tary, and Messrs. E. Wood, J. Wilson, Haffenden, H. Pye, W. Bensted, W. Jull, B. and T. Wickham, T. Powell, W. Manwaring, T. Wyles, A. Smith and P. Brine.

Votes of thanks to Mr. Whitehead and Mr. Lak terminated the proceedings.

PRACTICE WITH SCIENCE.

(From the *Mark Lane Express.*)

THE MOVEMENTS OF PLANTS.

No. I.

A Sensitive Plant in a garden grew,
And the young winds fed it with silver dew,
And it opened its fan-like leaves to the light,
And closed them beneath the kisses of night.

And the Spring arose on the garden fair
Like the Spirit of Love felt everywhere;
And each flower and herb on Earth's dark breast
Rose from the dreams of its wintry rest!

But none ever trembled and panted with bliss
In the garden, the field, and the wilderness,
Like a doe in the noontide with love's sweet want,
As the companionless Sensitive Plant.—SHELLEY.

Not many years ago the Sensitive Plant *Mimosa pudica*, was regarded as a *rara avis*; high-born ladies suffering from *ennui*, and wealthy men whose possessions made them indolent and weary were glad to have in their conservatories, for the amusement of their friends, a member of the vegetable world which, on being touched, would fold up its delicate leaves and keep them in that position so long as the irritation lasted, only slowly unfolding them when the exciting cause had been for some time removed. In course of time other plants, such as *Desmodium gyrans*, the moving plant of India, were found to possess the same remarkable power, and were added as companions to the original sensitive plant. Yet, even now, plants which on the application of some stimulus exhibit motion in any of their parts are regarded as prodigies, it being commonly considered a most wonderful thing for a plant to possess the very animal-like power of movement. Probably the reason these so-called sensitive plants attracted so much attention was that they respond almost immediately to such a stimulus as a gentle touch, and will continue to do so till they get wearied of the effort, when a period of inactivity is bound to supervene. It has long been known that many very ordinary wild plants respond to certain natural stimuli, such as the change between day-light and darkness, the approach of rain, the impact of the wind, or the touch of an insect. The leaflets of the wood-sorrel, *Oxalis acetosella*, close up on the approach of night, the flowers of the poor man's weather-glass, or scarlet pimpernel, *Anagallis arvensis*, close when rain threatens, and the stamens of the yellow-flowered barberry, *Berberis vulgaris*, when touched with a fine point on the inner side, spring violently inwards and strike the pistil. Moreover, readers who have glanced over the pages of the ponderous tome of Julius Sachs will remember that in his discussion of the mechanical laws of growth, and the periodic movements of the mature parts of plants, and of movements dependent on irritation, he paves the way for the general acceptation by vegetable physiologists of the doctrine that movements in plants are quite as frequent and quite as concomitant necessaries of life and growth as in animals. But facts which were hitherto known only to the studious few have now been enormously augmented, thanks to the unwearied energy of one whose capacity for work seems almost superhuman; and wondrous phenomena of plant-life, a knowledge of which has up to the present been almost exclusively confined to the ranks of physiologists, are now made known to all the world by the publication of the latest work of Charles Darwin, entitled "The Power of Movement in Plants."

The illustrious investigator had already in his work on "The Movements and Habits of Climbing Plants" broken the ground which his latest labours more effectually explore, and the chief difference between the two essays is that in his work on Climbing Plants he investigates those grosser and coarser motions which are at once palpable to the eye in the twining of a tendril round a twig, or of such a stem as that of the hop round a stouter support; whereas in his most recent work he attempts the more difficult task of determining the nature and causes of those far more delicate movements which constitute part of the phenomena of growth in almost all plants. With this object in view he has found it necessary not only to familiarise the English-speaking peoples with certain scientific terms of which the *profanum vulgus* had not yet heard, but to enrich the English vocabulary with a few of his own coining, which, apart from their intrinsic merit, are of much interest on account of the phenomena which they are employed to denote.

