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PROTEUS

OR

UNITY IN NATURE.

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BY

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SECOND EDITION.

„Die Geisterwelt ist nicht verschlossen;
Dein Sinn ist zu, dein Herz ist todt!
Auf, bade, Schüler, unverdrossen
Die ird'sche Brust im Morgenroth!"

Goethe (Faust).

„Ich nicht auf Menschen baue, sondern auf den Gott in mir und über mir."

Jean Paul (Titan).

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PREFACE.

MUCH of what I have to say in the following pages is likely to find little favour in a materialistic age like the present. The *zeit-geist*, I know full well, is decidedly against me: and, most assuredly, I should not have cared to put myself in opposition to it if I could have got rid of the feeling that truth was at stake, and that it would be cowardly to keep silence. And yet I am able to find some encouragement in the hope that my words may not be altogether out of season, for I believe, not only that the day will surely come in which all opposition on the part of the spirit of the time will be at an end, but also that there is light enough in the east, even now, to make it certain that this day is already dawning.

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INTRODUCTION.

In the story of Proteus, as told by Menelaus to Telemachus in the Odyssey, there is much to rouse the attention of anyone who desires to raise the veil under which the face of nature is hidden.

Menelaus and his companions have given up all hope of ever again reaching home when the story opens. They have been driven to a desert island in the Egyptian waters of the Mediterranean Sea. They have been detained there until they are in actual want of food. The night is fast closing in. No longer able to bear the sight of his foodless ships and hunger-bitten companions, Menelaus has escaped in the evening twilight to a distant and lonely part of the shore, whither Eidothea, the daughter of Proteus, has gone to meet him. He, dazzled and startled by the bright and sudden apparition, can only listen. She, without a pause, hastens to tell how, every day at noon, on the beach close by, her father (who is a seer to whom Neptune has entrusted the care of a herd of seals or sea-calves), may be seen counting his wards, or else sleeping for a short time, sleep always following the counting unless the numbers are found to be wrong,—how while asleep he may be mastered and made to tell all his master wishes to know,—how, struggling hard to escape, he will change himself into other forms, animate or inanimate, beast or plant or earth or air or fire or water, anything or everything, visible or invisible,—how he does not return to his human form unless he succeed in getting away or else is obliged to stay and speak,—how with the help of a chosen band of three men, Menelaus may and must get the mastery,—and how in order to this, he and they, in the disguise of seals, must lie in wait at the proper place until the right moment, and there and then do their utmost. She is in haste to begone, and, before his tongue is loosened, she is far away.

The story re-opens as the next day begins to dawn. Menelaus, now in very altered mood, is again where he was on the previous evening. Hitherto he has stood aloof from men and gods alike: now the three men who are to help him are at his side, and he himself is offering the morning sacrifice due to Neptune, and hoping that Eidothea may come again to help him in the work he is set upon doing without delay. And not hoping in vain, for, almost before his devotions are over, she, having with her, dripping with the nectar in which they had just been washed, the scarcely dead skins of four unlucky stragglers from her father's herd, is again at his side, and, a minute or two later, he and his companions are at the place where Proteus is wont to take his noon-day siesta, crouching in hollows scooped out in the sands, covered with the skins, and there left to wait and watch in the hope that the seer when he comes may mistake them for four seals which have got ashore before him, and may pass them as seals in the customary mustering. And as it should be so it happens. In due time Proteus comes, counts without detecting the trick put upon him, sleeps, and, while sleeping, is made prisoner, for the men who have been waiting and watching since daybreak for this moment do not fail to bestir themselves to good purpose when it comes.

In this way Proteus was out-witted and mastered; in this way, by the help of Eidothea and his comrades, Menelaus got to know how it had fared with his unhappy brother Agamemnon, and with Ulysses, and how, if he himself would prosper, he must begin by paying due honour to the gods—to Neptune more especially.

This is the myth in which Bacon detected the story of *matter*, and in which more still may be found by looking for it. And, certainly, the student of nature is only following the example set by his great master, and put on record in one of the ever-charming essays on the "Wisdom of the Ancients," when he deals with it as bearing directly upon his own studies, as being in truth a real unveiling of the face of nature.

The metamorphoses of Proteus, as Bacon points out, may very well be supposed to set forth the transmutations by which the same matter is made to serve in building up an endless succession of dissimilar creatures. They may show that there is, underlying all these dissimilarities, that common archetypal form of which Oken and Goethe and Geoffroy St. Hilaire and Carus and Owen and others have had vivid glimpses. They may symbolize the working of that law of unity in multiety and multiety in unity about which Plato discoursed so divinely. They may help to connect the visible world with the invisible, for the power of transfiguration which belongs to Proteus belongs to Zeus and the celestials generally. In a word, the metamorphoses may serve to teach much that must needs be learnt by him who hopes to find the key to the hieroglyphics of nature.

Without going at all out of the way to find them, indications of the same truth may also be found in the work which Proteus has to do every day as a herdsman, as well as in that nobler work which may now and then devolve upon him as a seer.

It is very possible that the *herd* itself may point to a law of communion as a primary law of nature. It is very possible that the counting of this herd by the herdsman, and the sleeping afterwards, may point to this law as working, not in the direction of evolution and development, but within certain fixed limits—as preserving a state of equilibrium which would be disturbed if any one herd, or species, or genus, or class, exceeded or fell short of the proper number allotted to it. And, without putting any great strain upon the fancy, a meaning may also be found in the work which has to be done in bringing the herd out of the waters to rest and sleep at noon, even this, that in order to repair the waste caused by exercise, and to fill up the gaps made by death, the herd must have more rest and sleep, as well as more light and heat and air, than can be had in the waters.

Nor is it a matter of wonder that Proteus should be a herdsman at one time, and a seer at another. For if "the invisible things of Him, from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and Godhead," it surely follows that 'the things that are made,' nature, may be *prophetic* in any other matter. So that, even here, Proteus may still serve for the authentic symbol of nature.

And not less significant are the parts of the story which yet remain to be noticed.

As her name implies, Eidothea is, not exactly a goddess, but goddess-like. Her work is to *reveal* to the Spartan King that the help he needs is to be found, not in himself, but in her father, or rather in the higher powers to whom she and her father are both subject, and to do what else she herself may in helping—a work for which, by her more delicate and docile nature, woman is better fitted than man. It may be, indeed, that Eidothea is intended to personify pure womanhood, and to show how needful the help of true woman is to man—a lesson which man is always slow to learn, and most of all that man who, like Menelaus, is bound by mere chains of sense to a woman who, like Helen, is little more than a creature of flesh.

Not altogether unintelligible, also, is the part which the companions of Menelaus have to play. The lesson here is plainly this, that the chief alone is unequal to the work he is called upon to do—that he may succeed by acting in concert with other men—that he must bow to the law of fellowship as paramount in human affairs. And most assuredly the conquest of nature agrees with the capture of Proteus at least in this, that the work to be done is altogether beyond the power of any one man in either case.

So, too, a deep meaning may be found in that part of the story which tells how the approach to Proteus was secured under the disguise of seals, and how the skins necessary for this purpose were purified in nectar, even this, that the heart of nature is to be reached most readily by the comparative anatomist who sees his own image reflected everywhere in the lower animals typified in the seal, and who, instead of suffering annoyance from the reek of death which fouls the atmosphere in which he lives and works, is continually finding therein a pleasant nectar-like perfume.

And yet more, a still deeper meaning may be found without difficulty in the representation of Proteus, not as the real helper, but as the oracle pointing to the only quarter in which help is to be found. All along this seer is spoken of as the subject of a higher power, and the real help he renders to Menelaus is by showing how helpless he is unless he submit to be helped by this power. Nay it may even be gleaned from the sequel to the story that the Spartans would not have been so long delayed in Egypt after their escape from the desert island if they had been more mindful of the instructions of the seer-herdsman as to their religious duties and less ready to stultify themselves with the nepenthe, which, in evil hour, Helen discovered in "the lotus land of good eating and drinking," and which—a plain proof that she did not forget to take it with her from Egypt to her home in Sparta—she offered to Telemachus when her husband's tale had come to an end.

All these thoughts passed through my mind the other day as I sat in one of the stalls of the great abbey which is not far from the place where I now write. Before my eye was a finial on which was carved a human head surrounded by what might be flowing waves or flames or locks or foliage. It seemed as if the artist had intended to figure Proteus at the moment when, his metamorphoses ended, he was showing his readiness to speak by resuming his human form. It seemed as if the words when spoken would testify to *communion in all things* if he were made to reveal his chief secret respecting nature. And this impression was only deepened when, a moment later, my eye chanced to rest on the mosaic of the Last Supper over the altar. I speak of what actually happened. While in the abbey, with the finial and mosaic before me, I could only think of a law of unity in diversity and diversity in unity as "the law within the law" in nature, of a law of communion as ruling all things, visible and invisible, natural and supernatural; and when I came out of the abbey my thoughts still ran on in the same channel, gaining strength and clearness in their course, until at last they had taken the shape here very imperfectly presented in words—a shape which is substantially a second and much enlarged edition of a very immature work published under the same title more than twenty-five years ago, and out of print shortly afterwards.

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PART I.

TRACES OF UNITY IN FORM.

Chapter I.

TRACES OF UNITY IN PLANTS.

Goethe was not the first to take the Ovidian view of the vegetable world which found expression in his well-known treatise on "Die Metamorphose der Pflanzen," or even to make use of this title, but he was assuredly the first to write so as to compel others to pay attention to the subject. Indeed, in this very treatise, so far from pretending to be the first, he refers, without naming them, to others who have written with the same object under the same title, and, elsewhere, he tells more particularly how the honour of priority must be conceded to Gaspar-Frederick Wolf, the author of the well-known "Theoria Generationis," a Prussian by birth, who spent the last thirty years of his life at St. Petersburg, and who, several years before his death in 1794, in a paper entitled "Du Développement des Plantes," and printed in the Memoirs of the Academy of the Russian capital, pointed out, incidentally but not indistinctly, that the leaves, the calyx, the corolla, the pericarp, the seed, the stem, and the root are all so related to each other as to be mutually convertible.

The parts of the plant which Goethe sets himself to examine are, not the root, nor yet the stem and its branches, but the cotyledons, the plumule, the ordinary leaves, the floral leaves, the calyx, the corolla, the nectary, the stamens, the pistils, the coverings of the seed, and the bud: and when his work is done not much is left to be done by others. Indeed, I know of no readier way of reaching the very heart of the subject under consideration than by taking the volume in which the results of this examination are recorded, and by jotting down, without any comment, short memoranda—by doing, in short, what I now proceed to do without any further preamble.

The cotyledons, or seminal leaves, are soon disposed of. They may be fleshy and little like leaves, or they may be so distinctly foliaceous as to be fully entitled to be named seminal leaves. In many instances, also, during germination, they become more leaf-like in form and colour as well as in structure, and now and then, as in the Vicia faba, this likeness is increased by the presence of buds in their axils. In a word, there is little difficulty in coming to the conclusion that these organs can be nothing else than modified leaves.

The plumule is evidently the first distinct effort of the young plant leaf-wards. In the case of the cotyledon there may often be doubt as to the leaf-nature of this part; in this case there can be none, the resemblance extending beyond shape and colour and structure to the manner of connection with the node.

Ordinary leaves differ infinitely in their appearance, but they all agree in being—leaves. Simple leaves are connected on all sides, by numberless intermediate forms, with compound leaves. A leaf which is simple at one time or in one case may be compound at another time or in another case, or *vice versâ*. The leaf of the date palm (*Phœnix dactilifera*), as simple as a blade of maize at first, ends by becoming in the very highest degree compound. The leaf of the common water crowfoot (*Ranunculus aquatilis*) is simple in the air and compound in the water, and the former or latter kind is developed as the level of the water happens to fall or rise. And the petiole, or leaf-stalk, which in its ordinary form is obviously a modification of the node which enters into the formation of the branch or stem, is as obviously connected with the leaf-blade by the exceptional forms which are presented in the orange tree, in the greater number of the acacias of New Holland, and in many other cases—forms in which the ordinary stalk-shape is more than half lost in the blade-shape: and so it is that a connection may be traced, not only between simple leaves and compound leaves, but also between the blade of the leaf and the stalk, and between the latter and the node.

The passage from the leaves to the parts composing the flower is exhibited in many ways. The wreaths called "floral leaves," which frequently enclose the flower, are true leaves, and the involucres of plants, such as the common sun-flower or marygold, are formed of elements between which and the ordinary leaflets every possible gradation may be traced upon the same stalk. Even the common arrangement of the parts of the flower in whorls is not peculiar, for the same plan holds good, not only in the case of floral wreaths and involucres generally, but also in that of many true leaves—a case, of which the needle-clusters of the conifers may serve as an example. Indeed, it is almost a matter of chance whether the growth of a plant should declare itself in foliage or flowers, the tendency being leaf-ward if the plant be overfed, flower-ward if the supply of food be stinted.

Nor is the case of the calyx or corolla in any way peculiar. Ordinarily the petals are gaily tinted, and the sepals are green like the leaves; but this distinction is by no means constant, and in many instances the latter organs are coloured in certain parts of the surface, or at the edges or tips, while at the same time the texture is more delicate and petaloid than usual. Within the calyx of the common pink, for example, there is often a second calyx tinted and changed in this manner. Sometimes it is difficult to say whether the floral envelope be a calyx or corolla. Sometimes the common leaves of the stem are coloured in a greater or less degree immediately before the period of flowering, or the leaves in the neighbourhood of the flowers may be constantly decorated in this manner. On the stem of the tulip there is often an anomalous organ intermediate between the leaf and the petal which is green in the part contiguous to the stem and brightly coloured in the remaining portion. Indeed, it is certain that petals and sepals and leaves would not run together as they do if they were not connatural in the fullest sense of the word.

The vague and ill-defined organs known as nectaries afford a natural passage from the corolla to the stamens: or an analogous mode of transition may be found in the changes which have come to pass in various double flowers. In many roses, for example, in the midst of petals perfectly developed and coloured, are other petals formed in such a manner as to resemble the filaments and anthers of the stamens. In many double poppies, also, perfect anthers are met with on some of the petals and antheroid tumours on others: while at the same time the discoid surfaces of these organs show a disposition to shrink into the form of filaments.

Nor are the anthers distinguished in any absolute manner by the presence of the pollen. The pollen in its most perfect condition consists of minute grains containing fluid; but in many instances the grains are wanting, and the fluid—which is the essential ingredient—exudes as a free liquid, which, as Goethe supposes, may be nothing more than a modification of the juices which appear as the honied or odorous secretions of the nectaries or petals or leaves.

The pistil too is often modified in such a way as to make it certain that it has no claim to be looked upon as an exceptional organ. In the crocus, for example, the stigma, or upper extremity of the pistil, is green and absolutely similar to the elements of the calyx; and in the double poppy the same part has the form of small and delicately-coloured leaves, precisely similar to petals. In the iris and ranunculus there is a true petaloid transformation of the stigmata, and also of the styles, or intermediate portion of the pistil, and, lastly, the ovary itself, or the essential part of the pistil, is an altered form of the same element. The leaf-nature of this part is concealed, it is true, in fleshy and succulent, or in woody and hard fruits, but even in these cases it cannot escape detection, especially if the parts be traced through the earlier stages of their history: or the real nature of the ovary may be detected in cases where, as in the common pink, it is no uncommon thing for the seed-organs to be metamorphosed into a calyx the divisions of which bear on their extremities the traces of the former styles and stigmata, while at the same time new flowers, of a more or less perfect character, are developed in the place of seeds.

And very certainly the ovule-producing faculty of the ovary is not so distinctive a feature as it may seem to be at first sight. The ovule is a germ closely akin to the germs on the fronds of ferns, and to the buds on the leaves of the Ruscus aculeatus, the Bryophyllum calycinum and certain other plants. There are also many true ovaries in which the carpels are imperfectly closed and the ovules left exposed like the sporidia of the frond, or like the buds of the leaves which have just been mentioned —in which, in fact, the ovule-producing carpel is scarcely to be distinguished from the bud-producing leaf or from the spore-producing frond.

Nor are the immediate coverings of the seed to be put outside the family circle which has been described so far. The flower-bud and the axillary leaf-bud are intimately related to each other, and in the realization of this relationship a stand-point is gained from which it is easy to see what must be the true nature of the coverings of the seed. It would appear that the two sorts of buds are reciprocally transmutable; indeed, so they must be if it be true, as it certainly is, that a plant will produce flowers instead of leaves if it be under-fed, and leaves instead of flowers in the contrary case. In some monstrous and accidental forms of vegetation, moreover, the character of the two buds interblend in one and the same instance. The rose, for example, is very prone to such anomalous productions, and there is nothing very extraordinary in the particular metamorphosis described by Goethe. A bud, destitute of any outward mark of distinction, opens out into a perfect calyx and corolla, and then, in place of the ovary and circlet of stamens, gives birth to a stem. This central and exceptional growth is gradually developed, and at length becomes a branch, furnished with the usual appendages of hairs, spines, and leaves, together with shrivelled and imperfect petals and stamens, and buds, which themselves expand in time into flowers of the same abnormal character as the parent-bud. Here, indeed, the flower-bud changes into the leaf-bud, and then again reverts to its former condition, and the difference between the two is completely lost. And, further, the seed and the bud are found to be related to each other in the very closest manner. In the more rudimental forms of vegetation the difference between the two is completely lost: in the more perfect plants, true seeds most undoubtedly exist, and true buds also: but even here instances occur, as in the plant which is the emblem of the Virgin Mary (*Lilium proliferum*), where some of the buds fall away from the plant-mother like true seeds, and in due time become developed into true plants—where, in fact, the history of the vagrant bud is that of the seed except in this, that fertilization does not figure in it. And if so—if, that is, the seed and the bud stand in this close relationship to each other—then the coverings of the seed and bud are brought into the same category, and it is fair to conclude that the coverings of the seed, no less than those of the bud, are nothing else than—modified leaves.

At this point Goethe stops short. Had his examination extended a little further he would have easily found the same traces of unity in all other parts of the plant as well: and what I have now to do, therefore, is to close the book from which I have been making these memoranda, and to try and verify this statement by an examination of certain parts of the plant to which no special reference has yet been made.

Among these parts the tendril and the aërial root occupy very conspicuous places, and they may well serve as starting-points for what remains to be said.

