Hence arose the erroneous theory, formerly much in vogue, that plants have two respirations, one by day, the other by night, and of inverse orders. The truth of the matter is, as M. Corenwinder, who, though not by any means the first to state it, has given the fullest proofs of it, declares, that 'in all living beings there is only one true respiration, and it is the same for all. The part played by the chlorophyll is of a different order; it is an act of assimilation.'[1]

At the same time it must be borne in mind that the consumption of oxygen by plants in respiration bears a very small proportion to that of carbon as food and the consequent evolution of oxygen; while, on the other hand, the manifold activities of animal life necessitate so large a consumption of oxygen and formation of carbonic acid gas as would soon render the atmosphere positively poisonous, if the balance were not maintained by vegetation. This beautiful mutual adjustment of the two great orders of living beings has been too often pointed out to require further remark.

During germination, as we have said above, the life of the embryo plant is supported by the material stored up in the seed. At the outset, though respiration begins at once, no organ exists for the assimilation of carbon. The plant will only begin to support itself when it has a green surface submitted to the influence of light. In his recent work on *The Power of Movement in Plants*, Mr. Darwin mentions a beautiful contrivance, the object of which is to facilitate the emergence of cotyledons[2] from the seed coats, in order that the light may reach them. Mr. Darwin gives to M. Flahault the credit of first describing it, but he has himself verified M. Flahault's observations. In the Cucurbitaceæ, or Gourd tribe, the seed coat forms a tough and rather hard envelope, which, however, may be easily split in two halves. The mere swelling of the cotyledons is sufficient to effect their liberation by thus bursting the inclosure. But the plant is provided with the means

[1] See *Annal. des Sciences Naturelles*, 6me sér. tome vi. 'Botanique,' p. 316.

[2] The cotyledons are 'organs which represent the first leaves,' and in many plants, though unlike the true leaves subsequently formed, assume the appearance and function of leaves. Plants are distinguished as Acotyledonous, Monocotyledonous, and Dicotyledonous—*i.e.* without cotyledon, with one, with two. In some species one cotyledon, in others two, remain undeveloped, rudimentary structures. Mr. Darwin points to the fact that in these cases the nutrition of the infant plant is provided for by the formation of a kind of bulb, and he is of opinion that the thickening of the radicle or hypocotyl in plants, which formerly produced two cotyledons, preceded and led to the abortion of these, or one of them, as being no longer necessary.—*The Power of Movement in Plants*, pp. 94–98.

by which their liberation, under ordinary circumstances, may be achieved two or three days earlier than they could accomplish it by themselves. To quote Mr. Darwin's description—

'A heel or peg is developed on one side of the summit of the radicle . . . . and this holds down the lower half of the seed coats (the radicle being fixed in the ground), whilst the continued growth of the arched hypocotyl,' the part of the stem above the radicle and below the cotyledons, 'forces upward the upper half, and tears asunder the seed coats at one end, and the cotyledons are then easily withdrawn.'

Mr. Darwin tells us that this contrivance is very general among the *Cucurbitaceæ*, and concludes with the remark that 'few cases can be advanced of a structure better adapted for a special purpose.' [1]

We have seen that there is one uniform process of respiration [2] for all forms of terrestrial life, and one source of the chief material of all terrestrial organisms. We need not linger upon the marvellous harmony between the scientific discovery of the effect of light upon the chlorophyll cell and the statement in Genesis that light preceded vegetation and vegetation preceded animal life. This point has been frequently insisted on, and it will suffice now to have recalled it to mind.