The growing end of the stem of a climbing plant is found to bend successively to all points of the compass, so that the tip revolves. Such a movement is called by Sachs revolving nutation, but Darwin prefers the word circumnutation (*circum*, around; *nutare*, to nod or sway), and such a revolving tip is said to circumnutate. The cause of the movement of circumnutation is the increased turgescence or swollen state of the cells from imbibition of water on one side of the stem as compared with the other, the extensibility of the cell-walls leading to an increased growth on the one side. Now, if a succulent stem be at first perfectly straight, and if then the cells on one side grow more rapidly than those on the other, it follows as a mechanical necessity that the stem becomes bent, and that the side on which are the more rapidly growing cells becomes convex, and the other side, of course, concave.

Dr. Darwin's investigations show that apparently every growing part of every plant is continually circumnutating, though often on a small scale. He shows that the movement is identically the same in all cases, that is, it is of the same character always; though the amplitude of the movement, that is, the width of the curve which is described, is subject to extreme variation. The stems of seedlings even ere they burst through the soil circumnutate in a microscopic degree, and there is no absolute difference between the character of this movement and that of the great sweeps made by the stems of twining plants and by tendrils of other climbers. In a leaf-bud all the young leaves are laid snugly together side by side, and it is by circumnutating movements greater in some one direction that they ultimately come to occupy the permanent expanded position which they gradually acquire during growth. It is circumnutation which enables the leaves of certain plants to sleep at night, by affording them facilities for assuming a vertical position, in order to protect their upper surfaces from being chilled through radiation. Many window plants are known to bend to the light; here again there is circumnutation, and the greater cell growth takes place on the side of the stem away from the light, which therefore becomes convex. Such bending towards the light is called heliotropism (*helios*, the sun; *tropos*, a turning to). Leaf-stalks always bend towards the source of light, and most stems do the same. Much less common is the phenomenon of apheliotropism (*apo*, away from), or the bending of growing parts away from the light, as may be seen in the tendrils of the vine and the Virginian creeper. Diaheliotropism (*dia*, right through) expresses a position more or less transverse to the light and induced by it. What Darwin calls heliotropism has hitherto been designated as positive heliotropism, and his apheliotropism as negative heliotropism; the Darwinian terms are decidedly preferable.

Gravitation, like light, exercises a powerful nfluence on growth. The most simple case is that of the primary root of a seedling. Let a pea or bean be laid on some soil in a flower-pot, and though it may be so placed that the young root emerges at the top of the seed, yet it will speedily be found to arch over and plunge downwards into the soil. It does this in virtue of the earth's attraction, and this bending towards the centre of the earth is called geotropism (*ge*, the earth; *tropos*, a turning to). Apogeotropism obviously implies a bending in opposition to gravity, or away from the earth. In the instance of the pea or bean, just cited, the primary stem, though it may emerge from the under side of the seed if the latter is conveniently placed, will nevertheless curve round and grow upwards, and this is an example of apogeotropism. Generally speaking, all primary roots exhibit geotropism, and all primary stems apogeotropism. After wheat has been laid by a storm it recovers the erect position by apogeotropism, in virtue of the slight growth of cells on the under side of the prostrate stems.

Growing parts usually exhibit an inequality in the date of growth at different parts of their length or circumference. Thus the young leaves of a plant grow at first more rapidly on the under side than on the upper; consequently the leaves arch over and form the protective covering or bud at the apex of the stem. Afterwards the upper side grows more rapidly, and the leaves bending in an opposite direction lead to the unfolding of the bud. Parts growing more rapidly on the upper side are said to be epinastic, the term epinastic (*epi*, upon; *nasso*, to pile up) denoting that the upper surface of an organ grows more rapidly than the lower surface, resulting therefore in a bending downwards of the part. Hyponasty (*hypo*, under) is the reverse process, so that in hyponastic parts there is increased growth on the under side, resulting in a bending upwards. Epinasty and hyponasty necessarily lead to movements of nutation, and these when due to internal causes are automatic, as in the opening of leaves and the movement of twining stems. But they quite as frequently arise from external causes, as is seen in the movements of tendrils and the periodic motions of foliage and floral leaves, such as the waking and sleeping of certain plants and the opening and closing of certain flowers, the white hedge convolvulus being an example of the latter.