The tendril is a transitional organ which cannot be assigned with strictness either to the aërial or to the terrestrial system of the plant. The connection with the leaf is evident in the vine, and in many other instances: the connection with the root is seen in the simple rounded form, and in the tendency to cling to other bodies. In the more unusual forms, moreover, as in the Asplenium rhizophyllum, may be found the direct realization of this double nature: for here the tendril, which is the direct prolongation of the median nervure of the frond, grows in a downward direction, and ends by burying itself in the earth, and so becoming a true root.

And as with the tendril so with the aërial root. The leaf-nature of this organ is apparent in many cases, and nowhere more so than in that of orchidaceous plants. In the Vanda teres, for example, the aërial roots, and the representatives of the leaves, exist as simple, rounded, and elongated soft tendril-like processes of a green colour, between which the mutual resemblance is such that one might readily be mistaken for the other. In the screw pine (*Pandanus*), on the other hand, the history of the growth of the plant shows plainly enough that there is no essential difference between the aërial and the common roots: for here the original true roots (in consequence partly of the pressure caused by the growth of the aërial roots) perish presently, and, contemporaneously with this change, the latter roots increase in size, sink into the ground, and eventually take upon themselves the functions of their predecessors, the true roots. In due time, these aërial roots, which have become ordinary roots, perish like the original roots, and are replaced by other aërial roots; and so it is that—by the carrying on of this process of dying at the centre and growing from an outer rim which is continually widening and rising higher—the Pandanus, when full grown, presents the singular spectacle of a tree raised up upon a circlet of stilt-like roots, with a cavity under it large enough to serve as a shelter for animals of considerable size. The case is plain enough. The aërial root is a true root if it reach the ground ; and, to say the least, the distinction between the aërial and terrestrial organ can never be insisted upon.

There are also certain passages in the life of a plant which, taken in connection with the history of the tendril and aërial root, may be appealed to as supplying evidence to the same effect.

Thus : many ordinary buds are developed as rootlets if a branch be buried in the ground during the season of growth. Thus: many points from which rootlets would spring under ordinary circumstances are developed as buds if a root be laid bare. Thus again : a branch, denuded of its summer dress of leaves and flowers, may be looked upon, at certain times, as an aërial root ; for, as Biot pointed out first of all, the current of the sap during frost sets, not from the spongioles to the branches, but, in the contrary direction, from the branches to the spongioles.

The leaf-nature of the stem, moreover, is plainly revealed in the Phyllocactus and in many other members of the cactacean family. Here the stem is formed from the quasi-leaves by a visible process of growth and coalescence, and in a plant of ordinary dimensions may be witnessed at one and the same time every gradation between the green and flat and succulent leaf-like organ, covered with rudimentary buds, and attached only by a narrow neck to the parent-plant, and the brown and woody and budless stem of which the constituent elements or nodes have coalesced so perfectly as to make it difficult to trace any longer the internodal lines. In so far as concerns its shape, and the manner in which the vessels are ranged upon its surface, the quasi-leaf of the Phyllocactus must be regarded as a true leaf. It differs from the ordinary leaf, no doubt, in bearing buds, but, as often happens, this very difference is a proof of unity. In point of fact, every leaf has a similar endowment. What, it may be asked, are the processes which cause the edges of a simple leaf to be serrated in various ways, and what is the significance of the leaflets of the composite organ? No other interpretation can be offered than this—that the processes are the rudiments of the leaflets—that many leaves are present potentially in every single leaf. Buds are constant elements in the leaves of the Bryophyllum calycinum and Malaxis paludosa; and not unfrequently they may be developed in the leaf of the orange after it has fallen from the tree. Ovules and sporules may also be singled out as indicating a bud-producing faculty in the carpel and frond respectively, both of which organs are only leaves in other forms. And, therefore, the buds of the quasi-leaf of the Phyllocactus, instead of being evidences of singularity, are evidences of similarity, which make the organ more leaf-like rather than less leaf-like. By the alteration and coalescence of these leaf-elements, the branches and stem of the Phyllocactus are evidently built up; and what happens here is the rule everywhere. All branches and stems are composed of bud-producing nodes, which are substantially bud-producing leaves. In the succulent euphorbiaceæ, for example, traces of rudimentary buds are as common as in the cactaceæ. In the Chamærops and bamboo, the joints of the stem present numerous minute processes, the germ-like nature of which is shown by the sprouts which often form in these places when the plant happens to lie flat on the damp ground. On the pseudo-bulbs of the orchids, also, traces of similar processes are to be found which often behave in the same manner: and in every stem, though the fact may not be so apparent as in the instances which have been given, the frequent appearance of "adventitious buds" points to the potential existence of the same faculty. In fact, the history of a Phyllocactus is the common history of the plant expressed in language which cannot well be misunderstood, and the grand lesson to be learnt from it is that the stem and its branches are only modifications of the same archetypal form which is present, not only in every part of the plant to which attention has been directed, but also in those transitional and doubtful organs, such as tubers and rhizomes, in which the stem and the root would seem, more especially, to come together and be, in the strictest sense of the word, at one.

And so, in conclusion, it is not too much to say that traces of unity are met with in every part of the plant.

Chapter II.

TRACES OF UNITY IN THE LIMBS OF VERTEBRATE ANIMALS.

The hand of man is in no sense a peculiar organ. It is the foot ennobled : that is all. Moreover, a comparison of the human hand and foot with the members corresponding to them in other vertebrate creatures only leads to the same conclusion by very many different ways.

In the quadrumana, in place of two hands and two feet, as in man, there are, as the name implies, four hands : and very generally the two which correspond to the feet in man are more handlike than the other two, in that the great toe is larger and better fitted for acting after the fashion of a true thumb. So also in the scansorial lizards and in many birds. The chameleon, for example, is a quadrumanous animal rather than a quadruped, rivalling the monkey in its power of climbing among the branches of trees : and the parrot, as is seen in the way in which it continually handles its food with one of its feet while it clutches at its perch with the other, is quite as much a bimanous animal as a biped. Indeed, the five-toed foot of the reptile and the four-toed foot of the bird may be looked upon as more hand-like than the hand as to thumb-power; for in both the thumbs are doubled.

In quadrupeds, on the contrary, the four hands of the quadrumana are replaced by four feet : but even here the characteristics of the hands are not always lost. The squirrel uses its fore-feet for climbing and holding its food almost as much as the monkey, and the bear and opossum do the same, their case being not very different from that of very many other unguiculate animals: while in the opossum and phalangers the hind foot is more hand-like than the fore-foot, for in them there is, not only a rotatory motion of the hind foot analogous to the pronation and supination of the hand, but also a large great toe which, as in the quadrumana, is fitted for closing strongly upon the other toes like a true thumb—an arrangement which (as the fore-foot is less like a hand in that its thumb lies parallel with the fingers) has led to these creatures being called pedimana or foot-handed.

Nor is there any difficulty in tracing the same common plan in every modification of the hand or foot.

In plantigrade animals, as in the bear, the whole or nearly the whole of the foot forms a sole: in digitagrade animals, as in the cat or deer, the heel and the corresponding part in the other foot are much raised and only the tips of the toes rest on the ground. Between quadrupeds with nails, the unguiculata, and quadrupeds with hoofs, the ungulata, there are many points of connection. In man and the quadrumana the nails are comparatively insignificant parts: in the cat and dog retractile and non-retractile claws take the place of these simple nails, the chief difference between the two forms of claws being in this, that in the retractile form the terminal phalanx of the toe, to which the claw is attached, is, when it is not drawn down by its flexor tendon in the act of striking or tearing or holding, pulled back over the second phalanx, and so kept out of the way, when the paw is merely used in walking, by the action of elastic ligament, which again is only the ordinary ligament of the part, shortened and made resilient: in the edentata, at the extremity of the unguiculate sub-class, as in the echidna, the claws, still five in number, with sometimes the rudiment of a sixth, as in the spur of the male ornithorhynchus, or in the scraper of the mole, are enormously developed, encasing the ends of the fingers on all sides with the exception of a button-hole-like slit on the underside, and being much more like hoofs than claws: and in this way a point is reached from which it is not difficult to pass on, through various transitional forms, of which the most remarkable instance is met with in the hind foot of the extinct Megatherium, to the more ordinary forms of hoof. In this hind foot, indeed, (not so in the fore foot, where there are three huge claws) there is a combination of unguiculate and ungulate characteristics which is not to be met with elsewhere, for of the three large toes which are present (two, the 1st and the 2nd, are absent) one, the 3rd, supports an enormous pick-like claw, while the other two, the 4th and 5th, terminate in tuberous phalanges which were evidently encased in hoofs.

There is a wide gap between the foot or hand of man and the parts corresponding to it in the horse, but it is one which is easily bridged over. The hand of the Ateles, or spider-monkey, differs from that of man or the orang in being thumbless, or all but thumbless; the thumb of the orang is much smaller than that of man: in each case the part which disappears or tends to disappear is the thumb. And so also in vertebrate creatures of still lower grade. The fore-paw of the bear or cat has the full number of five fingers; that of the dog has four fingers with a very rudimentary thumb supporting the dew-claw, and appearing at a considerable distance above the level of the other fingers—a part which is clipped off, as being 'in the way' in sporting dogs: that of the hyæna has the four fingers of the dog without the rudimentary thumb, and thus the differences met with in these several cases are brought about in the same way, that is, by the disappearance, to a greater or less degree, of the same part—the thumb. The thumb, too, is wanting in the fore-paw of the Megatherium and of the Unau, or two-toed sloth, and not this part only, but the 5th finger also, while in the sloth the foot is still further simplified by the absence of the 4th finger, so that the forefoot was three-fingered in the extinct animal, and is two-fingered in its living congener. The direct transition to the simple condition met with in the parts corresponding to the hand or foot in the horse, however, is not through the unguiculate but through the ungulate members: and the instances which have been cited are only brought forward for the purpose of showing that the same rule is followed in both cases. From the squat plantigrade foot of the elephant with its five fingers, each encased in a separate hoof, it is easy to pass to the semi-plantigrade foot of the rhinoceros and hippopotamus, the one with four fingers and the other with three, each one having its own hoof; and having arrived at this point there is no difficulty in passing on, through the digitigrade forefoot of the ox, with the tips of its two fingers capped in horn so as to form the 'cloven-hoof,' to the digitigrade forefoot of the horse with the end of its single fully-developed finger enclosed in a single hoof. Moreover, the passage from the four-fingered foot to the two, and from this to the foot with one finger, is opened out in other ways also. Thus: in the rein-deer the simple cloven foot of the ox is made complex by the addition of the two rudimentary fingers which support the hooflets behind the foot—an arrangement of fingers which, as a snow-shoe, prevents the foot from sinking so deeply into the snow as to make it difficult to withdraw it. Thus again, in the miocene extinct horse (*Hipparion*)—living specimens of which have cropped up now and then, not only in the days of Julius Cæsar and Leo X. but in modern times also—the 2nd and 3rd fingers, which in the modern horse are represented merely by the 'splint-bones' attached to the side of the 'canon bone' are developed so as to support the two 'spurious hoofs' which dangle behind the principal hoof. The case, indeed, is plain enough as exhibited in these different forms of hoofed fore-feet. In the elephant are five fingers, the 1st very rudimentary: in the hippopotamus the 1st finger is absent and the 2nd and 5th are small in comparison with the 3rd and 4th: in the rhinoceros the 1st and 5th are both absent, and of the remaining three, all large, the 3rd is the largest; in the deer, the cloven-foot is made up of the 3rd and 4th fingers while the two hooflets behind the foot have to do with the 2nd and 5th fingers: in the ox the difference in the cloven-foot is in the absence of the hooflets of the deer: and so, by watching the way in which this simplification is steadily brought about, on arriving at the horse, it is evident that the foot is now only the 3rd or middle finger, with rudiments of the 2nd and 4th attached to it high up as 'splint-bones,' the bone which is called the 'canon bone' being the metacarpal bone, while the three bones of the finger proper, reckoning from above downwards, are called respectively, 'great pastern' or 'fetter bone,' 'little pastern' or 'coronary bone,' and 'coffin bone,' the latter being encased in the hoof, which, in fact, is the homologue of the nail of the 3rd or middle finger in man—of that finger, the dominance of which, even in man, is indicated by its greater size and length. And this is all that need be said upon this point at present save this, that the hind foot is a repetition of the fore foot with this sole difference that the 'canon bone' there corresponds, not to the metacarpal bone, but to the metatarsal.

The fin of the dugong (*Manatus*) is to all intents and purposes a hand enclosed in a fingerless glove of integument through which the nails have worked their way a little. It differs very slightly from the webbed hand or foot of the seal or otter: it does not differ at all in the number of bones or joints composing it; and the difference between it and the paddle of the turtle or whale or ichthyosorus, or between it and the fin of a fish, is not at all considerable. The paddle of the turtle, in fact, is so much like that of the sirenian animal as to need no special notice. The paddle of the whale has more than the ordinary number of phalanges in the fingers, and the various bones of the hands are connected, not by proper joints but by continuous inter-articular cartilages: and what is said of this organ may also be said of the pectoral fin of the fish, for this member differs from the paddle chiefly in having many more fingers with many more phalanges, and in being constructed more delicately. In each case, indeed, there is that repetition of simple parts—that 'vegetative repetition' as it is called—which is a sign of that rudimentary phase of development to which the state of the joints also bears witness, for the formation of the true joint, as in the paddle of the dugong, is always preceded by a state in which the parts are connected by inter-articular cartilage, as in the paddle of the whale. In some cases, too, the real relationships of the pectoral fin in fishes are revealed in other ways. In the Gurnards, for example, the three lowest rays, detached and free, and more developed than the other rays, have to do work in feeling and holding like true fingers: and in many of the sharks the terminal phalanges of some of the rays have three or four horny filaments which are evidently the homologues of the claws or nails of vertebrate animals of higher grade.

In the wing of the bat, also, the same plan is traceable. The bones of the skeleton agree with those of any other hand, and their chief difference is in the wire-like prolongation of some of them. In point of fact, the wing in this case is only a webbed fore-paw, as in the otter, with longer fingers and with much more web, with this in addition, that the web (called patagium in the bat) is extended on the one side between the neck and the arm and forearm, and on the other side, between the fore and hind legs, and between the latter and the tail bone, the edge of the part between the two legs slanting from the top of the little finger in the fore paw to the ankle in the hind paw. The patagium, indeed, extends along each side from one end of the body to the other, and with the exception of the thumb in the fore limb and the small foot in the hind limb, by the nails of which, as by hooks, the animal suspends itself when at rest, both limbs are wholly enclosed in it. And as in the bat so it would appear to have been in the Pterodactyle, with this difference, that in the extinct animal the four fingers of the fore limb, the 1st, 2nd, 3rd, and 4th, were free, and that only one, the 5th, was employed in spreading out the patagium.

In the wing of the bird the part corresponding to the hand is the terminal segment, or pinion, which supports the principal feathers or "primaries," together with the "spurious or bastard feathers," while the rest of the arm is represented by the two other segments of the limb, the fore arm by the middle segment which supports the feathers called "wing coverts" or "secondaries," the arm by the innermost segment which carries the feathers to which the name of "scapularies" is given. The hand, and the whole limb belonging to it, are hidden under the feathers, except in birds like the penguin where the wing is represented by a paddle or fin, covered by mere vestiges of feathers, which at first glance resemble scales, but the component parts, though rudimentary, are easily identified. Three distinct fingers fused more or less completely together as one bone, are always present, and, so are the matacarpal bones belonging to them. There are also distinct carpal bones, usually not more than two in number. The fingers are the 2nd, 3rd, and 4th, the 3rd being largely developed and having two phalanges, the 2nd and 4th being quite stunted, and having only one phalanx. Usually these fingers are completely hidden under the integument: sometimes—from the 2nd in the Apteryx and from the 3rd in the ostrich—a claw protrudes from one or other of them. In all cases the principal feathers or "primaries" are supported by the 3rd finger, and the metacarpal bone belonging to it: in all cases, the "spurious or bastard feathers" are attached to the stunted index or 2nd finger: in no case does the stunted 4th finger take any share in the feather-bearing office of the 3rd and 2nd.

And so too in the simpler appendages which obviously take the place of the fore limb in the transitional mudfish or Lepidosiren (*Protopterus annectans*) which is neither fish nor reptile, and in the ichthyomorphous or perenni-branchiate batrachians. In the mudfish the single many-jointed cartilaginous style may be looked upon as a fin like that of the Ichthyosaurus or common fish reduced to a single ray: and that this is the right view to be taken is evident in the fact that in one species of Lepidosiren a number of stylets are inserted at right angles into the extremity of the style for the purpose of carrying a narrow fold of fin-like membrane, and that the same disposition to radiation is exhibited still more conspicuously in the ichthyomorphous or perenni-branchiate batrachians, where the single end of the digital ray of the Lepidosiren is represented by an appendage which is two-fold in the Amphiuma, three-fold in the Proteus, and four-fold in the Menopoma and Axlotes.

Nor are these the only signs of similarity which are to be met with in the limbs of vertebrate animals. On the contrary, instead of being few and far between these signs abound everywhere, the forearm answering to the leg, the arm to the thigh, and the "scapular arch" to the "pelvic arch," as the hand answers to the foot.