Where, however, can we find a more striking example of the modern perception of unity than in the two processes described? And what does that unity suggest? To our minds it suggests with overwhelming force the thought of a pre-ordered course. If life, according to some materialist theories, were the result of some chance combination of atoms, we should expect to find it, here and now, under one set of conditions, at another time and place under another set. Is it conceivable that chance should tie down life to these two universal conditions, the necessity of respiration and absolute dependence upon the action of a certain vegetable cell? In reflecting upon the character of those ultimate atoms which are inferred to form the substance of all matter,

[1] *The Power of Movement in Plants*, p. 101 *seq.*

[2] Fishes find sufficient air in the surrounding water, unless the temperature rises above a certain point. In hot weather their increased vital activity, approaching that of warm-blooded animals, creates a demand for more oxygen than they obtain from the water. To meet this demand they rise to the surface and take in air. They cannot live any considerable time out of water, owing to the drying up of the membrane of the gills where this is exposed to the air, and the flapping together of the filaments of the gills when water is no longer flowing between and separating them.—Carpenter's *Principles of Comparative Physiology*, p. 315.

scientists have found in the uniformity that is coupled with their marvellous combining possibilities the traces of One Will. They bear the mark, we are told, 'of manufactured articles.' With equal propriety, while we point to the uniformity that, notwithstanding the marvellous variability with which it is linked, prevails throughout the realm of terrestrial life, we claim to assert that every living organism proclaims its community of origin with every other, that—

'All are but parts of one stupendous whole'[1]—

and that all bear the impress of One Supreme Will.

But, after all, has science solved the mystery of life? She has done no more here than in regard to gravitation. She has formulated the law that terrestrial life is dependent upon the atmosphere for the stimulus of oxygen, and upon the same atmosphere, acted upon by light in the minute chamber of the vegetable cell, for carbon. Why oxygen should be charged with its important function we know not. We can at most compare its behaviour in the living organism to the part it plays in combustion and in other chemical processes in non-living substance. Why light should perform the marvellous operation which it does perform in the chlorophyll cell we know not. At the most we can discover which element of the luminous ray is the most effective; the yellow, we are told, doing more work than all the rest together; and we can find in the action of light upon the sensitive plates of the photographer some resemblance to its action upon chlorophyll. We cannot assert that all manifestations of life in all other regions of the universe must be subject even to these elementary conditions which we find on earth. All that we know is, that life on earth can only manifest itself under these conditions, which, we have abundant reason to believe, are imposed upon it by Creative Power.

We turn now to the consideration of a phenomenon in the world of plants to which a term derived from animal life has been commonly but incorrectly applied. There is nothing beyond the merest superficial resemblance to justify our speaking of the Sleep of Plants. What we mean by sleep is a state or condition characterized by a suspension of those faculties which distinguish animal life; that is to say, in the words of Dr. Carpenter's definition quoted above, 'the faculties of Sensation and of Self-determined motion, and, in its

[1] So far we may go with Pope. We shrink from the apparent pantheism of the second half of his couplet—

'Whose body Nature is, and God the soul.'

highest manifestation, that of the Intelligence and the Will.' Consequently, this condition cannot be correctly predicated of organisms that do not possess any of these faculties. Yet when the petals of many flowers were observed to close in the afternoon or evening, and open again the following morning,[1] when in so many plants the leaves were observed to bend downwards or upwards, or to close together at or before the hour of human repose, the time

> 'Quo prima quies mortalibus ægris
> Incipit,'

it was not unnatural to suppose that the plant passed into a condition analogous to that of the sleep of animals. Modern science had well-nigh dispelled this idea; but an explanation of the purpose served by the so-called sleep movements was wanting as regards leaves and cotyledons. As regards the so-called sleep movements of the petals of flowers, it has been shown 'that they are caused or regulated more by temperature than by the alternations of light and darkness.' Their chief purpose seems to be the protection of the delicate organs of reproduction, the pistils and stamens, from cold wind, and rain; but they also benefit many plants by preventing the entrance of 'nocturnal insects which may be ill-adapted for their fertilization, and [of] the well-adapted kinds at periods when the temperature is not favourable for fertilization.'[2] One of the latest scientific achievements of Mr. Darwin, whose powers of observation and of lucid exposition, whose ingenuity in questioning Nature and skill in interpreting her answers, are beyond praise, is to furnish a solution of the problem, which was yet unsolved, with regard to the so-called sleep of leaves. It appears to us that he has proved his point, and that in this case 'thought has wedded fact.'