It must be evident that these movements of epinasty and hyponasty accompany and make manifest the effects of heliotropism and geotropism. By not only remembering these terms, but by bearing in mind the fact that they are used to denote certain constantly occurring phenomena of plant-life, the reader will have no difficulty in understanding the wonderful investigations which Mr. Darwin has lately made, and of which we hope to give a description next week.

DAIRY FARMING.

(From the *Mark Lane Express.*)

THE MANUFACTURE OF OLEOMARGARINE.

Amongst the papers recently presented to Parliament is one compiled by Mr. A. E. Bateman, of the Statistical Department of the Board of Trade, upon the manufacture of oleomargarine in the United States. This paper is the result of personal investigation into the details of the production and sale of this novel and somewhat questionable compound, and in appendices are given statistics of its manufacture and export, extracts from American newspapers —some in favour of and some protesting against its sale, testimonials as to its wholesomeness as an article of diet by a formidable array of professors, and a draft of a Bill before the New York State Legislature regulating its sale, with a view to prevent fraud.

The Commercial Manufacturing Company are the principal makers of oleomargarine, by a process known as the Mége patent. The beef suet, on arriving from the abattoir, is washed in cold water, and then disintegrated by being passed through a "meat hasher" and passed through a fine sieve. It is then melted by being put in tanks surrounded by hot water pipes, but the heat is not raised above 120 deg. The more solid part of the fat sinks, and a clear yellow oil is left above, which is drawn

Practice with Science.

(From the *Mark Lane Express.*)

THE MOVEMENTS OF PLANTS.

No. II.

When a seed is sown, it must be evident that a considerable amount of mechanical work has to be done before the stage is reached at which the young plant is firmly fixed in the soil. In the case of a pea, for example, imbibition of water causes the two cotyledons, or seed-leaves, to swell so much that the testa, or seed-coat, is ruptured and, in the end, discarded. Simultaneously the radicle, or primary root, begins to emerge from between the cotyledons at the one end and the plumule, or primary stem, at the other. The radicle and plumule, constituting respectively the decending and ascending axes of the plant, have before them no easy task in that they have to penetrate the mass of soil opposed to them, and one of the problems Mr Darwin set himself to solve was: How does a filament of vegetable cells, so fragile and delicate that a slight pressure between finger and thumb will destroy it, explore for itself a passage through and amongst the hard coarse fragments which make up the soil? The answer is to be found in those movements of circumnutation which we discussed in these columns last week (p. 138).

The tip of the radicle, directly it protrudes from the seed-coats, begins to circumnutate, and the whole growing part continues to do so, probably for as long as growth continues. Darwin actually observed and measured this movement, microscopic though it is, in such widely different plants as seedlings of the cabbage, chestnut, bean, vetch, gourd, oak, and maize, and this he did either by means of extremely fine filaments of glass affixed to the radicles, or by causing the radicles to grow downwards over inclined smoked glass-plates, and so leaving tracks of their course on the latter. The tip of the radicle traced out a serpentine path on the smoked glass, and as the tracks were alternately narrower and broader, and sometimes interupted altogether, the only possible inference is that the tip of the radicle moves in a somewhat spiral fashion. If, now, the radicle in its downward course as determined by geotropism should, in virtue of its circumnutating movenents, break obliquely into any crevice, or a hole left by a decayed root, or one made by the larva of an insect, and more especially by worms, the revolving movement of the tip will materially aid it in following such open passages. It has often been observed that roots extend down the old burrows of worms.

But suppose the radicle should not meet with these favourable conditions; what then? Even in this case the radicle is well equipped for the work it has to do, for its tip. is sensitive, and in inquiring of what service this is to the growing root we must remember that a part or organ is said to be sensitive when its irritation excites movement in an adjoining part. Darwin shows by numerous experiments that when one side of the tip is touched or irritated the part of the radicle just above it tends to bend away from the source of excitement, or from the obstacle or object causing the irritation. Circumnutation, therefore, combined with the sensitiveness of the tip to contact, is of the highest use to the root, for as the tip is always endeavouring to bend to all sides, it will press on all sides, and will thus be able to discriminate between the harder and softer adjoining surfaces in the soil; and as the radicle will bend most from the hardest irritants, it will, as a result, select the line of least resistance as the easiest path through the soil. So it will be if it meets with a stone or the root of another plant, as must incessantly occur. If the tip were not sensitive, and if it did not excite the upper part of the root to bend away whenever it encountered at right angles some obstacle in the ground, it would be liable to be doubled up into a contorted mass. The tip of the radicle is, moreover, sensitive to differences of moisture, and this also determines a bending of the upper part; this capacity, perhaps, partly accounts for the extent to which drain-pipes often become choked with roots.