The two bones of the forearm, the radius and ulna, clearly correspond to the two bones of the leg, the tibia and fibula: and not less clearly does the single bone of the arm, the humerus, repeat the single bone of the thigh, the femur. There is never any difficulty in recognizing these relationships, for even in cases where, as in the fish, the only parts developed ordinarily are those which correspond to the hand and foot, the missing parts, or at least some of them, may be present. Thus, the modification of the scapular fin by which the flying fish can direct or retard its fall through the air when it leaps out of the water, and the frog fish or angler can hop briskly along the sands, is chiefly brought about by the development of two long bones which obviously correspond to the radius and ulna. Nor is it really otherwise with the scapular and pelvic arches, though here the underlying con-naturality is not so conspicuously displayed. Here, one thing seems to be tolerably evident, namely this, that there is an intimate connection between these arches and the ordinary ribs, and that the limbs of vertebrate animals are to be looked upon as costal processes. And certainly there is, on comparing the scapular and pelvic arches, no difficulty in seeing that the scapulæ may answer to the ilia, the two coracoid bones to the two ossa ischii, the two clavicles to the two pubic bones, and the sternum to the cartilaginous substance between the two pubic bones. The scapulæ and the ilia are more obviously related to the ribs than are the clavicles and coracoid bones, or the pubic and ischial bone, to the costal cartilages, but the relationship is not the less real on that account. And if so then the chief difficulty is disposed of. The pelvic arch generally is more developed than the scapular, but the latter arch is also highly developed where, as in birds, it is necessary to have a firm attachment for the wings. Here, and also in reptiles with fully developed legs, the scapulæ are connected with the sternum, both by the coracoid bones and by the clavicles—by the coracoids chiefly; in mammals, on the contrary, with the exception of the ornithorhynchus and echidna, where the reptilian arrangement holds good, and in man, where the clavicles are developed so as to form an inverted arch in which the end of the sternum is the keystone, the scapulæ are free, and the coracoid and clavicular bones alike are present only as insignificant projections from the scapulæ. Usually also the pelvic arch is more complete than the scapular, but not always. Indeed, in the whale and also in the

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dugong, where both arches are very rudimentary, the pelvic is the most so of the two, being represented by a single ossicle without a trace of an appendage. What particular ribs enter into the formation of these two arches is a difficult question to answer. Owen is of opinion that the scapular arch is formed by the ribs belonging to the occipital vertebra; and there is much to say in favour of this view. For my own part, however, I am disposed to think that the scapular and pelvic arches are formed, not of one rib only, but of several, and that the rib-less spaces in the neck and in the lumbar region are rib-less because the ribs belonging to those parts have been gathered together and modified, so as to form the scapular arch in the one case and the pelvic arch in the other. And that it may be so is, I think, made all the more probable by the particular construction of that part of these arches which corresponds to the costal cartilages, for how is it possible to account for the division into coracoids and clavicles in the one case, and into pubic and ischial bones in the other, except upon the supposition that at least two ribs enter into the formation of each arch, and that the spaces between the coracoids and clavicles, and between the pubic and ischial bones (the foramina ilii) are in reality analogous to *intercostal spaces!*

In dealing with this matter now, however, I am wandering beyond bounds. Indeed, all that I proposed to do in this chapter is done already, for he must be very sceptical who requires further proof before he is ready to allow that distinct traces of unity are everywhere present in the limbs of vertebrate animals.

Chapter III.

TRACES OF UNITY IN THE APPENDICULAR ORGANS OF INVERTEBRATE ANIMALS.

The parts of invertebrate animals which may be rightly regarded as limbs are very many and very varied, and not a little patience is necessary in order to arrive at any clear conclusions respecting them.

Taking a common prawn (*Palæmon squilla*) and comparing it with other crustaceans, and with other invertebrate creatures generally, it is easy to see that these parts are, not only the five pairs of legs which entitle the creature to the name of decapod, but also the false abdominal legs, the foot-jaws, the mandibles and maxillæ, the antennæ, the eyes, and certain other appendicular organs as well.

1. In the prawn the ten true feet, all of them substantially alike, are arranged bilaterally in five pairs. Each "foot" is articulated or divided by joints into six inter-articular or nodal parts, of which the names, reckoning from above downwards, are coxa, trochanter, femur, tibia, tarsus, and metatarsus. The interarticular parts are composed of a hard external crust and an internal cavity in which are the muscles and other soft parts. In the three hinder pairs the metatarsus is prolonged into a sharp stiff claw: in the two first pairs the foot terminates in a forceps or chela, the tarsus being elon-

gated into a finger-like process, against which the moveable claw-like metatarsus can be applied after the manner of a thumb. Attached to the base of each "foot" are two appendages, the palp and the flagellum, and also a gill, for in reality the gill is as much a part of the "foot" as the palp and flagellum. In the crab and lobster the four hindermost pairs of "feet" end in single claws and only the first pair is cheliferous, and no other special difference is to be noticed in these or other decapods except this, that in the hermit crab the flagellum is wanting, and the work of this appendage—which is that of sweeping over the surface of the gill so as to free it from foreign bodies of any sort—is transferred to the fifth pair, the edge of the carapace being raised so as to allow their insertion into the branchial chambers when the work of sweeping has to be done. In the stomapod, isopod, and branchiopod crustaceans the appendages corresponding to the "true feet" of the decapods are much more rudimentary and not readily distinguishable from the other appendages except by their relative position, especially in the two latter orders, these feet, all of them, being six-jointed and ending in simple non-retractile hooks in the isopods, and merely in jointless flattened plates or vesicles, serving for gills, or fin-feet, or marsupial plates for the attachment of ova, one or all, as the case may be, in the branchiopods. In these two orders the parts corresponding to the five pairs of "true feet" in the decapods are very much alike: in the stomapods, as in the Squilla Mantis of the Mediterranean, they differ materially, the first two pairs having modified chelæ, with the full number of six joints, and with the forceps differing from that of the decapods in this—that the unciform metatarsus, instead of closing upon a finger-like projection from the tarsus as in the decapod, turns back completely, and closes upon the body of the tarsus itself, while the remaining three pairs have fewer joints, usually not more than three or four, and are almost as rudimentary as the fin-feet of the branchiopods. In point of fact, the two first pairs of "true feet" in the stomapods serve to connect the forceps-feet with the ordinary claw-feet of the decapods, while the three hindermost pairs supply a similar bond of connection between the ordinary six-jointed foot of the higher crustacear and the simple fin-foot of the branchiopod.

The number of the organs which may be justly regarded as "feet" in the crustacea is by no means constant. Only a few are decapods, and very many are multipods if not myriapods. And so it need not be matter of wonder that the number of feet should vary as it does do in annulata and insecta and arachnida and cirripedia: indeed, the only inference to be drawn from this inconstancy as to number is that the foot is not so special and singular an organ as it seemed to be at first. And this is all that need be said now except this —that there are transitional forms in abundance which make it easy to pass without break from the feet of crustacea to the legs of other invertebrate creatures.

And even in some points wherein at first there might seem to be some peculiarity there is in reality nothing of the kind.

The simple legs of many of the branchiopods and isopods, articulated only at their bases, conduct naturally to the legs of many of the annulata: and in some of these creatures, as in the Aphrodite, the leg is evidently a sketch of the more complex true leg of the prawn and other decapod. Here, each one of the many feet is made up of a wide, soft, irritable, basal portion, topped by two hollow nipples, out of each of which may be protruded a tuft of barbed setæ or bristles, which are at once effective organs of locomotion and formidable weapons. These two projections are distinguished by their position as the dorsal branch and the ventral branch, and by some other peculiarities as well. The dorsal branch, which is the larger of the two, carries a certain lamelliform process to which the name of elytra is given, as well as a tolerably long palp or cirrus, and a number of thread-like processes, which seem to have a branchial office: the ventral branch may have the cirrus and the threads, but usually it has neither. This setigerous foot is often called pied-à-elytre. When the elytra is absent, as it often is in many congenerous forms, the name given to it is as often pied-sans-elytre. And in these pieds-sans-elytres it is that the relations of the elytræ, and of the hairy processes near them, as well as of the cirri, to branchiæ, come out most palpably; for on comparing the feet in congenerous forms of life it is evident that the branched dorsal tufts of the sand or lug-worm (*arenicola*), which is so favourite a bait with salt-water fishermen—which tufts are unmistakeable branchiæ or gills—are only modifications of the elytra and of the neighbouring hairy processes in the common aphrodite, while at the same time it is generally evident, that the analogous hairy processes, as well as the cirrus of the ventral branch of the setigerous foot may also undergo a similar transformation into true branchiæ. These parts, no doubt, are too rudimentary to make it possible to be very dogmatic in interpreting them, but this is plain, that they show a marked disposition to that two-fold division which is so conspicuous in the cirripedia, and that, while each of the branches may take upon itself a branchial office, the rule is for the upper one to do this rather than the under one. Indeed, the case is one which in some measure may serve to explain why the leg of the prawn or other decapod should have at its base an apparatus of gills and wisps and palps, or why both parts of the leg should be transformed into lamelliform gills in the branchiopods.

As between the leg and the gill of the decapod crustacean, so also between the leg and the wing of the true insect or hexapod, there is a very close relationship. Oken divined their true nature when he spoke of these wings as "aërial gills." The rudimental wings of the pupæ of certain water insects are true gills, acting in every way like the very similar membranous and vascular tegumentary expansions belonging to certain annelides; and, as in the Pterophora, the true wing may be split up longitudinally into rays so as to be no inapt representatives of the tufted tergal gills of the nereis. Moreover, the gills and the wings in these and other instances are both of them developed from the same part of the annular segment—the tergal arc. There is, in fact, no difficulty in admitting, not only that the wings are "aërial gills," but also that the wing may be related to the leg in the same way as that in which the gill is related to the leg in the decapod crustacean. It is customary to speak of the wings and legs of insects as developed from different parts of the same segment, and in the perfect insect, no doubt, a special connection is traceable between the wings and the tergal arc of this segment and between the legs and the ventral arc. In fact, however, the wings and the legs are developed, in close relationship to each other, on each side of the segment, from the part which lies between the contiguous ends of the tergal and ventral arcs, and the connection eventually formed with these arcs may be regarded as accidental rather than essential, the wing and the leg, in the process of development, becoming connected with the end of that arc which happens to be nearest to it. So at least it may be. And if so then instead of being an exceptional organ the wing may have to be looked upon as having the same relationship to the leg as that which obtains between the gill and the leg in the decapod crustacean. Nor is there anything in this supposition which is out of keeping with what has been said already about the compound limbs of the aphrodite and other annulata. For these have been seen to be composed of two branches, each of which might be either foot or gill, or both at the same time: so that, after all, the connection of the wing and leg in the insect, and of the gill and leg in the decapod, may only be another illustration of that doubling of parts, which, in one of its many forms, is met with in the pieds-à-elytres of the aphrodite.

Without difficulty, also, it is possible to account for the presence of the prolongations of the stomach, or gastric cæca, which pass from one end of the limb to the other in the legs of the Pycnogonum balnearum—an arachnidan parasite living upon whales—and which also penetrate to a greater or less depth in the legs and palps of the spider and its congeners. For in order to this all that is necessary is to suppose that the state of things met with in the ray of the asteria is repeated in these limbs—that, in fact, the gastric cæca are only so many evidences of what may be regarded as a rudimentary phase of development.

But it is not expedient to dwell upon these and other peculiarities of the sort in the present place, for the only full explanation is to be found, not in any particular statement, but in the general drift of what remains to be said under the present head.

2. The false feet of the prawn, of which their are six pairs, are not unlike the true thoracic feet of the branchiopod crustacean. Each foot consists of a flattened basal joint, on the top of which, side by side, are two longish flattened leaves, with ciliated edges; and this is the case substantially in stomapod, isopod, and branchiopod, as well as in decapod crustaceans generally, the chief differences being in the size and shape of the terminal leaves, and in the fact that in the stomapods one of these has a palp and a brush-like process which is obviously a rudimentary gill. In a word, there is nothing peculiar in these false abdominal legs, for many of them are little more than exact copies of the lamelliform, fin-like, thoracic legs of the branchiopods.

3. The organs called foot-jaws differ much among themselves, and from the true and false feet already noticed, but their real nature is never altogether hidden. There are three pairs of them, each pair having peculiarities of its own; and their place is always immediately in front of the true feet. In the prawn the first and second pairs have parts which correspond more or less closely, not only to the true feet, but also to its gill and flagellum; and the third pair is still more obviously in the same case. In the crab and lobster the mutual resemblances of the three pairs are more striking; and there is less difficulty in detecting the likeness to the true feet immediately behind them. They are evidently these latter feet but very slightly modified, and any little peculiarity is as evidently owing to mere differences of development in one or other of the component parts, all of which are there. In the squilla mantis (a stomapod),

for example, the first pair of feet is not unlike the third pair of feet in the prawn, and the third pair is absolutely like the first pair of true feet immediately behind them, but the middle pair is developed so as to form the large "pattes ravisseurs," which stand out from the other feet about as much as the cheliferous feet do from the ordinary feet in the lobster. Here, the office of cheliferous feet is transferred from the first pair of true feet to the second pair of foot-jaws—a transference which brings out very conspicuously the foot-nature of the foot-jaws. Here, too, the close relationship between the foot-jaws and the true feet is evident in the way in which the true feet close around the mouth so as to be capable of doing the actual work of the foot-jaws—an arrangement to which the squilla mantis and its congeners are indebted for their name of stomapods. The case is plain enough when looked at in this way. Nay it is plain enough in itself, for the "pattes ravisseurs" are manifestly only magnified forms of the feet behind them, with the metatarsi turning back in the same way upon the tarsi, and with strongly dentated instead of merely ciliated inner margins. Indeed the case is one which prepares the way for that which occurs in the isopods and branchiopods, where the only difference between the foot-jaws and the true feet is that which attaches simply to position.

4. In the prawn and in other decapods as well, immediately in advance of the foot-jaws, are three pairs of organs to which the name of true jaws is given, the first pair being the mandibles, the two hindermost pairs the maxillæ. These organs are more rudimentary than the foot-jaws, and in some cases they are so very rudimentary as to make it difficult to identify their particular parts, but now and then, in different crustacea, their

form is such as to make it certain that they are not special organs, but merely modifications of the foot-jaws and of the true and false feet behind them.

The trophi or oral appendages of a mandibulate insect consist of two pairs of lateral jaws, the upper being the mandibles, the under the maxillæ, which work from side to side like the true jaws of the crustacea, and of two lips, the upper one called the labrum, and the under one the labium, which act in an up-and-down direction like the jaws of a vertebrate animal. The maxillæ carry palps, and in other respects are not unlike the maxillæ of the crustacea: the mandibles are more simple in form, stronger, and palpless. In some instances, the maxillary palps "besides their sensitive and selective offices, serve also to seize and steady the alimentary substances whilst these are being divided by the mandibles and maxillæ, representing, in fact, a third pair of lateral jaws." The labium has usually a pair of palps, and, in addition, within the mouth, a process called the tongue, which is particularly developed in the dragon-fly and many beetles. In the haustellate insects the mouth is still made up of the same parts. In the bee tribe the mandibles are strong cutting organs very like those of the mandibulate beetle, but the maxillæ and labium, which go together to form the proboscis, are very much altered, especially the labium. The maxillæ have still their palps, and so has the labium; the latter organ may indeed have an extra pair. In the hemiptera mandibles and maxillæ alike are attenuated and prolonged into lancet-shaped organs, for which the elongated labium serves as a sheath: and the palps have disappeared. And so also in the diptera, with this difference that the labrum is also lancet-like, and that the sheath formed by the labium is terminated by two fleshy suckers. In the butterfly the mandibles are quite rudimentary, and the maxillæ have coalesced so as to form the long proboscis, or antlia, which when not in use coils up spirally between two lateral palps, which seem to be maxillary palps. Here, no doubt, it is difficult to be always positive as to the homology of the parts. In fact, the antlia may be a highly developed tongue, akin, perhaps, to the proboscis of many gasteropods; but generally, there is no difficulty in passing step by step from one form of mouth to another, and in tracing everywhere the presence of the same elements.

On comparing the oral appendages of a mandibulate arachnidan with those of a mandibulate insect the resemblances out-number the differences, and the differences only serve to bring out more clearly the limb-nature of the different parts. The mandible of the scorpion with its terminal pincers, or the mandible of the spider, with its sharp, moveable fang, perforated by a poison duct, point plainly to the jointed foot-jaws of the crustacean; and so, with still greater plainness, does the enormous cheliferous palp upon each of the maxillæ —an organ which closely copies the chela of the lobster, not only in shape, but also in relative proportions, its size being as much in excess of that of the true limbs as in the crustacean. Nor is it otherwise when this comparison is made to include arachnidans with haustellate mouths, for, with or without the key met with in insects having mouths of the same sort, it is easy to see that the oral appendages here are merely modifications of those which enter into the formation of the mandibulate mouth.

The mouth of the annulata may take the form of a sucker, as in the leech, or of a proboscis, which is really a protrusible and retractile pharynx, as in the arenicola, or sand-lug, with or without three or more teeth of one kind or another arranged around the entrance to the pharynx. Lateral jaws are not to be met with here: and even the teeth are not always teeth, for, as in the case of the sand-lug, the teeth become external spines, which can be used as organs of prehension, when the proboscis is everted. Around the mouth, also, and coming under the head of oral appendages, may be certain labial tentacles and branchial processes, but these do not require special notice now, for all that may be said about them is included in what has to be said immediately upon the oral appendages of the radiata.

Among the radiata the bilateral arrangement of limbs has given place to the radiate, and all the limbs may be looked upon as oral appendages. So it is in the great class of polypes: so also in the star-fishes and the cephalopods. In each of these cases the polype-type prevails, and, except in different creatures, the different limbs, with few exceptions, are all alike. The case is one, indeed, in which, in this similarity in the limbs, it is possible to see that the mandibles and maxillæ of the mandibulate or haustellate mouth may be nothing more than modifications of a certain number of the so-called arms of a radiate animal, and that the upper and lower lips, as well as the tongue and other parts of the same mouth, may in like manner be substantially other arms of the same sort. Nay, it is possible to go further in the same direction and find much in favour of a still wider generalization. In many of the star-fishes the roughened bases of the rays are made to do the work of the special teeth of the sea-urchin, and it is difficult not to see that these teeth are modifications of the same organs which exist on the ray of the star-fish as mere calcareous tubercles, and which are developed in the sea-urchin into long and strong articulated spines. Organs which are tubercles or spines in one part of the body are teeth in another; and the only difference between this case and that of the sand-lug already noticed, is that here the teeth are always teeth, and the tubercles or spines always tubercles or spines, and not the one or the other as the proboscis upon which they are implanted happens to be inverted or everted. A similar lesson may also be found in the suckers on the arm of the cephalopod, or in the ambulacral feet and pedicellaria of the star-fish and its congeners: for here the polype-type is still the type, and it is difficult to avoid the conclusion that the parts in which these organs are implanted are, in more than a figurative sense, polyparies. And so likewise with the very hairs, for it is impossible to see the various modifications of these organs—articulated and cheliform in the Eunice and many other dorsibranchiate annelidans, articulated and ramified in the large bird-spider (*Mygale*), like the down of birds, &c.—without being convinced that the hair is the rudiment of the same part which may be developed into the cheliferous and other limbs of the same or any other creatures. Everywhere, indeed, are abounding traces of the same plan: and the inevitable conclusion seems to be, not only that the mandibles and maxillæ are con-natural, but that this con-naturality extends equally to the lips and tongue and teeth—to all the other oral appendages, and to all the several parts of these appendages, great or small. And if so, then it is possible to see still further in several directions. It is possible to see why it is that the maxillæ and the base of the large cheliferous palps of the spider should contain cæcal prolongations of the stomach, for this state of things is only a repetition or that which is natural in the ray of the star-fish. It is possible to see why the mandible of the same creature should be perforated by a poison duct, for this may be no more than a modification of the hollow tentacle which is natural to the bryozoic and anthozoic polypes. It is possible that the close connexion between the gill and the foot of which so many instances are met with in the articulata may explain why it is that the gill and the "foot" are related to each other in the same manner in molluscs, and why, for the same reason, it becomes necessary to regard the latter foot as a modification of an oral appendage rather than as a vague "development from the ventral surface." It is a matter of indifference, however, whether the foot in question be an oral appendage or not. It is radically similar, and that is all that need be said about it, and also about the two arms of the branchiopods, and the two wings of the pteropods—which have some claim to be regarded in the same light—except this, that these latter organs lead back from the radiate arrangement of appendages to that bilateral arrangement which is natural to the crustacean and to the higher forms of articulate creatures.