Mr. Darwin remarks that since the idea is all but universally given up of there being any analogy between the sleep of animals and these movements in plants, the erroneous term should be given up likewise. He suggests nyctitropism, *i.e.*

[1] One of the best examples of this habit, which Mr. Darwin does not treat of in detail, is furnished by the not uncommon British wild flower *Chlora perfoliata*, or *Perfoliate Yellow Wort.* The eight bright yellow lobes of its corolla form, when expanded, a remarkably regular star. It opens in the morning and closes early in the afternoon. We have kept cut specimens in water, and found the same flower open and close for many days. Its relative, the *Common Centaury*, does not open its flowers at all except in bright sunshine, a habit shared by other members of the same order, the *Gentianaceæ*.

[2] *The Power of Movement in Plants*, p. 414.

the act of turning at night. There is, as he tells us, much variety and complexity in the nyctitropic movements of the leaves or cotyledons, or both, of various plants, but the one result common to almost all cases is that the blade is so placed as to stand nearly or quite vertically at night. The aim, so to say, of the plant is to avoid having the *upper* surface of the leaf facing the zenith. It is attained in various ways. Some leaves move so that their apex points upwards, some so that it points downwards; some rotate on their axes so as to present themselves edgeways to the zenith. The leaflets of some compound leaves execute a combined movement of singular beauty. Pairs, especially of leaflets, may so move that their upper surfaces come into close contact: the two lateral leaflets of a trefoil may first bend down, then approach each other until their upper surfaces are in contact; while the central or terminal leaflet rises up, and passing through an angle of 90° to 180°, bends over until it rests on and, face downwards, forms a roof over them. In many species of *Cassia* the horizontally extended leaflets sink down vertically, and, while doing so, rotate on their axes so as to bring their lower surfaces outwards. In *Mimosa pudica*, the well-known *Sensitive Plant*, 'the opposite leaflets come into contact and point towards the apex of the leaf; they thus become neatly imbricated, with their upper surfaces protected.' A simultaneous drawing together of the four pinnæ takes place, so that the imbricated and closed leaflets on each separate pinna form a single bundle. The different appearance of a bush of *Acacia Farnesiana* before and after the nyctitropic movement is very striking. Before the movement the numerous leaflets on each pinna (fourteen pinnæ are represented in Mr. Darwin's illustration as sharing one main petiole, or leaf stalk) are spread out, so that the leaf resembles the frond of a fern; after the movement the 'pinnæ look like bits of dangling string,' the leaflets on each pinna having moved towards its apex, the pinnæ towards the common apex of the whole leaf, while these have also sunk downwards, though the main petiole has risen considerably.' [1]

The phenomenon is, then, one of very marked character. It is also widely exhibited in the vegetable kingdom, Mr. Darwin's list, which he acknowledges to be very imperfect, including 'sleeping plants' (*i.e.* plants whose leaves sleep) 'in twenty-eight families, in all the great divisions of the Phanerogamic series, and in one Cryptogam.' The sleep of cotyledons,

[1] See for these and many other interesting details *The Power of Movement in Plants*, pp. 280–417.

Mr. Darwin says, 'seems to be a more common phenomenon than that of leaves.'

Mr. Darwin, as is well known, combines a teleological idea with the doctrine of Natural Selection. When the nature of an organ or of a function has been ascertained, he is not satisfied until he has found the *raison d'être* of the organ or function, or, in other words, the benefit which the whole organism derives from it. What, then, he asked himself, is the purpose served by the complex and varied nyctitropic movement in so many plants? What is gained by avoiding the direct aspect of the upper surface of the leaf towards the zenith? The answer that suggested itself—namely, the protection to a certain extent of that surface from the loss of heat by radiation—was only possible since the doctrine of the radiation of heat has been formulated. Yet gardeners have from time immemorial known the great service rendered on cold nights to delicate plants, seedlings, and fruit trees, by a very slight covering, such as a mat, a little straw, or even a net. Mr. Darwin put to Nature herself the question whether nyctitropism has so much effect in preventing radiation as to be sometimes of vital consequence. His method of questioning was to expose, on cold clear nights, plants, some of whose leaves were free to assume the nyctitropic position, some delicately fastened with their upper surfaces facing the zenith. The answer showed that he was right. 'Our experiments,' he says, 'show that leaves thus compelled to remain horizontal at night suffered much more injury from frost than those which were allowed to assume their normal vertical position.' [1] And again, 'the difference in the amount of dew on the pinned-open leaflets and on those which had gone to sleep was generally conspicuous, the latter being absolutely dry, whilst the leaflets which had been horizontal were coated with large beads of dew.' The effect of radiation in causing the deposition of dew is well known, so that it was evident that the leaflets fully exposed to the zenith must have become much cooler than the others.[2]