In addition to the reasons already mentioned, radicles are able to penetrate the ground by the force due to their growth in length and breadth, the seeds themselves being held down by the weight of the superincumbent soil. The pressure in a downward direction, determined by geotropism, was measured in several cases; the tip of the radicle of a bean lifted up a quarter of a pound in twenty-four hours. The transverse strain was determined by clamping the radicle between the hollowed-out faces of wooden pincers, and after a certain time finding what weight would be required to force the pincers as far apart as the expanding radicle had done; in one instance this was found to amount to 8 lb. 8 oz. in six days.

It is not difficult now to see how a radicle penetrates the ground. The apex is pointed, and is protected by the root-cap, a layer of used-up cells; the terminal growing part is rigid, and increases in length with a force equal to the pressure of at least a quarter of a pound, and probably with a much greater force when prevented from bending to any side by the surrounding earth. Whilst thus increasing in length, it increases in thickness, pushin away the damp earth on all sides with a force which in one case exceeded 8 lb. The growing part, therefore, does not act like a nail when hammered into a board, but more like a wedge of wood, which, whilst slowly driven into a crevice, continually expands at the same time by the absorption of water, and a wedge thus acting will split even a mass of rock.

The direction which the apex takes at each successive period of the growth of a root ultimately determines its whole course; it is therefore important that the apex should pursue from the first the most advantageous direction, and we can thus understand why sensitiveness to geotropism, to contact, and to moisture, all reside in the tip, and why the tip determines the upper growing part to bend either from or to the exciting cause. A radicle may be compared to a burrowing animal, such as a mole, which wishes to penetrate perpendicularly down into the ground. By continually moving his head from side to side, or circumnutat ng, he will feel any stone or other obstacle, as well as any difference in the hardness of the soil, and he will turn from that side; if the earth is damper on one than on the other side he will turn thitherward as a better hunting-ground. Nevertheless, after each interruption, guided by the sense of gravity, he will be able to recover his downward course and to burrow to a greater depth.

In such telling words as these does the illustrious author describe his researches and his inferences, and we have dealt thus long on the case of the radicle merely that it may serve the reader as a type of the kind of investigation to which Mr. Darwin has subjected every part of the plant. He shows how the parts of the radicle and plumule immediately adjacent to the cotyledons circumnutate even during the early stage of their existence while buried and arched, how they straighten themselves, and how the seed-leaves also are sensitive to light and to contact. He describes the circumnutating movements of erect and prostrate stems, aid being thereby afforded to the latter in winding among the stems of surrounding plants. Flower-stems, leaf-stalks, and leaves exhibit similar movements, the leaves generally rising in the evening and sinking in the morning. The heliotropic movements of such plants as beet root, potato, oat, cabbage, canary-seed, garden-nasturtium are investigated, and the uses of heliotropism indicated. Insectivorous and climbing plants are not heliotropic. The same organ may be heliotropic at one age and not at another. Some plants are much more sensitive to light than others, but the effects of light do not correspond with its intensity, and depend to some extent on previous illumination. Circumnutation is, according to surrounding conditions, convertible into heliotropism or apheliotropism, and into geotropism or apogeotropism, and these movements themselves may interfere with or modify each other. The flower-stalks of one of the clover family, *Trifolium subterraneum*, bend over by geotropism and bury the flowers beneath the ground, where the seed is perfectly ripened; in such flower-heads as are unable, in consequence of their position, to reach the ground very few fertile seeds are formed. The underground shoots of the troublesome couch-grass, *Triticum repens*, become apogeotropic, and thus aid in keeping up a continually increasing source of vegetation at the surface of the ground, and leading to the bedded or couch-like habit of the plant. The long, thin, light pods of *Cyclamen Persicum*, a plant of the primrose family, bury themselves in the soil with the aid of the apheliotropism of the flower-stalks. The young leaves of the Swede turnip draw together in the evening so much that the horizontal breadth between them diminishes about 30 per cent. of the daylight breadth, and those who have the patience to watch and measure may be convinced that the leaves of the homely cabbage move somewhat similarly. The ivy climbs by the adventitious rootlets of its stem, and the apheliotropism of the stem drives it, as it were, against the wall or other support up which it climbs. When the sun shines brightly on the leaflets of Robinia, they rise up and present their edges to the light in virtue of paraheliotropism; at night their position is vertically downwards. And so we might go on multiplying instances of movements which, though apparently extraordinary and fantastic, are nevertheless perfectly normal, and are brought about solely by the operation of natural agencies. There are other phenomena more striking, perhaps, than those of which we have spoken, concerning the sleep of plants, and with this fascinating subject we hope to deal at some future time. Suffice it now to say that Darwin's "Movements of Plants" is a book written in so artless and simple a style, while the facts it describes are so novel and curious, that the reader almost seems to hear a voice whispering "What is't you read—romance or fairy fable?"