5. The eyes of the prawn are organs of a very different sort to those which have been under consideration, but the peculiarities are not so very real as they seem to be at first sight. They are compound eyes, that is, they are composed of many eyelets; they are two in number, arranged bilaterally; and they are placed upon peduncles made moveable by being jointed at their base. In the Limulus, and in certain other entomostracan crustaceans, several simple eyes (ocelli or stemmata) are associated with compound eyes, pedunculated or sessile, each simple eye, like every single eyelet of the compound eye, having its separate lens, and nerve, and pigmentary layer, and humours, as well as a transparent speck of integument which does duty as

a cornea. The moveable ocular peduncle is very long, much longer than in the prawn, in the podophthalmic crabs, in the Gelasimus telescopicus more especially, where it projects considerably beyond the edge of the carapace. Here, indeed, the term podophthalmic is rightly used, for the eye is as much a foot as an eye: and still more so in the Ocypode cerophthalmus, where the peduncle, in addition to being long and jointed at its base, is prolonged as a calcareous spine far beyond the part to which the compound eye is attached, and where, consequently, the organ may be rightly looked upon as half-eye, half-antenna. The close relationship of the eye to the antenna is also seen in the gasteropods, where two of the "horns" carry small simple eyes, one on each, and two are plain antennæ—where, in fact, the "horns" agree in being inversible or eversible like the finger of a glove, or rather like the throat of a bryozoic polype, and disagree only in this, that two have eyes, and two are eyeless. Nor is this podophthalmic arrangement peculiar to the crustaceans or gasteropods. On the contrary, each of the two eyes of the nautilus and of many other cephalopods is supported upon a short peduncle containing a cartilage which is evidently the homologue of that which is met with in the same place in the pedunculated eyes of the sharks and rays. In many of the cephalopods, also, the eye presents a peculiarity which leads to the same conclusion by another way. At all events, I find it difficult to look at this form of eye without thinking of the sucker on the arms, and of the polypodal or radiate type of development which finds expression in both. For what is the actual case? It is that of an eye the cornea of which is pierced near its centre by an opening through which the sea-water enters and bathes the front of the crystalline lens. It is that of an eye from which it may be supposed that the lens and humours would have escaped if the opening in the cornea had been a little larger. It is a case in which, if the lens and humours had escaped in this manner, it is not difficult to detect a sort of likeness between the open and empty eyeball and the sucker on the arm, or even between it and an actual polype, for the ciliary processes may be supposed to repeat the radiating ridges around the throat of the sucker, and the crown of tentacles around the mouth of the polype. After what has been said, all this may be conceded as not improbable: and if so, then the particular construction of the eye becomes in some measure intelligible, and at the same time some light is thrown upon the disposition to radiation and ramification which is displayed conspicuously in so very many of the appendicular organs already noticed.

6. Returning to the prawn the organs which have next to be examined are the posterior and anterior pairs of antennæ which project in advance of the eyes, and which seem, at first sight, to have little in common with the parts already attended to. Each member of the posterior pair has a lower portion and an upper portion, with a joint between them, and also between the lower portion and the head of the animal, and so has each member of the anterior pair. The lower portion of the member belonging to the posterior pair is developed above into two prominences, one in advance of the other, the hindermost being prolonged into an immoveable flat spine, the foremost carrying, over the joint which is there present, two long and one shorter, many-jointed, tapering, antennæ. The lower portion of the member belonging to the anterior pair is also developed above into two prominences, the one

before the other, the hindermost carrying a moveable, large, elytra-like scale, the foremost serving as a base for a single, moveable, many-jointed, tapering, antenna. There is a bifid arrangement in the basal portion in each case which is evidently a shadow of the double-foot of the isopod and branchiopod crustaceans and of many of the annulata; and there can be little doubt that the antennæ are modifications of the palps which occupy the corresponding situation in many other crustaceans, and that the basal portion below the antennæ agrees in like manner with the parts corresponding to them in the more ordinary feet. Nor is a different conclusion to be drawn from the more exceptional forms which the antennæ take in other invertebrate creatures. In the spider, for example, the fact that the antenna is confounded with the mandible, is only another proof of the common nature of the antenna and the mandible: and what other conclusion is to be drawn from the similarity of the eye-less and the eye-bearing "horns" of the gasteropod except this, that the eye-less horns, which are the homologues of the antennæ, and the eye-bearing horns are radically connatural? In short, it would not be difficult to show that the antennæ may take upon themselves the form and office of the limbs which have to do the work of prehension and locomotion, or that they may even become transformed into root-like processes. The larval barnacle (*Lepas*), for example, is provided, not only with pedunculated eyes, but with long antennæ which may be used in creeping and holding, as well as in feeling, but the adult creature is both blind and palpless, the eyes having disappeared in the course of moulting, and, contemporaneously with this change, the palps or antennæ having become transformed into the peduncle by which the animal is fixed, as by a root, when its period of juvenile freedom is at an end—a change by which this particular part of the larval barnacle is made to move many steps towards the position occupied by the byssus-forming foot of the common mussel and by the spinnaret of the spider.

7. If there were room it would not be difficult to muster many other facts of like significance: as it is, I must content myself by singling out certain external appendages of the prawn which can hardly be overlooked, namely, the central spike projecting from the anterior edge of the carapace, the tail, and the external genital organs.

The spiny-edged, lamelliform, immoveable appendage which projects from the anterior edge of the carapace in the prawn, may, for anything that appears to the contrary, be homologous to any one of the limbs which lie at its side—may be, in fact, nothing less than one of these limbs aborted in the state of spine. It lies among these limbs like one of themselves, and unless it were sought out it might be confounded with them. And, in short, it is difficult to reject this claim to relationship—difficult to avoid the conclusion that the anterior part of the trunk may take upon itself the form of a limb so far as to be confounded with it.

The tail, too, would seem to show still more plainly that the limb-nature which may lie hidden in the anterior end of the trunk is also present in the posterior end. The tail of the prawn is to all intents and purposes a large and strong limb: and more emphatically still is it so in the poison-fanged tail of the scorpion. In the latter case, indeed, the limb and tail agree very much in dimensions, and their other differences are not at all irreconcilable. But this is only a hint in passing.

for the evidence upon which it is possible to come to a conclusion upon this point, and upon that which was last under consideration, is not yet available without going very much out of the way to find it.

Nor are the traces of a common plan absent in that case which now alone remains to be noticed—namely, that of the external genital appendages. In the male prawn, on the under surfaces of the basal joint of the last ambulatory leg, is an opening the edge of which may be everted so as to form an intromittent organ; in the female, in the corresponding part of the third ambulatory leg is an opening into which the intromittent organ of the male is inserted at the proper time. This is all. The case recalls the presence of the sexual openings at the base of the rays of the starfishes, which are either male or female, or both; nay, this difference between male and female openings is not so great as it seems to be at first, even in the crustaceans, for in the prawn, and lobster and many of their congeners it not unfrequently happens that male openings are developed on one side of the body and female openings on the other. Nor are these the only proofs of the close relationship between the organs in question and the limbs of which so much has been said. In the male spider, for example, the tumid and unarmed terminations of the long, maxillary palps, which palps are legs to all intents and purposes, contain the parts analogous to vesiculæ seminales, and are in reality limbs modified and devoted to a sexual purpose. And again, the spermatophorous or sexual arms of the octopus, or the "sail" of the argonaut, may be looked upon in the same light, for it is now known that each of these parts agrees with the ends of the maxillary palps of the male spider in containing what must be regarded as seminal receptacles. And this, too, is now known—that the part which was long regarded, either as a special parasite, or else as the male octopus himself, is nothing else than the sexual arm of this creature, detached from the body, and adhering by its suckers to some part of the mantle of the female octopus—the case of this sexual arm being in reality not unlike that of the spermatophorous limbs of the male of the cyclops and of some other entomostracan crustaceans. Nor is there anything exceptional in the organs which do duty as ovipositors. In the wasp, for example, these are made up of two long, sharp, slender blades, with serrated edges, which are closely opposed in the act of piercing, and which are afterwards separated so as to leave an inter-space for the passage of egg or poison as the case may be. The resemblance between the parts which serve as ovipositors or stings, one or both, and the long sharp lancet-like oral appendages is not to be mistaken. This may not be quite so close as that which exists between the cephalic and caudal suckers of the leech, but it is scarcely less so: and so, after what has been said, it is scarcely possible to avoid coming to the conclusion that the external genital appendages, male and female, are in their nature true limbs modified so as to answer a particular purpose, and also that there is a tendency to a repetition of these limbs in the same form at each extremity of the trunk.

And thus, as in the various limbs of vertebrate animals so in the various appendicular organs of invertebrate animals, it is possible to assert positively that unmistakeable traces of unity are to be detected everywhere.

Chapter IV.

TRACES OF UNITY IN THE SKULL AND VERTEBRAL COLUMN.

The conviction that the skull was made up of modified spinal vertebræ flashed upon the mind of Oken at the sight of a deer's skull, blanched, and partly disjointed, by the weather, which skull caught his eye as he made his way down one of the wooded southern slopes of the Hartz Mountains in the autumn of 1806. "Er ist eine Wirbelsäule! fur es mir wie ein Bliz durch Mark und Bein . . . . . und seit dieser Zeit ist der Schädel eine Wirbelsaule." * A month or two later this conviction became confirmed and matured by an examination of certain skulls in Dr. Alber's museum at Bremen ; and before another year was over he made it the subject of an inaugural address delivered at the University of Jena, and printed shortly afterwards.† As usually happens, however, the thoughts of others, in this case of Goethe, Autenreith, Frank and Kielmeyer, had already moved in the same direction. In 1820, in a sketch of his own anatomical labours, Goethe shows that the bones of the skull may be *deduced* from those of the vertebral column, and in a

* Isis, 1817, p. 511.

† Ueber die Bedeutung der Schädelknocken : Programme beim Antritt der Professur. 4to. 1807.

note appended to this sketch by his French translator and commentator, Dr. Martins, it is stated that this idea dawned upon Goethe nineteen years previously in a way which is surprisingly like that in which it blazed upon Oken. "Goethe se promenant dans le cemetière des juifs au Lido, près de Venise, remassa sur le sable une tête de belier dont le crâne était fendu longitudinalement, et, en la regardant, l'idée lui vint à l'instant même que la face était composée de vertebres : la transition du sphenoïde anterieur à l'ethmoide lui parut évidente au premier coup-d'-œil. C'était in 1791, and à cette epoque il ne fit point connâitre son idée." So writes Dr. Martins. And as to the claims of the other three, Owen in a few words says all that need be said in a report on the homologies of the vertebrate skeleton presented to the British Association for the advancement of science at the meeting in 1846. "Autenrieth and Jean-Pierre Frank had alluded, in a general way, to the analogy between the skull and the vertebral column, and Ulrich, reproducing formally Oken's more matured opinions on the cranial vertebra, says, 'Kielmeyerum præceptorem pie venerandum quamvis vertebram tanquam caput integrum considerari posse in scholis anatomicis docentem audivi.' And the essential idea was doubtless present in Kielmeyer's mind, though he reversed the proposition, and, instead of calling the skull a vertebra, he said each vertebra might be called a skull."

In the inaugural lecture already referred to Oken finds in the skull of a lamb, which served him for a text, three vertebræ, the ear-vertebra (ohrwirbel), the jaw-vertebra (kieferwirbel), and the eye-vertebra (augwirbel). The ear-vertebra has for its great foramen the foramen magnum of the occipital bone, the occipital condyles for its oblique spinous processes, the "partes condyloidæ" for its laminæ, the crista occipitalis for its spinous process, the pars basilaris for its body, and the foramina for its intervertebral foramina. The jaw-vertebra has for laminæ the parietal bones, and for body and transverse processes the posterior sphenoid. The eye-vertebra has for its laminæ the frontal bones, and for its body and transverse processes the anterior sphenoid. At the time of the delivery of this lecture, Oken saw no more than these three vertebræ in the skull; at a later period he also saw, in advance of the eye-vertebra, the rudiment of a fourth vertebra, of which the vomer is the body, the lachrymal bones the laminæ, and the nasal bones a bifid spinous process. Without doing more than merely turning a skull like that of a lamb round, and looking at it attentively on all sides, it is easy to see that the case may be as Oken put it: by removing the bones which take no part in the formation of the "basis cranii," *i.e.* the frontals, the parietals, the temporals, the lachrymals, the orbitals, the nasals, and the æthmoids, and by then replacing them, the difficulty is to avoid seeing that it must be so; for on removing the bones, and looking from above, the basis cranii is evidently a prolongation of the bodies of the vertebral column into which at least three vertebræ may enter, and on replacing them the cavity which is thus arched over, is as evidently an expanded portion of the vertebral canal.

Oken also saw very clearly that the "pars petrosa" of the temporal bone is related to the third vertebra in the same way as that in which the jaw and the eye are related to the two other vertebræ—that it was, not a part of the actual vertebral zone, but a sense-organ (Sinnorgan), the eyes, jaws and ears being all essentially limbs (Gleider), and these again ribs. "Freye Bewegungsorgane können nichts anderer als frey gewordene Rippen seyn," he says: nay, he even goes so far as to describe particular parts of the cranial vertebræ as ilium capitis, femur capitis, and so on.

Since the time of Oken much has been done, by Owen more especially; and now it may be regarded as a well-established fact that the skull is really made up of modified vertebræ, and that the ears and jaws and eyes are appendages which are related to the cranial vertebræ in exactly the same way as that in which the ordinary limbs are related to the spinal vertebræ. There is much disagreement as to particular homologies: there is scarcely any as to the general connaturality—the point with which at present I am alone concerned—of the skull and the vertebral column. Upon this point, indeed, Goethe, and Bojanus, and Spix, and Cuvier, and Geoffroy St. Hilaire, and Wagner, and Agassiz, and Sömmering, and Carus, and Meckel, and Owen, and all, with one or two exceptions only, who have paid any serious attention to the subject, are perfectly in accord with Oken.

Chapter V.

TRACES OF UNITY IN THE VERTEBRA AND ANNELLUS.

As commonly defined, the vertebra and the annellus have little or nothing in common. The former is made up of a series of rings arranged in the same plane around a solid centre or "body," and the muscles belonging to it are on the outside. The latter is a single, centreless ring, with its special muscles on the inside. It is difficult, however, to rest satisfied with this way of looking at the matter. It is certain that the line of demarcation between the vertebra and the annellus is drawn with little firmness in many places, and not at all in others: it is by no means certain that it is to be found even where it is supposed to be most firmly drawn, that is, across the "body" of the vertebra. And there is no great difficulty in making good this statement.

In the thoracic vertebræ of chelonian reptiles the place of the "bodies" is occupied by narrow bony belts or arches, while the most body-like parts of the vertebræ are *over* the spinal cord instead of *under* it. In certain extinct ganoid fishes of the Devonian or Old Red Sandstone period, as in the Coccosteus, there is a blank space between the neural and hæmal spines where the bodies of the spinal vertebræ ought to be—a plain proof that in the living animal this space was occupied by tissues too perishable to allow of calcification, by nothing more than the very softest of soft notochords.* In many cartilaginous fishes now living, as in the sturgeon, a wide continuous canal runs through the bodies of the spinal vertebræ from one end of the spinal column to the other: and, besides this, the bodies themselves are cut up into segments by deep fissures running in an antero-posterior direction. And even in mammals some of these changes in the bodies of the spinal vertebræ are repeated, for the bodiless upper cervical vertebra, or atlas, approaches evidently to the bodiless dorsal vertebra of the chelonian, and the division of the lumbar vertebra into two lateral halves by a deep groove which occurs in the sea-cow (*Manatus*), and, in a lesser degree, in man himself, and in many other mammals, may be an exemplification of the same segmentation as that to which reference has just been made as existing in the cartilaginous fish.

Very often, also, the bodies of the cranial vertebræ are represented by a mere plate of bone; and now and then even this plate may be wanting. Thus, in some of the seals there is a large *aperture* in the dry skull where some of these bodies should have been—an aperture which during life is only closed by soft tissue; and thus again, in the cyclostome fishes, as the myxine and lamprey, the floor of the skull is in the main formed by *two* cartilaginous ridges—homologous with the trabeculæ of the embryonic skull—which separate for a short distance and then re-unite so as to enclose a space which is occupied by a layer of cartilage not much thicker than paper.

The cyclostome fish, which occupies an intermediate position between fishes and reptiles, represents a very rudimentary phase of development; the seal may be said to be the least developed of mammal forms; and

* Owen: Comp. Anat. and Phys. of the Vertebrata; vol. i., p. 197.

hence it may be expected that the peculiarities to which attention has been directed are signs of immaturity, and that a corresponding state of things is likely to be met with at one time or other in the embryonic condition of animals of higher grade. And so it is.