Nyctitropism has been removed by modern science from the category of functions common to plants and animals. Plants do not sleep. But in the vegetable kingdom the phe-

[1] *The Power of Movement in Plants*, p. 286.

[2] *Ibid.* p. 294. Mr. Darwin says, on the same page, that it is not clear 'whether the better protection of the upper surface has been gained from its being more easily injured than the lower surface, or from its injury being a greater evil to the plant;' but he mentions facts which seem to show greater delicacy of constitution in the upper surface.

nomenon in question is not an isolated one having nothing in common with any other. It is one of a variety of movements exhibited by plants, all which movements are declared by modern science to be brought about by the same proximate mechanical means, while many of them are effected by one part of the organism in obedience to an impression received by another. In the way of reduction to unity, the theory propounded by Mr. Darwin in his latest volume would carry us, if it were true—and we are not now disputing it—further still. He believes that, some very exceptional cases apart, all the movements of plants can be reduced to one original movement, of which the rest are modifications. 'As with plants,' he says, 'every character is more or less variable, there seems to be no great difficulty in believing that their circumnutating movements may have been increased or modified in any beneficial manner by the preservation of varying individuals.'[1]

Circumnutation is the term employed by Mr. Darwin to denote a movement which, from numerous observations described by him in detail, he concludes to be going on in every growing part of every plant. It consists in the bending of the part successively to all points of the compass, in such a manner that its apex describes irregular elliptical figures, with their longer axes at one time in one direction, at another time in another. The proximate cause of this bending to one side is increased turgescence of the cells on the opposite side.[2] After germination has commenced, as soon as it is possible to observe the growing parts of the embryo plant, each is seen to be circumnutating. In radicles, one of which projected only $\frac{1}{20}$ of an inch, in hypocotyls, cotyledons, epicotyls,[3] from a very early stage of growth, in the stems of small seedlings, in the stems, in the stolons or runners, in the flower stems or peduncles, as well as in the sub-peduncles, and, lastly, in the leaves of older plants Mr. Darwin detected

[1] *The Power of Movement in Plants*, p. 491.

[2] A very clear practical illustration of the effect of turgescence on one side in causing curvature towards the opposite may be obtained by simply moistening one side of a strip of cardboard. The increased turgescence of the plants' cells is ordinarily followed by growth, but not so in the case of fully grown *pulvini* or cushioned joints, whose temporary turgescence is the means whereby many movements are effected, as, for example, those excited by contact in the Sensitive Plant.

[3] Hypocotyl and epicotyl are Mr. Darwin's abbreviations for hypocotyledon and epicotyledon respectively, the former denoting the portion of the stem immediately below and the latter that immediately above the cotyledons. The radicle is 'distinguished from the hypocotyl by the presence of root-hairs and the nature of its covering.'—*The Power of Movement in Plants*, p. 5.

circumnutation.[1] We must here quote a passage which is calculated to clothe with a new interest objects already abounding in interest to the lover of nature.