It is impossible, says the author, not to be struck with the resemblance between the movements of plants and many of the actions performed unconsciously by the lower animals. With plants an astonishingly small stimulus suffices, and even with allied plants one may be highly sensitive to the slightest continued pressure, and another highly sensitive to a slight momentary touch. The habit of moving at certain periods is inherited both by plants and animals, but the most striking resemblance is the localisation of their sensitiveness, and the transmission of an influence from the excited part to another which consequently moves. Yet plants do not of course possess nerves or a central nervous system, and we may infer that with animals such structures serve only for the more perfect transmission of impressions, and for the more complete intercommunication of the several parts.

There is no structure in plants more wonderful, as far as its functions are concerned, than the tip of the radicle, of which we spoke at the outset. The course pursued by the radicle in penetrating the ground must be determined by the tip, and this is the reason it has acquired such diverse kinds of sensitiveness. It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals, the brain being seated within the anterior end of the body, receiving impressions from the sense-organs, and directing the several movements."

In his simple concluding words, "The tip of the radicle acts like a brain," Charles Darwin rivets one more link in the chain of that bold and comprehensive theory with which his name will ever be inseparably associated.

DAIRY FARMING.

(From the *Mark Lane Express.*)

THE MANAGEMENT OF SHORTHORN DAIRY HERDS.

One of the most interesting and instructive articles in the last-issued volume of the R. A. S. *Journal*, Vol. 16, Part 2, is that upon "The Management of a Shorthorn Herd," by William Housman. This writer, whose ability and experience in connection with this subject are well known, has visited some of the best Shorthorn herds in various parts of the United Kingdom, and records in this article some of the leading points of management which appear worthy of note in each of the herds visited, varying as they do widely in character and locality. We propose to consider those portions of the report which have special reference to milk production and the breeding and management of Shorthorns, with a view to stimulate and perpetuate their dairy usefulness.

The management of Shorthorns in the north of Scotland is first described; but here, whilst the value of milking properties is freely allowed, chiefly on the ground that a good milking cow will give her offspring a better start in life than a cow which can barely rear her calf, everything is secondary to heavy flesh and beef production in this district, which is renowned for its beef, and where little profit is sought from the dairy.

In the north of England, however, we find a higher value set upon the development of dairy usefulness. Mr. Housman's remarks upon breeding dairy Shorthorns are so forcible that we give an extract. "There is no recipe for the production of cows that can fill the dairy, breed the primest steers, and make good beef when they have done breeding; all must be done by judgment acquired only in practice. But there are certain rules which cannot be set aside with impunity. If, for instance, heifers be forced for show or sale, all chance of developing their milking properties should be abandoned at the outset. The happy medium of liberal but not extravagant beef, early use of the milk secreting organs by early breeding, frequent and clean milking, to stimulate the flow of milk, especial attention to the forebag in heifers in calving, and the use of such foods as support and sustain the animal while increasing the yield of milk, are among the means of