The cerebro-spinal column makes its first appearance as a line, or primitive streak upon the pear-shaped pellucid area, or embryonic shield. Then this primitive streak deepens into a groove and at the same time is divided into two portions by the formation of a transverse fold, the lower portion, which is the first to appear, becoming in due time the spine, and receiving the name of primitive groove, the upper portion, out of which the head has to be formed, being called medullary groove. Then the neural canal is formed by the gradual development and coalescence of the laminæ dorsales, or edges of the primitive groove, and of the medullary folds, or edges of the medullary groove. Then, the spinal portion of this neural canal becomes divided by transverse lines into segments known as protovertebræ, each of which consists of two lateral masses, and a central space, which, along with other spaces of the kind, enters into the formation of the *chorda dorsalis*. In the lateral masses of the protovertebra, the main arteries and veins, the Wolfian bodies, certain bony centres, &c., are subsequently developed, the history of each mass being a repetition of that of the other in every particular. The place of the "bodies" of the future vertebræ is occupied by the chorda dorsalis, but only the *place*. Each "body" is, in fact, formed by the coalescence of certain osseous elements belonging to each of the two lateral portions of the protovertebra, just as the heart is formed by the coalescence of the vessels present in each of these two lateral portions. As the bony portions of the two halves of the protovertebra coalesce the chorda dorsalis disappears: and, in short, the whole history of the chorda dorsalis is that of a part in which development does *not* take place, rather than that of a definite centre of development—that of a mere pith-cavity, it may be. Nor is this conclusion invalidated by anything that is met with in creatures where, as in the lamprey, the chorda dorsalis remains permanently: for the place of the chorda dorsalis in the dried skeleton in these creatures is occupied by a hollow space with some scant remains of shrivelled soft tissue in it, the process of drying having brought about a change which would seem to be not unlike that which happens to Meckel's cartilage on drying an embryonic lower jaw bone. Everything, indeed, goes to show that the "body" of the vertebra, instead of occupying a central position primarily, is formed by the secondary coalescence of certain parts belonging to each of the lateral halves of the protovertebra. So it is certainly in the chick and pig, and so it is also, so far as is known, in vertebrate animals generally. Nor is the case otherwise with the cephalic portion of the vertebral column. Here there is no very distinct chorda dorsalis—for this part does not extend beyond the spinal portion of the vertebral column—and no very distinct division into protovertebræ, but there are eventually two lateral ridges, called traberculæ, which diverge and meet again so as to enclose a space called the pituitary space. Here, indeed, there is strong confirmatory evidence in favour of the conclusion already drawn respecting the nature of the chorda dorsalis, and the mode of formation of the "bodies" of the vertebræ, for little imagination is required to see how the pituitary space may agree with the *space* of the chorda dorsalis, and the soft pituitary body with the soft contents of the chorda dorsalis, and how the two traberculæ enclosing the pituitary space may be none other than the homologues of the two lateral halves of the body of the vertebra in the stage prior to coalescence. This is an inference which may be drawn from the facts ; this, so far as I can see, is the only inference which seems to be justifiable or even permissible.

And in favour of this inference collateral evidence may easily be found in the construction of the cerebro-spinal axis of the nervous system : and in the peculiar relation which this part holds to the 'bodies' of the vertebræ. Whatever may be the ultimate reason of this conformity, it cannot be doubted that between these major centres of the nervous system and the 'bodies' of the vertebræ, there is a very close connection ; and inasmuch as the nervous and osseous systems agree in that each system is composed of corresponding zones, it may, without any very extravagant flight of fancy, be supposed that the law of formation of the so-called centre in one case may be the law of formation of the so-called centre in the other case also. At all events, it must be allowed that the result of bringing the nervous and osseous systems together with a view to observe their parallelism is strangely confirmatory of the inference that has been made as to the nature of the 'bodies' of the vertebræ. The great cerebro-spinal so-called centres are, not simple and central elements, but composite structures produced by the more or less complete coalescence of two lateral masses. The double nature of the great neural axis is clear and unmistakeable. And that the history of this axis is applicable to the elucidation of the more obscure history of the bony column is scarcely less clear and unmistakeable. It is in the trunk, where the bodies of the vertebræ are most conspicuous, that the two lateral neural columns have coalesced into the single spinal cord ; it is in the cranial region, where the bodies of the vertebræ are least conspicuous, that these lateral neural columns have diverged as crura cerebri, and, by so doing, have put an end to the existence of the central neural axis.

The heart, also, is not a single and central structure, but a composite structure formed by the coalescence of two lateral arterial and venous trunks ; and therefore the inference which has been drawn as to the double nature of the body of the vertebra from the history of its development, may derive some support from the history of the development of the heart no less than from that of the development of the great cerebro-spinal neural axis.

Again : the idea of the non-centrality of the body of the vertebra gains not a little in probability, if an attempt be made to deduce the nature of the body from the office which it is destined to fulfil. The principal office is not peculiar and special. In one point of view, indeed, the body is only one of several processes which serve to connect the vertebræ ; and so it may be expected that a comparison of the vertebral junctures each with the other, will issue in a clearer knowledge of the real nature of each and all. And so it falls out actually.

In the vertebræ of the cranial region, and also in those belonging to the thoracic region, in chelonians, as in the annelli of the cranial and thoracic regions of insects and many other articulata, the vertebræ are joined together by the complete apposition of the entire edge : but in the trunks of vertebrate animals generally the office of connection is confined to certain points of the vertebral zone, which vary in number and position in different instances.

On looking into the matter more particularly there is found to be a tendency to the formation of articular processes by which contiguous vertebræ are connected together at those parts where limbs or appendages of various sorts spring from the vertebræ. The skeleton of the fish is especially significant in this respect. At the parts where the sternal and dorsal fins are given off (provided these fins be well developed) there is a chain of osseous bodies formed by the development and articulation with each other of the bases of the fin-rays, and thus is formed, as it were, an additional spinal column in the median line above and below the true spinal column. In animals higher in the scale of being than the fish, the development of limbs from the median regions is no longer manifest, but a tendency to it may be detected still in cases where the ridge of the sternum and the spinal processes of the vertebræ are especially developed. In the chelonian, moreover, the bases of these latter processes in the region of the carapace *are* developed into perfect articular processes, by the union of which a quasi-spinal column of a rudimentary character is formed *behind* the neural axis. In the majority of vertebrate animals, behind the bodies of the vertebræ there is also a double chain of lateral connecting surfaces—the oblique or articular processes—which would seem to have a close relation to limbs or organs. At any rate, in connection with them are osseous projections which, though more rudimentary than other processes belonging to the same vertebræ, are yet now and then (especially in marsupial animals and birds) developed to such a degree as to make it impossible to overlook them. In the animals which have just been named, indeed, the outwardly projecting portion of the oblique processes are so highly developed, and the resemblance to the spinal and transverse processes of the vertebræ in the same animal is so marked, as to make it as difficult to doubt that the spine of a vegetable is an aborted branch or other organ, or the ridge of the sternum and the spinal processes of the vertebræ in the bird the rudimentary analogues of the limb developed in those regions in the fish, as to doubt that the processes in question are other than limbs, or limb-like organs of some sort, potentially.

Of the several means of connection between contiguous vertebræ it may thus be argued that four are connected with limbs, or organs of some sort; and therefore, it becomes a question whether the last and most important means of connection, the 'body,' is not in like manner connected with limbs or limb-like organs. And certainly there is nothing intrinsically unreasonable on the face of such a notion. Such a connection is possible—because there yet remain two important processes of the vertebræ to be accounted for, namely, the transverse processes. Such a connection is probable—because these transverse processes are in reality more directly connected with the 'bodies' of the vertebræ than the other processes, and because there is good reason to believe that they are specially related to the limbs, by being, as it were, abutments of the arches, scapular, costal, and pelvic, which carry the limbs. And thus, by connecting the body of the vertebra with the lateral limbs, additional ground is found for the belief in the double-nature of the body, while at the same time the notion itself becomes more definite, for, looked at in this light, the body is seen to be formed by the coalescence of articular surfaces in connection with the transverse processes and lateral limbs, which surfaces are analogous in their nature to those of the oblique processes, and of the elements of the quasi-vertebral columns at the base of the rays of the median fins in certain fishes.

It may perhaps be an open question whether this latter inference is fully justified by the facts: it can scarcely be doubtful that a very different view must be taken of the 'body' of the vertebra to that which is commonly taken—a view in which this part is regarded, not as a primary centre, but as a centre formed secondarily by the coalescence of two of the several centres which make their appearance at different points of a simple ring or zone—a view which finds in the bony part of the vertebra and in the nervous and vascular parts, the same common plan, namely, a simple ring which may become *nodulated* at certain points by the development of centres which may be osseous or neural or cardiac as the case may be, and which simple ring may become divided by the intergrowth of centres on opposite sides so as to form vertebral body or spinal cord or heart as the case may be—a view which, by dividing the 'body' in this way, opens out the vertebra into a simple ring, and by so doing breaks down the partition between it and the annellus.

Nor is this view invalidated by anything that is seen when it is looked into more particularly.

The zones of the carapace of the tortoise and of the plastron of the crab are forms in which the vertebra and the annellus are brought very closely together. In the chelonian the soft tissues are absent externally and the conformation, in this respect, is substantially that which is typical, not of the vertebra, but of the annellus: and in the crustacean the calcareous processes which project inwardly and form a grove for the lodgement of the great central nervous system, and which in some instances unite in such a manner as to form distinct arches, would seem to be rudiments of a spinal column — indeed, between these calcareous arches of the crustacean and the bony belts which take the place of the bodies of the vertebræ in the carapace of the chelonian the resemblance is evidently that which is more than merely accidental.

In every vertebrate animal also there are vertebræ which are transitional to the annelli in a degree which is only less perfect than that which is met with in the carapace of chelonians, and these are to be found in places where any such meeting would seem to be least likely, even in the cephalic region. For here, the broad ring-like vertebræ, articulated by the edge with their fellows, the tendency to the formation of a simple cavity by the disappearance of the floor of the skull, and the rudimentary development of muscle outside the bone, are certainly features which, when taken in connection with those that have been already noticed, may easily serve as bridges to any one who wishes to get across from the side of the vertebra to that of the annellus, or vice versâ.

On the other hand, the annellus, in being more or less covered by soft irritable tissues may move, as it were, from the outside to the inside, and so take up the internal position ordinarily occupied by the vertebra. The annellus of the ray of a starfish, for example, which is known curiously under the name of 'vertebra,' is *covered* by the coriaceous layer which has to do the work of muscle: and in some cases, as in that of a rare starfish which not many days ago I saw taken by trawling off the coast of Arran by the Duke of Argyle, this covering was thick enough and soft enough to make the likeness to an external layer of muscle very obvious. In this case, indeed, the sheath of soft structure around the spines might be protruded and retracted so as to hide or expose the tips of the spines, an arrangement strikingly like that met with in the armed sucker on the spatulose extremities of one of the ten-footed cephalopods, for here in the same way the central hooks may be hidden or exposed by the protrusion or retraction of the soft parts surrounding it. Or the moveable spine of the sea urchin may be made to supply another illustration to the same effect, for here the moving power has its seat in the external capsule of the ball and socket joint at the base of the spine. Or, lastly, a still better illustration may be found in the cephalic cartilages of a cephalopod, which are deeply buried under muscle-like structure, and which, according to the fancy of the observer, may be classed with equal propriety under the head of annellus or under that of vertebra.

In a word, the vertebra and the annellus, in spite of all their differences—and these are legion—are found to have so much in common as to necessitate the conclusion that both are framed upon a common plan—that there are in both the same unmistakeable traces of unity.

Chapter VI.

TRACES OF UNITY IN THE ANIMAL AS A WHOLE.

The body and its appendicular organs agree in being made up of segments, and the segments themselves do not disagree as much as they would seem to do at first sight. Thus, the annelli of the tail of a scorpion are intermediate between those of the body and those of the limbs. Thus, the vertebræ of the tail of a cat are intermediate between the vertebræ of the body and the bones of the different segments of the limbs. There are numberless differences between the segments of the body and those of its appendicular organs in these and other cases, but none that are in any measure irreconcileable. There are none so great as those which exist between the segments of the body and those of the head; and even the presence of a visceral system in the segments of the body, which may be looked upon as the chiefest of all differences, is done away, not only in the ray of the starfish, but also in the legs and great oral palps of many arachnidans. Indeed, it is impossible to look attentively at the arachnidan parasite of the whale without being convinced that the presence of a visceral system is not to be regarded as distinctive of the segments of the body. For here, as in the starfish, the cavities within the limbs communicate directly with the visceral cavity of the body, and are occupied throughout their entire length by cæcal prolongation of the stomach, the limbs and the cæcal prolongations within them being very nearly of the same dimensions as the narrow limb-like body and the narrow alimentary canal within it. Or, to take a more familiar case, it is almost impossible to watch a worm or snake in motion without being convinced that the body here is scarcely less limb than body.

If, then, it be true that animals agree with plants in that no clear line of demarcation is to be drawn between the central parts of the body and the appendicular parts, what is to be said about the archetypal idea of these parts? Is it necessary to try and apply the notion of the annellus or the vertebra to the interpretation of the appendicular parts, or is it necessary to try and find in these latter parts another and simpler archetype which may contain and explain the annellus and vertebra? The appendicular parts may be regarded as representing a more simple phase of development than the central parts, and, therefore, it is to be expected that the latter alternative is that which must be accepted. And, to say the least, the result of examining the appendicular organs with this end in view is—very significant.

Taking the eye of the eagle as the exemplar of appendicular organs, and using it as a text, it may be noticed first of all that the coats of this organ are composed of several laminæ or layers, nervous, vascular, quasi-muscular, osseous and others, arranged concentrically the one within the other, so as to form a hollow sphere, open to the front, or rather only closed in that direction by a transparent window. All the several layers mentioned are evidently arranged upon the same plan: the osseous layer is a simple ring made up of segments fitted together like the staves of a shallow tub and there is nothing in it to renew the perplexity caused by the presence of the "body" of the vertebra : the nervous and vascular layers, are cup-like layers, open in front, and tending to open at the bottom also, if the point called the foramen of Sömmering may be taken as indicating such a tendency: the quasi-muscular layer is also a ring, undivided in that part which forms the iris, divided like the osseous ring into segments at the ciliary processes by a series of cross-cuts : and so even, though not quite so obviously, in the true muscular layer, external to the eye-ball, for here it may be supposed that the four recti muscles have been formed by the segmentation of a primary ring like that of the iris or ciliary-processes. As in the osseous layer there is nothing to represent the "body" of the vertebra, so in the other layers, vascular, nervous, muscular, and the rest, there is nothing to represent heart, or brain, or the like, except it be that the muscular masses outside the eye are indications of such centralization. The case, indeed, is one in which the two great varieties of zone, the vertebral and the annellar, are brought so closely together as to make it easy to see how the one may pass into the other. In the region of the tunica albuginea, the osseous layer is practically external, for the parts which represent the muscular layer—the ciliary processes and the iris—are *within* the eyeball. The case is substantially that which is typical of the annellus. In the region *behind* the tunica albuginea, on the other hand, the relative positions of the osseous and muscular layers of the coats of the eyeball are reversed, the latter, now forming the straight and oblique muscles, being not within, as in the last case, but *without.* The case, that is to say, is one which is as typical of the bodiless vertebra of which so much has been said, as the other was of the annellus. And so, as in an experiment, it is possible to find in the eye of the eagle a key to the door which must be unlocked and opened and passed through, before it is possible to get near enough to gain a clear glimpse of the archetypal form which underlies the vertebra and the annellus.

A bodiless vertebra or annellus, however, does not wholly represent the notion of the archetype which is suggested by an examination of the coats of the eye of the eagle. This notion is suggested, no doubt, but only secondarily. It is, in fact, ushered in by that of a hollow spheroid, or cell, with laminated or laminable walls, which cell may become changed, first into a cup by the formation of a mouth-like opening, and then into a broad ring by the addition of another opening at the bottom of the cup, the mouth of the cup which precedes the ring copying the polype in its disposition to radiation. Without going very far out of the way it is also possible to see, in some measure at least, why it should be so, and to provide answers to many questions which naturally present themselves when the eye is made the text of the inquiry. What, it may be asked, is the significance of the ciliary processes, of the curtain of the iris, of the pupil? What is the significance of the foramen of Sömmering? What of the eyelids, and eyelashes, and eyebrows? What of the lens, of the humours? What, indeed? Is it that the ball of the eye is subject to the same law as that which obliges the sea-urchin and many other radiate forms to open out at opposite poles, the pupil being the mouth and the foramen of Sömmering the rudiment of the vent? May the eyeball be looked upon as a polype whose mouth is upon the point of opening, is to some extent actually opened in the pierced cornea of the cephalopod, and whose oral tentacles are represented by the ciliary processes and curtain of the iris? Do the eyelids and eyelashes and eyebrows point to the outer ring or rings of tentacles which in bryozoic polypes serve to close the orifice by a lid or operculum when the polype is withdrawn within its cell? Does the eyeball tend to change from the shape of the cell into that of a ring because it is subject to the same law as that which causes the sea-urchin and so many other radiate creatures to open out at opposite poles into the mouth and vent? Does the chief chamber of the eye correspond to the stomachal cavity of the simple polype, and by implication, to the visceral cavity of the higher animals, vertebrate and invertebrate--to cavities, that is to say, between which the very closest connection is easily traceable? Is the lens a modification of that nuclear body which may be developed into that polype within the polype which is, as it would seem, destined to become the visceral system of creatures higher up in the scale of being than the hydrozoic polypes? Is the polype-type thus revealed in the eye inherent in every part of the body, appendicular and central? Does the hand of man open out into fingers and clasp upon another body because it remembers its relationship to the polype? Have the humours of the eye anything in common with the crude substance within the pith-cavity in plants, or with that included within the bounds of the chorda dorsalis in animals? These questions, and others like them, present themselves naturally, and have, as I think, some claim to be answered affirmatively. Indeed, if it be as true as it would seem to be that all parts of the body, appendicular and central, are framed upon the same archetypal plan, I do not see how they can be answered otherwise.

And thus, to bring these cursory remarks to a close, I may say, not only that the traces of unity which are everywhere met with in the appendicular organs of animals are also everywhere met with in the central parts, but also that the common archetypal form which is thus brought to light has its final expression, not in the vertebra or annellus, nor yet in a polypoid form, but in the *cell*—a conclusion which, in fact, is tantamount to widening the grand generalisation of Harvey, *omne animal ex ovo*, so as to make it applicable to every part of the body as well as to the body as a whole.

Chapter VII.

TRACES OF UNITY IN PLANTS AND ANIMALS.

Between plant and animal and between animal and plant there are many superficial traits of resemblance some of which it may be well to call to mind before proceeding to consider whether there are any deeper ties of kindred beneath them.