'If we look . . . . at a great acacia tree, we may feel assured that every one of the innumerable growing shoots is continually describing small ellipses; as is each petiole, sub-petiole, and leaflet. . . . The flower peduncles are likewise continually circumnutating. If we could look beneath the ground, and our eyes had the power of a microscope, we should see the tip of each rootlet endeavouring to sweep small ellipses or circles, as far as the pressure of the surrounding earth permitted. All this astonishing amount of movement has been going on year after year since the time when, as a seedling, the tree first emerged from the ground.'[2]

The reader who desires to learn Mr. Darwin's ingenious methods of observation must be referred to the scientist's own pages; and, in regard to the direct benefit effected by circumnutation, we can now do no more than mention the assistance which it renders to the radicle in penetrating the ground, and in entering 'any lateral or oblique fissure in the earth, or a burrow made by an earth worm or larva;'[3] to the arched hypocotyl or epicotyl in breaking upward through the ground;[4] to stolons or runners in 'passing between and over surrounding obstacles;'[5] and to the stems of climbing plants in finding their supports. We do not find stated by Mr. Darwin any direct benefit obtained by the circumnutation of leaves, and if there be none, this fact, perhaps, lends some support to his theory that circumnutation is most important as forming the groundwork, or, we may say, the raw material, out of which other still more important movements have been developed. Plants are affected in a special manner by

[1] The different parts of flowers, it may be noticed, are not included in this enumeration. Their movements were not observed by Mr. Darwin.—*The Power of Movement in Plants*, p. 226.

[2] *Ibid.* p. 558. [3] *Ibid.* p. 550.

[4] In very many plants the part that breaks through the ground is arched. For illustrations of the habit and explanation of its utility see *The Power of Movement in Plants*, chap. ii.

[5] *Ibid.* p. 558. For details see pp. 214–222. We quote the account of one experimental observation of the behaviour of strawberry runners. 'Many long pins were next driven rather close together into the sand, so as to form a crowd in front of the same two thin lateral branches; but these easily wound their way through the crowd. A thick stolon was much delayed in its passage; at one place it was forced to turn at right angles to its former course; at another place it could not pass through the pins, and the hinder part became bowed; it then curved upwards and passed through an opening between the upper part of some pins which happened to diverge; it then descended and finally emerged through the crowd.'—P. 219.

certain influences which, by modifying in various ways the universal circumnutatory movement, which he regards as not acquired for a special purpose, have turned it into purposive movements. In this way he explains, as consistent with the doctrine of evolution, the fact that so many special purposive movements exist.

The example to which Mr. Darwin points first as being 'the simplest case of modified circumnutation is that offered by climbing plants,' in which 'the modification consists in the greatly increased amplitude of the movement' and in its greater regularity. It may be remembered that in a previous volume Mr. Darwin showed the use to twining plants of what he there called 'the continuous bowing movement directed successively to all parts of the compass.' 'When a revolving shoot meets with a support,' he told us, 'its motion is necessarily arrested at the point of contact, but the free projecting part goes on revolving.'[1] In support of the view that the movements of climbing plants consist of modified circumnutation, he urges the fact that when very young 'they move like other seedlings, but as they grow older their movements gradually increase without undergoing any other change.'[2]

The nyctitropic movements of which Mr. Darwin has given so interesting a description are likewise brought under the head of modified circumnutation. He observes that there is already a periodicity in the circumnutatory movements of plants generally, the leaves, some more, some less, rising a little in the evening and sinking in the morning, and the periodicity being doubtless determined by the daily alternations of light and darkness. From the most insignificant of these movements, he says, a series of gradations can be traced in different plants up to the most pronounced nyctitropism, insomuch that it is difficult to draw the line between mere circumnutation and nyctitropism.[3] From this and other facts Mr. Darwin draws the conclusion that the movement whose purpose he has succeeded in explaining is a modified form of the universal movement that seems a necessary accompaniment of all vegetative growth.

The nyctitropic movement, though dependent upon the alternations of light and darkness, is not, according to Mr.

[1] *The Movements and Habits of Climbing Plants*, p. 15. Second edition. London, 1875.

[2] *The Power of Movement in Plants*, p. 265.

[3] Mr. Darwin draws an arbitrary line, so as to include among sleeping plants those only whose leaves assume at night a position at least 60° above or beneath the horizon.—*Ibid.* p. 317.

