no. 4 all of the stems except two came out of the ball into free air: two grew horizontally into the bell-jar. A large cluster of the roots came out of the ball and entered the jar, and continued to grow horizontally, only depending so much as was necessary by their own weight. Others of the roots emerged from the lower side of the outer half of the ball, but soon entered it again. In no. 5 all of the stems came up in the dark, damp atmosphere; and the roots emerged from the lower side of the ball, but re-entered it again, or else perished. Many of the stems (oats in this case) threw out a pair of opposite bodies, apparently secondary rootlets, which grew horizontally, in all cases observed, to a length of about one inch. The color of the stems in this case was a pale yellow. In no. 6 all of the stems came from the ball upward into the light, and very many of the roots protruded horizontally into the can, some of them leaving the ball above its centre. A corn-root extended itself horizontally four inches beyond the surface of the ball, and in that distance was only depressed one-half of an inch. On the corn-roots back of the sensitive tips, the delicate root-hairs were so numerous and long as to give it a resemblance to the hair-brush for

cleaning lamp-chimneys. In this ball a number of roots also emerged from the lower side of the ball, but only to re-enter it again, as in the other cases. In no. 7 stems and roots came out together indiscriminately, and from all sides of the ball; the roots, however, after protruding from half an inch to an inch, re-entering the ball or withering. This experiment was twice repeated. In the first case more stems appeared from the side of the ball away from the face of the clock, and the greater number of roots made their appearance on the opposite side of the ball. It was observed in this case, however, that the spindle slanted about two degrees toward the clock. In the next experiment the spindle was made horizontal, and no difference as to place of emerging of root and stem was observed.

These experiments in combination appear to show with clearness the influence of moisture and gravitation in determining the course of the root, and to suggest that the influence of moisture is the stronger of the two.

The emergence of the sensitive tips of the primary roots from the damp ball into the dry atmosphere I suppose Darwin would have explained as the result of the persistence of the impressions in the root behind. The horizontally extending roots in the damp atmosphere, both dark and light, suggest that the response to gravitation in both cases was *nil*. May it not be true that the diageotropism of roots is such in no other sense than that of direction of growth? that it is in reality simply a growing toward the proper amount of moisture? This would appear to explain the oblique direction of secondary branches, and the largely indifferent direction of tertiary ones. The balls in the jars placed in the horizontal attitudes indicate that the stem does not grow simply in a direction opposite to that of the principal root, for they were turned toward each other through an angle of nearly ninety degrees. The two inverted jars show that the stems did not seek a dry atmosphere, for in both cases they grew up into that which was more moist. The inverted dark jar shows that the effect of the impact or absorption of light on the lower half of the ball, and the absence of these effects upon the upper half, did not produce a sufficient contrast to guide the stem into the light; but since, of the two jars placed in the horizontal attitude, only the ball in the mouth of the glass one sent stems into the jar, it seems possible, since other conditions were alike, that light may exert a small influence in guiding the stems from the ground.

F. H. KING.

River Falls, Wisconsin, May 17, 1883.

SOME GLACIAL ACTION IN INDIANA.

WITH members of my class in geology, I have been examining the glacial deposits in this vicinity (Montgomery county). Our chief water-course is what is called Sugar Creek, a tributary of the Wabash River, which occupies a valley with a general south-westerly bearing, virtually the same trend which the Wabash has across the state before it makes its sharp bend to the south. Along the valleys of the Wabash and Sugar Creek, there are abundant evidences of a glacier which moved in the direction of the valleys, and is known as the Lake Erie glacier, as it advanced in the direction of the axis of that lake, and so up the Maumee, and across the low divide at Fort Wayne, into the Wabash. Sugar Creek itself has been compelled to bend sharply to the south a few miles to the west of us by the deposits of this old glacier, and has cut its new channel through the soft subcarboniferous sandstone. At one place in this county, where the creek still occupies its preglacial valley, it cuts through what we formerly considered a large terminal moraine, which lies squarely across the valley. Recent floods have swept away some of this moraine, and laid bare the country rock. This rock is found to be smoothly planed, and absolutely covered with glacial scratches all trending N. 20° W., or almost at right angles to the valley of the creek and the course of the former glacier. These scratches of the second glacier are now found in many places throughout the county; and our old terminal moraine proves to be a medial moraine, and bears upon its back a line of huge bowlders with the same north-westerly trend. These facts are recorded here in the hope that they may be of some use in the consideration of a much-vexed question.

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THE UNITED STATES FISH-COMMISSION STEAMER ALBATROSS.

I.

PROBABLY no department of scientific investigation has made greater progress in its methods of work during the past ten years than that of deep-sea research. The successful introduction of steel piano-wire for sounding, and of wire rope for dredging purposes, marks a new era in this class of exploration, for which credit is mainly due to American skill and energy. While claiming so much in behalf of our own country, we frankly acknowledge that the only feasible method of using sound-