The flower of the dove plant (*Peristeria elata*), the loveliest of all orchidacean flowers, consists of a rose-like crown of white sepals, from the bosom of which a white dove, with outstretched wings, is, as it were, upon the point of taking flight. The flowers of many other orchids resemble insects of various sorts in the very strangest manner—insects which have only to make a slight effort to break loose from their fetters and get away; and not unfrequently the plants to which these flowers belong, as if unwilling to be tied down like ordinary plants, are parasites living on the topmost parts of lofty trees, and resting rather than clinging there, for more than half their roots dangle loosely in the air as aërial roots. Several of the globular echinocacti, with their long spines and quasi-ambulacral lines, set with buds in place of pedicellaria, are startlingly like globular sea-urchins. The Astrophytum myriastigma is not less like a short-armed star-fish, the buds being still arranged in lines after the manner of the feet in the radiate animal. The Mammillaria nivea v. cristata, might easily be mistaken for a brain-madrepore; the Monsonia Burmanii is the image of an ordinary coral; and the Rhipsalis copies not less closely the Isis hippuris, and other articulated corals. Indeed it is quite conceivable that in some of these cases plant and animal might be confounded if they were seen lying together on the sea-beach, as might very well happen after a storm in many parts of the torrid region of America.

The acorn-shell (*Balanus*) has a multivalve shell in which the valves are arranged in a whorl like the sepals in the flower of the dove plant, and the resemblance to this flower is further increased by the position in the heart of the shell which is occupied by the body of the cirrhiped, and by the way in which the shell itself,—at least in the mature condition—is attached to some foreign body. The wings and winged legs of the Mantis siccifolia, or walking leaf, resemble shrivelled, autumn-stained leaves so closely that the insect may readily be mistaken for an emancipated orchid-flower. The mussel may exhibit in a fixed form a state of things which is only transitory in plants, the shell corresponding to the husks of a seed, the gills to the cotyledons, the foot to the radicle, the fibres of the byssus to the spongioles. And what may be said of the common coral and encrinite save this—that these and kindred creatures are almost as much plants as animals, that the name of zoophytes is rightly applied to them, and that plants are excluded from the order radiata on no just pretext? Indeed, only one conclusion may be drawn from the fact—which is too familiar to need illustration by instances—that plants and animals in so many ways exhibit the same radiate and ramified and helical modes of growth.

Nor do these traces of unity become more shadowy when they are looked into more steadfastly.

The conclusion arrived at in the last chapter was that nerve and muscle and vessel and bone and other special structures appear as layers in the walls of a hollow sphere or cell, and that subsequently these layers are transformed into rings or zones by opening out at opposite poles. The course of development in this case, that is to say, is from the cell, first towards lamination, and then towards zonulation. Nor is it otherwise in the plant. In the rounded and hollow peach there is a distinct separation into layers of which that which forms the stone may be rightly regarded as homologous with the bony layer in the eye of the eagle—of that layer which elsewhere may become the vertebral ring: and the state of things which is met with here is substantially that which is met with in the husks of seeds, in the walls of the nodes of the stem and branches, and in many other parts of the plant. There is ever at work a "law of compensation" by virtue of which any over-development of one layer is at the expense of one or more of the others. Usually the woody layer is the only layer which is developed very conspicuously: always, however, there are traces of soft layers, and in many succulent fruits these are in excess of the hard layer. In some cases, too, as in the leaves of the sensitive plant, and Dionœa muscipula, certain parts—probably altered axillary buds in the first case—approximate closely to the "irritable" textures of animal bodies in their characters. Nor are traces of zonulation wanting in plants. One such trace is found in the case where several cells unite so as to form a vessel with a continuous cavity, for here each cell becomes more or less zonular by opening out in opposite directions. Another such trace is found in the case where, in consequence of the disappearance of internodal septa in a branch or stem, several nodes may come to be traversed by a continuous pith-cavity: indeed, the pierced nodes in such a case, as in that of the reed, is the nearest approach in plants to the zonular type, which enters so largely into the construction of animal bodies —is perhaps the simplest expression of the archetype in its zonular phase. Nay it is possible that the set of pipes in the hand of Pan—who is a personification of Nature—may point quite as much to this archetypal significance of the reed as to the harmonious dance of all things to the music of the spheres.

On following out the progressive evolution of the animal frame the next step appears to consist in a partial or complete division of the zone into segments. Just as the zone itself is formed out of the cell by the increase of the equatorial region at the expense of the polar regions, so now the division of the zone into segments would seem to be formed by the development of certain parts of the zone at the expense of the intermediate parts. The effect of the segmentation is manifested in the formation of ganglia in the nervous layer, of muscular masses in the muscular layer, of cardiac centres in the vascular layer, of bony masses in the osseous layer, and so on. The ambulacral lines of the starfish or sea-urchin are traces of the division of the zone into segments. The tentacles of the polype and of the cephalopod are formed in part by the division of the edge of the zone into segments, and in part by the subsequent growth of the portion of the edge belonging to them; and the multiplication of certain polypes by "fission" is only an extension of the same process which is seen at work in the cutting out of the tentacles.

A division of the zone into segments would also seem to operate in plants. The meridional lines on the surface of the echinocactus may have the same significance as the ambulacral lines on the surface of the sea-urchin. The separation of the original cups of the bud into leaves or petals or stamens is an undoubted case of segmentation: and, not less plainly, so also is the dehiscence of the fruit in certain directions.

In both cases the facts are sufficiently conclusive to justify the conclusion that segmentation of the zone in the course of development is a phenomenon common to plant and animal.

The analogy between plant and animal holds good, also, when an attempt is made to trace it in the opposite direction, with a view, that is, to realize the way in which various zones are united to each other.

On making a horizontal section of a succulent melocactus the slightly formed woody zone which has its place in the midst of the softer structures is found to be strengthened here and there by fibres proceeding from the rudimentary buds on the surface of the plant, which, as Du Petit Thouars pointed out long ago, are really the roots of these buds. In point of fact these buds root themselves in the plant-mother in precisely the same way as that in which the plant-mother roots herself in the earth. And as it is with these buds so it is with all other buds, though seldom so obviously. The roots of the buds, therefore, have much to do in keeping the different parts of the plant-mother together. They act like commissures: they are, as it would seem, the only parts so acting; and this is the point to which attention is now directed particularly.

In animals, also, there are not a few facts which seem to point to the same conclusion. One and the same archetype is present in the body and in every appendicular organ belonging to it; and this archetype is so closely related to that which pervades every part of the plant, that what holds good of the plant may very fairly be supposed to hold good of the animal also. After what has been said, indeed, there is really nothing intrinsically improbable in the notion that the different layers of the vertebral and annellar zone may *bud* out at certain points into rudimentary organs, nerve-ganglia, hearts, "bodies" of vertebræ, and the like, as the case may be, and that the commissural connections of various sorts between these organs may actually correspond to the bud-roots which connect the buds with the central woody system of the melocactus. Nay the notion may be looked upon as a natural inference from the premises, for if there be a common archetypal plan for the central and appendicular parts of plants and animals it follows that each of these parts has that in it which is potentially a *root*.

And if this be so—if, that is, the bud-roots of the melocactus supply the key to the interpretation of the commissural connections in animal bodies—then the distinction between plant and animal breaks down in another very important particular, and little remains to hinder anyone from coming to the conclusion that there is one and the same archetypal plan in plants and animals. Indeed, the only hindrance of any moment that remains—the apparent absence of a visceral system in the plant—is one that may soon be disposed of.

An intelligible idea of the visceral system of animal bodies is easily attainable. The simplest manifestation of this system is that which is met with in the hydrozoic polypes—a simple sac scooped out in the substance of the body, with a single opening which is at once mouth and vent, and without any trace of visceral space or visceral organ. Next to this is the arrangement met with in the actinia—an arrangement differing from the one just named in this, that the stomachal sac is now separated from the walls of the body by a number of visceral spaces in which are the first traces of visceral organs—ovaries. Then follows the more complicated visceral system of the starfish—a system which copies that of the actinia in the main, but which differs in this, that the stomach is now provided with a vent as well as with a mouth, and also with certain large cæcal prolongations which may be stomachal or glandular or anything. After this, as in the holothuria or sea-slug, the state of things met with in the starfish is complicated by the appearance of an intestinal canal between the stomach and the vent, and by various additions which plainly show that the plan is a sketch of that which is carried out in the higher animals. So far the case is simple enough, and further it is not necessary to trace it. For if there be any connection between animals and plants in these particulars, it is likely to be found in the very lowest forms of animal life rather than in the higher. And in these very lowest forms—where the visceral system is reduced to a simple sac scooped out in the body of the animal, with a single orifice which is at once mouth and vent, and without either visceral cavity or organ—the connection with the plant is sufficiently obvious. For in reality a point is here arrived at in which the very notion of a visceral system is all but explained away. In plants, therefore, but very faint traces of a visceral system are to be expected, and a feeling of surprise is experienced when such marked traces are met with as those which are present in the sac of the pitcher plant, in the space between the armed leaves of the

Dionæa muscipula, and in certain other cases. Here, indeed, are hollows in which an actual process of digestion would seem to be carried on, for the plant is rightly believed to feed on the insects drowned in the sac of the pitcher-plant or captured and killed between the armed leaves of the Dionæa muscipula. Nor is the possession of viscera and visceral cavities an absolute peculiarity of animal bodies. In the "placenta" and seed-chamber of the fruit the ovary of animal bodies and the visceral cavity in which it is lodged would seem to be copied not inexactly; and, after all, there is but little that is really peculiar in any other of the visceral organs. The most complex gland is developed from an original of the simplest sort—a simple follicle, which again has much in common with a simple polype or a simple ciliate-cell; and the hollow, moveable, poison-fang of the serpent—which may be regarded either as a glandular follicle with the lips prolonged into a formidable weapon, or else as one of the many forms of limbs and appendicular organs—may be taken as one of many bonds of connection between the ordinary internal visceral organs on the one hand, and the ordinary external organs of the body on the other.

And thus, in plant and animal alike, distinct traces of unity are met with, not only in the primordial cell which is the common starting point of development for every part of this organism, and for the organism as a whole, but also in the manner in which development is carried out subsequently in every case.

Chapter VIII.

TRACES OF UNITY IN ORGANIC AND INORGANIC FORMS.

There are many gaps in the barrier which has been erected between the domains of organic and inorganic nature.

A very wide gap of this sort is to be found in many of the solutions with which the microscopist has had so much to do of late, for here it is often not a little puzzling to know whether certain granules may be rudiments of crystals, or of definite cellular growths like Bacteria. Indeed, the gap here is so wide, and the debateable ground on both sides so uncertain and far-reaching, as to make it more than difficult to decide where the barrier ought to be.

Even in respect of growth a crystal may have something in common with the cell. At all events, many difficulties have to be disposed of before it is possible to say that the selective power by which a crystal appropriates to itself its proper material from the mother-liquid is altogether dissimilar to that by which the cell feeds and grows upon protoplasm.

The crystal, moreover, is not necessarily bounded by sharp angles and plain surfaces. Diamonds, for example, have convex surfaces, and at times these gems differ but slightly from perfect spheres. Curvatures are constant in the grains of hail and in the plates of hoar-frost.

Oolite and pea-stone are composed of spherical granules, and, as Sir Charles Lyell points out, "in some masses of decomposing green-stone, basalt, and other trap-rocks, the globular appearance is so conspicuous, that the rock has the appearance of cannon balls." Rounded nodules of flint stone are common. The mammillated or botryoidal masses of certain ores of manganese, copper, silver, and occasionally of chalcedony, exhibit curved outlines, and lastly—to compare small things with great—satellites and planets and suns and stars are inorganic bodies of which the chief distinguishing feature is rotundity.

Of the substances mentioned, as having curved outlines, it may also be observed that some are important ingredients in organization. Carbon, the matter of which the diamond is formed, is a principal element in the constitution of living fabrics. Water, in itself, or in its separate elements, is not less indispensable: and lime and silex and iron are all necessary for the same purposes. It cannot be other than a significant fact, therefore, that these substances, when left to themselves, present crystalline forms which are partly devoid of angles. And this, too, may be noted, that the parts of the organism in which curved outlines are most conspicuous are those which, if not fluid, are *soft*, or in a condition intermediate, as it were, between fluidity and solidity. The curved shape, moreover, appertains equally to inorganic bodies when in such a state. The drops of dew and rain are rounded, and so are the drops of quicksilver and of melted metals and earth. Roundness in these cases is a consequence of the state, and it may be that the form of the cell, instead of being special and peculiar, has to do necessarily with the *condition* in which the material is found. Hence, in the matter itself, and in the condition of the matter, there is a double reason for thinking that roundness is no peculiar characteristic of organic form.

Again: instead of being solid and homogeneous crystals frequently resemble cells in the possession of internal chambers. Cavities are well known to exist in many saline crystals. Cavities, which frequently contain minute detached grains, are very common in the spherules of oolite and pea-stone. In silex, again, the condition is similar: and the well-known flint nodules are hollow egg-like stones, containing a smaller nodule, which is often so loose as to rattle when shaken. The wall of these earthy chambers, moreover, is occasionally composed of layers so arranged as to be not unlike the laminated coats of the true cell. In the granules of oolite and pisolite, for example, this arrangement is very perfect, and a polished cross-section agrees closely with that of the spine of a sea-urchin. The laminated structure, also, is seen where no cavity exists, as in the globular masses of resinous trachyte, or pitch-stone porphyry, met with in one of the small islands near Terracina or Gaieta, which when acted upon by the weather separate readily into concentric scales like those of a bulbous root.

Other and higher shapes, which seem to reflect the images of polypes and flowers and branches, are also to be found in the domain of the crystal. The flakes of snow and hoar-frost, for example, are composed of crystals arranged in such a manner as to afford no inapt likeness to the disc of the flower or polype. In stalactite pendants are often found the images of fungoid plants: and in the mammoth-cave of Kentucky Dana describes alabaster rosettes a foot in diameter, surrounded with circlets of elegant leaves, and vines with a full complement of leaves and tendrils. The moss-like appearance of the mocha-stone,—the miniature trees of hoar-frost,—the branched forms in which native silver and copper are often found, and the like appearances which so frequently occur in artificial crystalline masses, as in those of lead and silver, are other instances in which the radiating and ramifying features of organic life would seem to be shadowed forth in inorganic nature.

Nay it may be difficult to insist upon the angularity and plane surfaces of crystals as denoting an absolute distinction between the crystal and the cell, for, after what has been said, who would venture to say that the angle in the crystal has no relationship to the process in the cell, or that the plane surfaces may not be due to various extraneous circumstances, sometimes affecting the crystal and the cell equally, of which pressure may be one?

Crystals, moreover, would seem to correspond with cells of a very low type—a type lower even than that which is met with in the bone-cell, much lower. The inorganic world, indeed, may be said to be related to the organic world in a way not dissimilar to that in which the skeleton parts of plants and animals are related to the soft parts of these creatures, or rather that it occupies the still lower position of skeleton to these skeletons; and, therefore, it is to be expected that inorganic bodies will present at the best but rudimentary traces of organization, and but few indications of functional activity. It is scarcely to be expected, indeed, that these indications should be greater than those which are revealed in crystallization. And crystallization, for anything that appears to the contrary, may be a manifestation of growth—a first movement life-wards. The present question, however, is, not this, but whether the traces of unity which have been met with everywhere in organic nature are carried on into inorganic nature: and this question, as it seems to me, may be answered affirmatively without going further. Indeed, it were scarcely necessary to have gone so far, for this answer would seem to be implied in the simple fact that the matter of which the things of life are made is being continually taken from and restored to the inorganic world, the things of life, like waves in the ocean, rising and falling in the substance of the outer world rather than in any substance which is specially their own.

—— And, thus, instead of being an idle story, the metamorphoses of Proteus may be nothing less than a revelation in poetical guise of the grand truth that there is every where in nature one and the same archetypal plan.

PROTEUS:

OR,

UNITY IN NATURE.

Part II.

TRACES OF UNITY IN FORCE.

CHAPTER I.

TRACES OF UNITY IN THE VARIOUS MODES OF PHYSICAL FORCE.

IN a library where books of science are arranged with some regard to their merits a place of honour not far from that assigned to Goethe's "Die Metamorphose der Pflanzen" must be assigned to Grove's "Correlation of the Physical Forces." Each work opens out, as it were, several stages of the way along which I am bent upon travelling as far as I can. Each work is the production of a master-mind in such engineering, and, to say the least, it is difficult to think that the time will ever come in which a nearer or easier road will be opened out through the same regions.

The many stages of the road in which Mr. Justice Grove is the engineer is, not in the clouds, but on the hard ground. Throughout their entire length the one ruling idea is to discard the hypothesis of subtle, occult, imponderable entities of any sort, and to resolve the various modes of physical force which form the subject of inquiry—motion, heat, light, electricity, magnetism, chemical affinity and the rest—into correlative and mutually dependent changes in ponderable matter, which changes are themselves resolvable into modes of motion. No one of these forces, taken abstractedly, can be held to be the essential cause of the others, each one producing or being converted into another, or all the others together. Thus, "when a substance, such as sulphuret of antimony, is electrified, at the instant of electrization it becomes *magnetic* in directions at right angles to the lines of electric force; at the same time it becomes *heated* to an extent greater or less according to the intensity of the electric force. If this intensity be exalted to a certain point the sulphuret becomes luminous, or *light* is produced: it expands, consequently *motion* is produced; and it is decomposed, therefore *chemical action* is produced." Each force in relation to every other force may be looked upon as cause and effect; and it would seem to be an irresistible inference from observed phenomena that any one force cannot originate except by devolution from some pre-existing force or forces.