Darwin, to be considered as directly *caused* by these alternations, which, to quote his remarkable words, 'merely give notice to the leaves that the period has arrived for them to move in a certain manner.'[1] However this may be, 'the action of light in modifying the periodic movements of leaves' is to be clearly distinguished from movements determined by the *direction* of light, by means of which movements plants or parts of plants place themselves in certain relations to the source of light. The most common of these movements are Heliotropism, or, turning towards the light, and Diaheliotropism, the assumption of a position more or less transversely to the direction of the light; Apheliotropism, the opposite of Heliotropism, being rare.[2] All these, as well as Geotropism, in virtue of which some parts of plants, as the primary radicle generally, direct themselves towards the centre of the earth, Apogeotropism, the opposite of Geotropism, and Diageotropism, which gives a direction more or less at right angles to the earth's radius and which facilitates the spreading of secondary radicles, are clearly proved examples, Mr. Darwin thinks, of modified circumnutation. It has already been stated that the proximate cause of circumnutation is the increased turgescence of the cells on one side, and it should now be added that the same proximate cause is assigned for all the other movements named above. It may perhaps be well to quote here a few lines from Mr. Darwin:—

'When light strikes one side of a plant, or light changes into darkness, or when gravitation acts upon a displaced part, the plant is enabled in some unknown manner to increase the always varying turgescence of the cells on one side; so that the ordinary circumnutating movement is modified, and the part bends either to or from the exciting cause; or it may occupy a new position, as in the so-called sleep of leaves.'[3]

There is yet another very interesting subject on which Mr. Darwin's observations have thrown much new light, the transmission from one part of a plant to another of the influence which sets on foot, or, as it were, gives the signal for, many of these movements. Most readers will be astonished to find how widely this power of transmission prevails. It begins with the first stage of plant life. No sooner has the radicle protruded from the germinating seed than it is acted

[1] *The Power of Movement in Plants*, p. 407.

[2] Some tendrils are apheliotropic and their tips crawl into any dark crevice.—*Ibid.* p. 489.

[3] *Ibid.* pp 547, 548.

upon by geotropism. But it is only the tip of the radicle that is sensitive[1] to gravitation ; 'and it is the tip which transmits some influence to the adjoining parts, causing them to bend.'[2] This same tip of the radicle is sensitive to contact. When it meets an obstacle it causes the adjoining parts to bend away.[3] This is the more remarkable because these parts are acted upon by contact in an opposite manner, so that they bend *towards* an object. It will be obvious that this endowment of the radicle enables it to steer clear of an obstacle, when geotropism will at once guide it downwards, while the peculiar endowment of the adjoining parts prevents the deviation from becoming unnecessarily great. In the same wonderful organ is localized also a sensitiveness to moisture.[4] Other illustrations of localised sensitiveness might be given from Mr. Darwin's volume, though, except as regards the sensitiveness of the tips of some cotyledons to contact and to light, and the consequent transmission of an influence to the tender stem,[5] he has not treated this part of the subject in such detail as he has the sensitiveness of the tip of the radicle.

In the fact that certain parts of the plant organism receive impressions, and that the effect of such impressions is transmitted to other parts, it is impossible not to see another remarkable link of connexion between the vegetable and animal kingdoms. The sensitiveness of the plant may even exceed that of the organs of sensation in animals, at any rate that of the human retina. 'A difference in the illumination of the two sides of the cotyledons of Phalaris, which could not be distinguished by the human eye, sufficed to cause them to bend.'[6] Plants do not indeed 'possess nerves or a central nervous system ;' but Mr. Darwin infers that 'such structures serve only for the more perfect transmission of impressions, and for the more complete intercommunication of the several parts.'[7] An interesting line of scientific inquiry is here suggested, which will doubtless engage the attention of investigators ; namely, what element of matter, or what form of energy, is concerned in the transmission of influence in plants, and whether it is merely a more complicated organization of the same means that produces a similar effect in animals. But suppose these questions solved, we shall be as far as ever from an answer to the question how sensory

[1] 'A part or organ may be called sensitive when its irritation excites movement in an adjoining part.'—*The Power of Movement in Plants*, p. 191. [2] *Ibid.* p. 548. [3] *Ibid.* p. 198.
[4] *Ibid.* p. 180 *seq.* [5] *Ibid.* p. 126 *seq.* and p. 484 *seq.*
[6] *Ibid.* p. 487. See for the details p. 455. [7] *Ibid.* p. 572.

impressions result in consciousness. Sensitiveness and consciousness are two very different things. The one is exhibited in the telegraphic instrument, the other is confined to the operator.