Simple *motion* is resolved into heat, when an anvil is beaten by a hammer, when a wheel grates upon its axle, and in a thousand other ways. Where the moving and resisting bodies are homogeneous, as when iron encounters iron, the resolution of motion is chiefly into heat, though light also often puts in a claim to be noticed, as when *fire* is the result of percussion or friction. Where the moving and resisting bodies are heterogeneous, as in the case of the ordinary electrical machine, where glass encounters the rubber coated with amalgam, motion is resolved chiefly into electricity. The resolution of motion into other modes of force is also beautifully illustrated by an original experiment exhibited by the author of the 'Correlation of the Physical Forces' in the lectures in which he first made known his views, and of which the following account is to be found, not in the work under consideration, but in the inaugural address on "Continuity," delivered by him, as president, at the meeting of the British Association held at Nottingham in 1866. "A train of multiplying wheels ended with a small metallic wheel, which, when the train was put in motion, revolved with extreme rapidity against the periphery of the next wheel, a wooden one. In the metallic wheel was placed a small piece of phosphorus, and as long as the wheels revolved the phosphorus remained unchanged ; but the moment the last wheel was stopped, by moving a small lever attached to it, the phosphorus burst into flames. My object was to show that while motion of the mass continued heat was not generated, but that when this was arrested, the force continuing to operate, the motion of the mass became heat in the particles. The experiment differed from that of Rumford's cannon-boring and Davy's friction of ice in showing that there was no heat while the motion was unresisted, but that the heat was dependent on the motion being impeded or arrested. We have now become so accustomed to this view, that the moment we find motion resisted we look to heat, electricity, or some other force, as the necessary and inevitable result." And so, to use again the author's own words, "Motion will directly produce *heat* and *electricity*, and electricity, being produced by it, will produce *magnetism* —a force which is always developed by electrical currents, at right angles to the direction of these currents. *Light*, also, is readily produced, to all appearances, by motion directly, when accompanying the heat of friction, or mediately, by electricity resulting from motion, as in the electric spark, which has most of the attributes of solar light, differing from it only in those respects in which light differs when emanating from different sources, or when seen through different media ; for instance, in the position of the fixed lines in the spectrum, or in the ratio of the spaces occupied by rays of different refrangibility. In the decomposition and composition which the terminal points proceeding from the conductors of an electrical machine develope when immersed in different chemical media, we get the production of *chemical affinity* by electricity, of which motion is the initial source. Lastly, motion may be again reproduced by the forces which have emanated from motion; thus the divergence of the electrometer, the revolution of the electrical wheel, the deflection of the magnetic needle, are, when resulting from frictional electricity palpable movements reproduced by the intermediate modes of force, which have themselves been originated by motion."

Without parallax, or relative change of position, motion is unproduceable, probably unimaginable. Motion, in short, has to do very obviously with ponderable matter. Nor is a different conclusion arrived at when *heat* is made the starting point of enquiry. At any rate the difficulty is to realize heat except as motion in a direction opposed to that of the attraction of cohesion, and made known by its action on certain nerves of sensation. With certain not unintelligible exceptions in which the question is complicated by the introduction of crystallization, polarization, dessication, &c., a body expands when heated and shrinks on cooling. This is all. The heat doing this work may be regarded as a communicable repulsive force; as a *thing* it is unknown. Certain changes of ponderable matter, for which changes heat is the generic name—these are all that are known. Even the notion of *latent* heat must be discarded with as little compunction as phlogiston. That heat will produce *electricity* is seen in the discovery of Seebeck, that when dissimilar metals are soldered together, or made to touch, and then heated at the point of contact, a current of electricity flows through the metals in one direction as long as the temperature continues to rise, and in the other direction in the contrary case of cooling. Heat and light go hand in hand continually in such a way as to suggest the notion that they are inseparable. And certainly the modes of action of radiant heat and of light are so similar, both being subject to the same laws of reflection, refraction, double-refraction, and polarization, that their difference appears to exist more in the manner in which they affect the senses than in their modes of physical action. With regard to *chemical affinity* and magnetism, perhaps, the only method by which in strictness this form of heat may be said to produce them is through the medium of electricity, the thermo-electrical current, produced by heating dissimilar metals, being capable of deflecting the magnet, of magnetizing iron, of forming and decomposing chemical compounds, and that too in proportion to the amount of heat.

Whatever else it be *electricity* is certainly an affection of matter for which electrolysis and polarization and induction are other names. There is no reason to believe that conductors, and non-conductors or dielectrics, behave differently. That a dielectric is molecularly polarized is seen in more ways than one. One way, pointed out by Matteucci, is to take a number of thin plates of mica, to arrange them like a pack of cards, to face the two outer plates externally with tin foil, to electrify one of the facings from a friction-machine, and then to separate the plates with insulating handles. When this is done it is found that each plate is separately electrified, one side of it being positive and the other negative—a result showing very conclusively a polarization throughout the whole pack of plates as the effect of induction. Another way pointed out by

Grove himself, lies through an experiment of M. Karstan, which is this. A coin is placed on a pack of thin plates of glass and then electrified. On removing the coin, and breathing on the glass plate, an impression of the coin, which cannot be removed by polishing, is perceptible. And this is not all: for, on separating carefully the glass plates, images of the coin may be developed (by breathing it is to be presumed) on each of the surfaces of each one of them—a proof that a molecular change has been transmitted through the substance of the glass, and a reason for supposing that a piece of glass or other dielectric body, if it could be split up while under the influence of electric induction, would exhibit some molecular change at each side of each lamina, however minute the subdivision. The spark, or brush, or voltaic arc, also points, with not less certainty, to a change in ponderable matter in connection with the electrical phenomenon. The colour of the light, and the lines in the spectrum, show that the material of the electrodes, or that between the electrodes, one or both, is mixed up in the phenomenon; and other considerations make it certain that this light is more than that of combustion. If it were only due to the latter cause it could not happen, as it does do, in vacuo. In point of fact the material of the electrode is volatilized. Thus: "If a voltaic discharge be taken between zinc terminals in an exhausted receiver, a fine black powder of zinc is deposited on the side of the receiver: this can be collected and takes fire readily in the air by being touched with a lighted match or ignited wire, instantly burning into white oxide of zinc. To an ordinary observer the zinc would seem to be burned twice—first in the receiver where the phenomenon presents all the appearance of combustion, and secondly in the real combustion in air. With iron the experiment is equally instructive. Iron is volatilized by the voltaic arc in nitrogen or in an exhausted receiver: and when a scarcely perceptible film has lined the receiver, this is washed with an acid, which then gives, with ferro-cyanide of potassium, the prussian-blue precipitate. In this case we readily distil iron, a metal by ordinary means *fusible* only at a very high temperature." A very good vacuum, like that which remains in a receiver after carbonic acid has been absorbed by caustic potash, will, until it becomes partly filled by the volatilization of the material of the electrodes entirely stop the discharges of a Rhumkorf coil: and a conductor of insufficient dimensions is ignited or actually fused by such discharge or by the current equally. Matter is needed for the transmission of the electricity in both these cases. The matter, too, must be in a particular state. One body is favourable to the transmission of electricity, another not. The same body may be favourable at one time and unfavourable at another: thus carbon is a good conductor in the state of graphite and a very bad conductor in the state of diamond. The transmission of electricity, that is to say, is dependent upon the presence of certain molecular conditions. In a certain part of the voltaic circuit these take that form of chemical disturbance which is known as electrolysis. Whether an analogous condition is present in other parts of the circuit is another question, but this must be conceded—that there is some material change in these other parts. Thus: a wire is fused if it be too small to allow the free passage of the current or discharge, and even in the case of a thick large wire, stretched as in the ordinary telegraph, where little or no heat may be developed by the electricity, the sonorous vibrations which attend the passage of the electricity, and the manifest diminution of tenacity when the wire has been used for some time, are only to be explained on the supposition that the transmission of the electricity is attended by some definite molecular change in the wire. And surely the shattering or burning of a house, or other imperfect conductor, by lightning, is only still more striking evidence to the same effect. The case is one, indeed, in which it is more than difficult to separate the idea of electricity from that of electrolysis. It would seem as if the hypothesis of imponderable matter were as gratuitous in one case as in the other. It would seem as if electricity had as much to do with ponderable matter, and as little to do with imponderable matter, as the force of heat or the force of gravity even. Like either of these forces it would seem to be resolvable into a mode of motion. And, certainly, there is no want of agreement between electricity and the other modes of physical force on the score of correlation. Commencing with *electricity* as an initiating force it is not necessary to go further than ordinary electrical attraction and repulsion, as seen in the electroscope, to see how the transition into *motion* is effected by a direct path. How electricity directly produces *heat* is seen in the ignited wire, the electric spark, and the voltaic arc—heat intense enough to dissipate every form of matter being given out in these instances. In these instances, too, *light* and heat are inseparably connected: and not less intimate is the direct connection between electricity and *magnetism*, for, as is shown in many familiar experiments with the coil and needle, electricity cannot pass without the generation of magnetism. And, lastly, by electricity it is possible to obtain effects of analysis and synthesis which are not to be got in any other way, and so electricity may be looked upon as becoming *chemical affinity*. In point of fact, the rule of correlation holds good with electricity no less than with the two modes of physical force which have been already under consideration—heat and motion.

Light and heat have so many points of agreement as to make it difficult to conceive of disagreement in their relation to matter. "Gases which have transmitted light are altered, *e.g.*, chlorine rendered capable of combining with hydrogen, liquids are altered, per-oxalate of iron is chemically changed and gives off carbonic acid, and the light which had produced this effect is less able to produce them a second time. Solids are altered as is shown in the extensive range of photographic effects." Fluorescence and phosphorescence may also be reckoned as light writing itself as light upon material bodies, and remaining legible for some time. The luminosity is evidently connected with some material change wrought by light, and not passing off at once. Sometimes, as in the case of the soap-bubble, iridescence has something to do with varying degrees of thickness in the transparent film or plate upon which the ray of light impinges, a given degree of thickness being connected with a given colour: and always the *colouring matter* of plants may be held to point to a material foundation laid by the light. Light too cannot act upon certain liquids and gases without producing those very unmistakeable and intelligible material changes which are distinguished as chemical. Thus, hydrocyanic acid throws down a solid carbonaceous deposit, and is partly decomposed in some other ways, when left exposed to white light: and thus again, a mixture of chlorine and hydrogen, which remains unaltered in the dark, soon becomes hydrochloric acid in the light. As is seen in this and many other instances it is more than difficult to de-materialize the notion of light. The case of light, indeed, does not seem to differ much from that of heat. Nay it does not follow that the passage of light through extra-mundane space can be appealed to as a proof that light is something independent of matter. For who can say that such space is a vacuum in the strict sense of the word? Matter, there is every reason to believe, is diffusible to a degree which passes conception, and the best vacuum is only a plenum from which some, perhaps not very many, of the more solid particles have been taken. The Torricellian vacuum over the column of mercury in the tube of the barometer is not devoid of mercury: and it is difficult to regard the case of this vacuum as in any way peculiar in its relation to a plenum. Indeed, until it is possible to assign limits to the diffusibility of matter it seems necessary to believe that cosmical space is not matterless even when most empty of matter—that in this very place, with sufficiently delicate tests, might be detected unequivocal traces of every material body in the universe, planet, or sun, or star, great and small, one and all. Nor does the extreme velocity of light present any valid objections to this notion. For, as is shewn by the rate at which electricity traverses a metal wire — a case where each particle of matter is undoubtedly affected—electricity *can* travel with equal or even greater velocity; and not only so, but—as is proved by Mr. Latimer Clarke in some experiments when the wire used was 760 miles in length—electricity agrees with light and also with sound, in travelling (provided the effects of lateral induction be the same) at the same rate of velocity whatever be its intensity. Indeed, for anything that appears to the contrary, light may be a mode of motion in ordinary matter, which has nothing to do with anything imponderable, be this luminous ether, or any other agent of like nature. Or perhaps the residual idea is that of motion rather than matter, in which case the view taken approximates to that which supposes light to be some peculiar rare matter emitted from, that is, put in *motion* by, luminous bodies, as well as to that other view, which is now in favour, and which differs in this, that this peculiar rare matter is supposed to be, not emitted, but put into a state of vibration or undulation, that is *motion*, by these bodies. Between these views there is agreement so far as the resolution of light into motion is concerned, and no great disagreement even beyond this point, for the material basis of the more materialistic view now under consideration is in fact rarefiable until it is all but matterless. Be this as it may, however, there is one argument in favour of the materialistic view which can scarcely be shaken, and this is to be found in the facts which go to show that light is inseparably connected with the other modes of physical force by ties about the existence of which there can be no doubt, even those of correlation. Upon this point much might be said in the way of proof, but one proof which Grove himself supplies, must suffice. "A prepared daguerreotype plate is inclosed in a box filled with water, having a glass front with a shutter over it. Between this glass and the plate is a gridiron of silver wire; the plate is connected metallically with one extremity of a galvanometer coil, and the gridiron of wire with one extremity of a Brequet's helix—an elegant instrument formed by a coil of two metals, the unequal expansion of which indicates slight changes in temperature—the other extremity of the galvanometer and helix are connected by a wire, and the needles brought to zero. As soon as a beam of either daylight, or the oxyhydrogen light, is, by raising the shutter, permitted to impinge upon the plate, the needles are deflected. Thus, *light* being the initiating force, we get *chemical action* on the plate, *electricity* circulating through the wires, *magnetism* in the coil, *heat* in the helix, and *motion* in the needles."

There are many facts which seem to connect *magnetism* with a particular state of matter. One of these is to be found in a beautiful experiment by the author of the Correlation of the Physical Forces, of which this account is given, "A tube filled with the liquid in which magnetic oxide of iron had been prepared, and terminated at each end by plates of glass, is surrounded by a coil of coated wire. To a spectator looking through this tube a flash of light is perceptible whenever this coil is electrized, and less light is transmitted when the electrical current ceases, showing a symmetrical arrangement of the minute particles of magnetic oxide while under the magnetic influence. In this experiment it should be borne in mind that the particles of oxide of iron are not shaped by the hand of man, as would be the case with iron filings, or similar minute portions of magnetic matter, but, being chemically precipitated, are of the form given them by nature." Another fact, scarcely less striking, is to be found in the action of a magnet upon a ray of polarized light. If this ray be passed through a column of water or any other transparent liquid or solid which is equally incapable of deflecting the plane of polarization, in a direction which corresponds to the line of magnetic force—the line, that is, which unites the poles of the magnet—the column acquires, with reference to the light, the property belonging to oil of turpentine and certain other bodies, of rotating the plane of polarization, to the right if the ray pass along the line of magnetic force from the north pole to the south, to the left in the contrary case; or if the substance through which the ray be transmitted be, like turpentine, itself capable of deflecting the plane of polarization, then the magnetism, according to its direction, increases or diminishes this rotation. Material change in connexion with magnetism is also made evident in the altered dimensions of a bar of iron in passing to or from the magnetic state, as well as in the loss of magnetism which is caused by beating or twisting or heating a magnetized rod of steel; and there are other facts which seem to show that this material change has in it something of chemical nature. One of these may be found by seeking for it in the composition of magnetic oxide of iron, for here is a substance which is apparently magnetic *because* in it two oxides are mixed together in certain proportions. The magnetic oxide is made by *mixing* the two non-magnetic oxides, and, therefore, this fact may not suffice to connect magnetism with material changes of a chemical nature: and certainly it does not do this so closely as a fact supplied in an experiment of which this account is given by Grove. "If a battery of one cell, just capable of decomposing water and no more, be employed, this will cease to decompose while making a magnet. There must, in every case, be preponderating chemical affinity in the battery cells, either by the nature of its elements or by the reduplication in series, to effect decomposition in the voltameter; and if the point is just reached at which this is effected, and the power is then reduced by any resistance, decomposition ceases; were it otherwise, were the decomposition in the voltameter the exponent of the entire force of the generating cells, and these could independently produce magnetic force, this latter force would be got from nothing, and perpetual motion be obtained." The whole history of static magnetism, moreover, can be scarcely said to point beyond matter. This force becomes an initiating force when associated with motion, that is, when it is rising or falling, or when a magnetized body is moved in the neighbourhood: but not otherwise. It does not differ from the other physical forces in this respect, for each of these has to be initiated in some way: and it certainly agrees with them in having a title to membership in the same brotherhood, and this the same title, for as is shewn in so many different magneto-electric contrivances, when *magnetism* is associated with *motion*, *electricity* is at once developed, with *heat* and *light* and *chemical affinity* and *motion* in its train.

It is difficult not to look upon *chemical affinity* as a mere mode of molecular attraction between dissimilar substances. There is nothing about it to make it necessary to call in the aid of any mysterious imponderable entity: there is much about it to make it certain that it agrees with the other physical forces which have been under consideration in being subject to the same rule of correlation. What is called voltaic electricity might, perhaps more appropriately, be called voltaic chemistry. A proportionate and equivalent electrical effect is always produced by a given amount of chemical action: and if this action be only turned in a given direction, as in the voltaic battery, the idea of chemical affinity merges in that of electricity, and, once developed, this electricity in turn becomes magnetism, and heat and light and motion and chemical affinity again. The correlation is as comprehensive as it can be, no one single force being left out in the cold. The case is merely a repetition of the other cases, in each of which one of the physical forces has in turn been taken as the starting point of enquiry.

Much, however, remains to be done before the subject is exhausted. Much, very much—more a good deal than is set forth in the broad *resumé* of the argument which has been given—has been done by the author of the Correlation of the Physical Forces, but not all. It is left undecided, in particular, whether the view propounded is of universal or only of partial application—whether cosmical physical forces, light, heat, electricity and the rest, are reducible to the same rule. What then? It is, I think, scarcely possible to come to an absolute decision upon this point yet. At the same time, without closing my eyes, I cannot help seeing that even now, there is some reason for widening the sphere of the correlation in question until it is co-extensive with that of the physical universe.

It is difficult to regard the heat of the solar ray as a distinct force: it is less difficult to regard it as a modification, brought about under particular circumstances, of some other force. In distant space this ray is coldness itself: and the simple fact appears to be that it acquires heat in its transmission through the atmosphere chiefly. Indeed, the case is one which agrees very well with the notion that heat may be correlated with the force of gravity, or some other force, and that heat is evolved out of this force by the resistance of the atmosphere just as heat is evolved out of electricity, by the resistance of an insufficient conductor.

And as with the heat of the solar ray so with the light. This ray is invisible unless it be intercepted in its passage by some material object, and in distant space, for anything that appears to the contrary, it may be as lightless as it would seem to be heatless, the force of gravity, perhaps, being there all in all. And if so then light must be regarded, not as a separate entity, but as some other force modified under particular circumstances. Indeed, there is no very obvious reason why all that has been said of heat may not be said equally of light, and why heat and light and the force of gravity should not be held to be, not distinct forces, but correlated aspects of one and the same force.

So too with that working of the solar ray which displays itself in the direction of chemical affinity. It is scarcely possible to think even of referring this to any distinct force: it is not difficult to believe that it may have to do with light or heat, or with the force of gravity, as an altered mode of motion, and nothing else. At all events, there can be no possible reason for thinking that any valid objection to the doctrine of correlation is to be found in the way in which chemical affinity is related to the solar ray.

Nor is this conclusion at variance with the facts which have yet to be considered.