To conclude: We have seen that science has unravelled many of the secret operations of what we call Nature, and has frequently found a bond of unity in many diverse phenomena. But at the end of every line of investigation which she follows she arrives at length at that which baffles scrutiny. We have only to turn to the most recent work published by the most famous of the scientists of our generation, perhaps of several generations, for new testimony to the truth of this statement. Thus, with regard to the (supposed) fundamental movement of circumnutation, we read, 'Why every part of a plant, whilst it is growing, and in some cases after growth has ceased,[1] should have its cells rendered more turgescent, and its cell-walls more extensile, first on one side and then on another, thus inducing circumnutation, is not known.'[2] Then, assuming the truth of Mr. Darwin's theory, that various external forces have modified this single original movement in the manner that he describes, if we ask how these forces exert their special influences, the answer is still a confession of ignorance. 'In what manner light, gravitation, &c., act on the cells is not known.'[3] With regard to other movements, as those of the Sensitive Plant when touched, which Mr. Darwin does not believe to depend on modified circumnutation, science is equally at a loss. 'Why a touch, slight pressure, or any other irritant, such as electricity, heat, or the absorption of animal matter, should modify the turgescence of the affected cells in such a manner as to cause movement we do not know.'[4] Along with these facts we recall to mind that science has not yet formulated explanations of either of the two foundation principles of the theory of evolution; namely, the transmission of habit from an organism to its descendants and the rise of variations. Even in his latest volume Mr. Darwin tells us that the cause of most variations is unknown.[5] Summarily, science points to unity, but science provides no explanation of the origin of energy, nor of the action of its subtler forms on living organisms, nor of the stability and regularity of the laws under which it is exhibited to us, nor of the power of variation whereby the organic forms through

[1] The movements 'after growth has ceased' are those of organs provided with pulvini.

[2] *The Power of Movement in Plants*, p. 546.

[3] *Ibid.* p. 569.

[4] *Ibid.* p. 571.

[5] *Ibid.* p. 492.

which life is manifested accommodate themselves to changing circumstances. The theist may claim to assert that his ultimate principle is necessary as the complement of science. If evolution is a scientific truth he can accept it and yet say, 'It is God that made us and not we ourselves.' . . . . 'He upholdeth all things by the word of His power.' And, to close with a reference to the latest addition to the arguments for evolution, the theist will see no more danger to his crowning principle in the assertion that the complex nyctitropic or other movements of plants are developed out of an almost purposeless and irregular circumnutation than in the assertion that, when 'man goeth forth to his work and to his labour until the evening,' he is exhibiting a development of the irregular and comparatively purposeless movements of his infancy.

ART. VI.—THE LETTERS OF POPE GREGORY I.

Gregory the Great. By the Rev. J. BARMBY, B.D., Vicar of Pittington, late Principal of Bishop Hatfield Hall, Durham, and formerly Fellow of Magdalen College, Oxford. (London, 1879.)

WE have called attention to the light thrown by the letters and despatches of Cassiodorus on the political and social life of Italy, in its details and daily course, when the German invaders first appeared there as masters and settlers, and the struggle began, in numberless and varied points all over the peninsula, between their customs and spirit and the strong but damaged fabric of Roman civilization. The collection of Cassiodorus shows this, under the wise and generally benignant policy of Theodoric, and when the forces and habits which had for centuries governed life under the Empire, though for the moment surprised and shaken, had in no way lost their sway on the imagination and faith of the population. The campaigns of Belisarius and Narses seemed to show what power was still left in the Roman Empire. These great captains, with armies recruited from the steppes of Scythia and the Isaurian highlands, tore the great prize of the Italian cities and provinces out of the obstinate grip of the Germans, and for a few years held it fast. But there was nothing solid in the deliverance. It was not to restore the dominion of the world to