The investigations of the last few years have brought to light certain fluctuations and oscillations in atmospheric electricity which are full of interest in the present enquiry. Every day there are two maxima and two minima of potential, one maximum between 8 A.M. and 11 A.M., the other between 7 P.M. and 11 P.M., one minimum between 3 P.M. and 7 P.M., the other between 11 P.M. and 3 A.M. Atmospheric electricity, in fact, exhibits tidal movements closely corresponding with those to which the barometer bears witness, and pointing not less unequivocally to the action of the sun and moon upon the earth. Moreover, the fact that the under and upper surfaces of the atmosphere are in opposite electrical conditions may serve to bring out the same action even still more prominently, for, as Sir Wm. Thomson points out, this fact is readily accounted for by supposing that the atmosphere is a dialectric across which the earth and sun and moon act and react upon each other inductively, and that the necessary consequence of this reaction is to charge the two surfaces of the atmosphere to a certain depth with opposite electricity. The facts, without question, lend themselves readily to this view: and there is nothing at all forced in the view itself. It is difficult also to avoid the conclusion that what appears as atmospheric electricity at one time appears as atmospheric heat at another, and vice versâ, the heat and the electricity being, in fact, inseparably correlated. For, to mention only one among many other reasons for so thinking—a reason, too, to which attention has not yet been directed sufficiently—it is surely a significant fact that the electricity and heat of the air are inversely related to each other in the summer and winter months, the potential being lower and the temperature higher in the summer months, the temperature being lower and the potential higher in the winter months. And if these be the relations between electricity and heat it is not very likely that the relations between electricity and light will be different: for heat and light are so closely related as to make it all but certain that what may be said of the one may be said of the other also. Nor is it a matter of indifference whether it be so or not, for if it be so it is necessary to take a very different view of light and heat to that usually taken, and to regard them as originating, not in the sun solely, but in an action in which the earth also is concerned—an action, it may be, of the nature of induction. It is necessary, that is to say, to assimilate natural light and heat to electric light and heat. There is, as it seems to me, no escape from this conclusion if the doctrine of the correlation of the physical forces be universally applicable: and, therefore, the only question is as to the value of the evidence in support of the soundness of the doctrine. And certainly I see no reason so far to underrate the value of this evidence.

About terrestrial magnetism it is less easy to come to any conclusion beyond this—that electricity and magnetism must stand or fall together. Electricity in motion must generate magnetism, and, vice versâ, magnetism in motion must generate electricity. This rule, however, would seem to fail when it is applied to the explanation of terrestrial magnetism. Here the magnetism is an obvious phenomenon, but where are the constant electric currents which ought to pass at right angles to the magnetic plane? There are vague and partial and inconstant currents, and that is all. Indeed, there seems to be no escape from this dilemma except it be that the currents in question are masked, partly by passing in a closed circuit through a very ample and excellent conductor, and partly by being transformed into motion or some other mode of force, and that, after all, the magnetism itself may be the only possible manifestation of the currents under the circumstances.

More than once in the course of these remarks it has been hinted that the force of gravity may be obedient to the law of correlation about which so much has been said, but here again the subject is beset with difficulties which are not easily disposed of. By the force of gravity all material bodies, quite irrespective of their molecular condition, are supposed to attract each other proportionately to their mass, and inversely as the square of their distance. The law is that of any other attractive force, but the force itself is held to be independent.

The idea is one which excludes anything like that of correlation with electricity or any other force—which has nothing whatever to do with any change of the nature of induction more especially, for if it had it might be difficult to avoid the conclusion that the force of gravity is in some way connected with a force of repulsion, and that there might be a very intimate connexion between electro-magnetic movements and those movements in the production of which the force of gravity is held to have so much to do. These are questions, however, which may perhaps be entertained at the end of this volume in a supplement, but which are out of place now, where it must suffice to have noticed that the force of gravity is obedient to the same law as that which rules all other attractive forces, and that it seems to be correlated with light and heat and chemical affinity and electricity and magnetism in the very closest manner.

More might easily be said upon the correlation of the physical forces, but not without venturing further than I am prepared to go: and I therefore bring my remarks to a close abruptly by simply saying that the idea of unity underlies that of correlation, and that, so far as I can see, the two ideas must stand or fall together.

Chapter II.

TRACES OF UNITY IN VITAL AND PHYSICAL MOTION.

On several occasions during the last five-and-twenty years I have attempted to show that a radical change is necessary in the doctrine of vital motion—that, in fact, vital motion is to be regarded as a mode of physical motion. The argument is too long and complicated to allow of justice being done to it in the short space at my disposal. Indeed, all that I can now do is merely to refer to my last publication on the subject,* for everything in the shape of demonstration, and to reproduce, with a few omissions and additions, what is there said by way of introduction, and to give a brief *resumé* of the argument—to do as much as may be necessary (and no more) to state the case, and to show broadly how I have ventured to deal with it.

I.

More than five-and-twenty years ago my faith in all that I had been taught to believe about vital motion received a rude shock in this way. I happened to be present at an experiment in which a rabbit was killed by injecting a solution of strychnia under the skin; I watched the strong cramps produced by the poison, and

* "Vital Motion as a Mode of Physical Motion." Post 8vo. Macmillan, 1876.

wished again and again for death to come and put an end to them: I was amazed to find that the spasm seemed to keep firm hold *in spite of death:* I had to wait until the evening of the fourth day after death, when putrefaction had evidently set in, before any unmistakeable signs of muscular relaxation were to be detected. The animal, when the spasms were at their height, stood tip-toe on its up-stretched hind legs, leaning against a hamper which happened to be within reach, pawing the air, and with the body arched backward until the ears lay over the scut—a rampant position from which it must have fallen down at once if the muscular contraction had yielded for a moment to relaxation ; and yet it did not so fall until the muscles were softened by putrefaction. This is what I witnessed. It seemed as if the spasmodic rigidity which existed before death had passed without any interval of relaxation into the cadaveric rigidity which always comes on, sooner or later, after death, and which is only relaxed by the actual decomposition of the muscular tissue. It seemed as if the spasm had passed at once into *rigor mortis.* At first all my prejudices were against such a notion ; in the end, I came to believe, most unhesitatingly, that a radical change was necessary in the doctrine of vital motion,—that the interpretation of spasm was to be sought, not on the side of life, but on that of death, that spasm and *rigor mortis* were to be regarded, not as signs of vital action in certain vital properties of contractility, but as physical phenomena akin to, if not identical with, the return of an elastic body from a previous state of extension,—that muscular contraction in all its forms might be the simple consequence of the operation of the natural attractive force or forces inherent in the physical constitution of the muscular molecules,—that life is concerned in antagonizing contraction rather than in causing it,—that this antagonizing influence itself might have a physical basis,—that, in short, vital motion might have to be regarded as a mode of physical motion.

And yet more did this conviction grow in strength on the food supplied by two other facts to which my attention was called at a later period.

Of these two facts the first was brought to light in an epileptic patient in whom it had been thought expedient to try and cut short a succession of very violent convulsions by taking blood from the temporal artery. The artery was divided when the fit was at its height, and the blood escaped by jets in the usual way, but not of the usual colour. Instead of being *red*, the blood was *black;* instead of being *arterial*, that is to say, it was *venous*. The state during the convulsion was evidently that of suffocation; and, on this account, black unaërated blood had found its way into the arteries, and was being driven through them at the time. The case was intelligible enough as regards the *suffocation*, for in this state the simple fact is, that black blood does for a time penetrate into and pass along the arteries; but it was not intelligible as regards *convulsion*, if convulsion were, as it is assumed to be, a sign of exalted vital action. I could connect such exaltation with increased supply of *red* blood to certain nerve-centres, but not with the utterly contrary state of things involved in the actual circulation of *black* blood; and, do what I would, I could see no other conclusion than that which had been already forced upon me by the history of the poisoned rabbit, namely this, that the convulsion pointed to a state of things which had to do with death rather than with life,—that, in short, this state of muscular contraction was due, not to the *black* blood having acted as a stimulus, but to the withdrawal of an *inhibitory* influence which had served to keep up the state of muscular relaxation as long as certain nerve-centres were duly supplied with *red* blood.

And so likewise with the second of the two facts to which I have alluded. I had the good fortune to be present on one occasion when Matteucci was watching the action of strychnia upon the common electric ray of the Mediterranean. I saw very plainly that this action was marked by involuntary electric shocks as well as by involuntary spasms, and I was much struck by what was said by this excellent physiologist in support of the notion that muscular contraction was attended by a discharge analogous to that of the torpedo, and that there was much in common between the action of the electric organ and the action of the muscles: and, so seeing and hearing, I could not help wondering whether muscular relaxation might not be the consequence of the muscular molecules being kept in a state of mutual repulsion by the presence of an electrical charge, and whether the discharge of this charge might not bring about muscular contraction by allowing the attractive force or forces inherent in the physical constitution of the muscular molecules to come into play. I could, indeed, bring myself to adopt no other conclusion than this: and thus it was that this experiment upon the torpedo proved to be the means of adding not a little strength and definitiveness to the conviction at which I had already arrived respecting vital motion.

Looking back, I can now see plainly enough that there are not a few faults and shortcomings in the argument by which hitherto I have hoped to bring others to the same way of thinking with myself in this matter. About the first published statement* of this argument, I may say, in the words of Dryden, that it was 'only a confused mass of thoughts tumbling over one another in the dark, when the fancy was yet in its first work, moving the sleeping images of things towards the light, there to be distinguished, and then either chosen or rejected by the judgement:' and, most certainly, no feeling of complacency is called up by the remembrance of any other statement published subsequently†‡§. I should, in fact, be very glad if much that I have written on this subject at different times could be cancelled.

What has been done, however, has been done, and all that I can do is to express the hope that anyone who chooses to interest himself in this matter will do me the justice to take nothing short of what is stated in my last work ‖ as a sufficient statement of the case of vital motion as it now stands.

The history of vital motion reveals sundry changes of opinion about which it is expedient to know something before proceeding further.

In the days of Thales—beyond which it is difficult to go back—any movement would seem to have been referred to a living being of some sort with which the

* "Philosophy of Vital Motion." 8vo. Churchill, 1851.

† "Epileptic and other Convulsive Affections of the Nervous System." (Incorporating the Gulstonian Lectures for 1860.) 3rd edition. Post 8vo. Churchill, 1861.

‡ "Lectures on certain Diseases of the Nervous System." Delivered at the Royal College of Physicians. Post 8vo. Churchill, 1864.

§ "Dynamics of Nerve and Muscle." Post 8vo. Macmillan & Co., 1871.

‖ "Vital Motion as a Mode of Physical Motion." Post 8vo. Macmillan, 1876.

moving thing was supposed to be *possessed* at the time.

Hippocrates believed in the universal presence of a living, intelligent, active principle, to which he gave the name of *nature* (φύσις), and to him, as to many in the present day, it was enough to refer motion to *nature*—to regard it as *natural*. The power of motion, indeed, was one of the faculties with which the principle of nature was endowed.

Plato says little to the point. With him science merged in philosophy and theology; to him vital motion, and motion generally, when traced to its source, resolved itself into a display of divine power.

Aristotle, the great contemporary of Plato, recognized, not a Divine Being as Plato did, but a *First Moving Cause*, a *primum mobile*, one in essence, eternal, immaterial, at once immoveable, and the spring of all movement. According to him, this First Moving Cause worked in the living body (ζῶον) through the instrumentality of a principle which was distinctive of this body, and to which he gave the name of soul (ψυχή)—a principle possessing various energies or faculties of its own, distinct from the organs in which it was manifested, and yet requiring these organs for its manifestations. To this soul, when most developed, belonged several faculties (δυνάμεις)—the faculty of receiving nourishment (δύναμις θρεπτική), the faculty of sensation (δ. αἰσθητική), the faculty of motion in place (δ. κινητική), the faculty of impulse or desire (δ. ὀρετική), the faculty of intelligence (δ. διανουτική). Vegetables even, by having the lowest of these faculties, the threptic, were supposed to have souls. Moreover, it is hinted that the seat of this kinetic faculty in animals is in the muscles, and that—a conjecture for which Praxagoras, who lived two hundred years previously, ought to have credit—there were nerves, some of which had to do with movement and others with sensation. Nay, it is scarcely just to speak of the localization of the kinetic faculty in the muscles as being only hinted at, for this was the definite conclusion at which Aristotle arrived after witnessing the working of the intercostal muscles of a living chameleon as displayed under the transparent pleura.

After this time, for a thousand years and more, when anything was done in this direction it was little beyond a servile copying of what had been said by Hippocrates and Aristotle. Even Galen had nothing to say that was really new; nor yet the schoolmen of the middle ages, with many of whom the notions chiefly in the ascendant were those of alchemy and magic and astrology. At the revival of letters, indeed, the only light of importance was that derived from the old Greek fathers in science; and at the end of this epoch no new light had arisen to dissipate the darkness. No new light, for instance, was shed by the doctrine of occult causes which found most favour in these times—that there were elementary spirits, intermediate between material and immaterial beings, in the four elements of air, water, fire, and earth—sylvans or fairies in the air, nymphs and undines in the water, salamanders in the fire, gnomes, trolls, pigmies, spirits of the mine, little folks, little people, cobolds, in the earth,—that the body had its double or dæmon, called Archæus, whose primary function was to superintend the work of the stomach, and who managed the various functions of the body, that of motion included, through the instrumentality of a legion of underling deputies undignified by any distinctive names.

Indeed, it was not until Von Helmont, Stahl, and Hoffman appeared on the scene that the notions handed down from the ancients began to be materially modified, and to take the forms belonging to modern times.

With Paracelsus, Von Helmont held that the Archæus and its underlings were the agents in all vital manifestations, but he also thought for himself a little, for to him belongs the credit, if credit it be, of being the first to maintain that the living body had powers of a specific character altogether different from those belonging to inanimate nature.

Accepting the doctrine that there was one law for animate and another for inanimate nature, Stahl went further, and maintained that matter is essentially and necessarily passive and inert, and that all its active properties or powers are derived from a specific and immaterial animating principle imparted to it—a principle to which he gave the name of *anima*. The body, he held, as body, has no power to move itself. All vital motion is the result of animation. The physical powers of matter, which have only free play after death, are in every way opposed to, and controlled by, the *anima*, of which he further says, as the followers of Hippocrates said of *nature*, that "it does without teaching and without consideration what it ought to do;"—a remark which makes it evident that the *anima* of Stahl is not to be confounded with the conscious personal Archæus of Paracelsus and Von Helmont.

What Stahl explained in this way, Hoffmann, who took the next noticeable step in advance, explained on the hypothesis of *nervous influence*, or *nerve-fluid*, whatever that may mean. By this influence or fluid, according to him, the moving fibres have a certain power of action, or tone, which may be increased or diminished. If increased unduly, spasm is the result: if decreased, atony.

Next in order have to be named Glisson, Haller, and *the* Brown, known as the author of the Brunonian system of medicine, men whose speculations form the basis of the doctrine of vital movement now in favour.

Glisson, an eminent professor at Cambridge in his day, was the first to advance the present doctrine of *muscular irritability*. He asserted that there was in muscle a specific vital property, to which he gave this name, and that contraction was due to this property being in some way put in action.

Haller expanded this idea, and drew for the first time a line of distinction between the special vital property of muscle and the special vital property of nerve. He retained the name of irritability for this property in muscle; he gave the name of sensibility to this property in nerve. Each property was something vital, something departing at death, and therefore in nowise akin to any power in inanimate nature. The property was a *life* of which muscular contraction and nervation were *acts*.

Brown, starting from this point, added another idea—that of *stimulation*. Everything acting upon the vital property of irritability or sensibility (to which he gave the common name of *excitability*), according to him acted as an excitant or stimulus. Action is caused by a process of stirring-up, as it were, the capacity for action being asleep, or at rest, until it is so stirred-up. The idea would seem to be none other than that all vital movement in its nature is identical with that which is produced by teasing a sleeping man until he wakes up and strikes about him in anger.

And this doctrine of vital motion, which thus took form in the speculations of Glisson, Haller, and Brown, is, with little change, the doctrine at present in favour.

In point of fact, the position taken at present has but little shifted since the days of the schoolmen, when occult qualities of one kind or another were thought to be a sufficient explanation for everything—when, for example, terreity, aqueity, and sulphureity, the occult qualities of the three elements, earth, water, and sulphur, of which, in varying proportions, according to Paracelsus, all bodies are composed, were supposed to account for all that was general in these bodies,—when Petreity was thought to be a sufficient explanation of the peculiarities distinguishing Peter from Paul or other men,—when the answer of Argan* to the question, 'quare opium facit dormire,' in the mock examination for the diploma of physician, would have been listened to without a smile if it had been given in sober earnest before the examiners of a real faculty of medicine :—

> Mihi a docto doctore
> Demandatur causam et rationem *quare*
> Opium facit dormire.
> Et ego respondeo
> *Quia* est in eo
> *Virtus dormitiva*
> Cujus est natura
> Sensus assoupire.

For in referring vital motion to a property of irritability, what more is done than to say, that the moving body moves because it is actuated by an occult quality which is suspiciously akin to terreity, aqueity, or sulphureity, or to Petriety, or to the 'virtus dormitiva' of opium in the comedy? 'To tell us,' as Newton said, 'that every species of thing is endowed with an occult specific quality is to tell us *nothing*.' Even to say that the phenomenon is *vital*, is, as Whewell remarks, 'very

* Molière "La Malade Imaginaire :' 3ième intermède.

prejudicial to the progress of knowledge by stopping enquiry *by a mere word*.' Moreover, the very assumption upon which the doctrine in question is based—that vital motion is altogether distinct from physical motion —is itself not altogether satisfactory. 'At the best,' as Coleridge says,* 'it can only be regarded as a hasty deduction from the first superficial notions of the objects that surround us, sufficient, perhaps, for the purpose of ordinary discrimination, but far too indeterminate and diffluent to be taken unexamined by the philosophic enquirer. * * * * By a comprisal of the *petitio principii* with the *argumentum in circulo*—in plain English, by an easy logic which begins by begging the question, and then, moving in a circle, comes round to the point where it begins—each of the two divisions has been made to define the other by a mere re-assertion of their assumed contrariety. The physiologist has luminously explained y + x by informing us that it was a somewhat that is the antithesis of y — x, and if we ask what then is y — x, the answer is, the antithesis of y + x;—a reciprocation that may remind us of the twin sisters in the fable of the Lamiæ, with one eye between them both, which each borrowed from the other as either happened to want it, but with this additional disadvantage, that in the present case it is, after all, but an eye of glass.'

At the time of Paracelsus the facts of chemistry began to occupy a large share of the attention of philosophers, and soon afterwards a school, called the iatro-chemical school, propounded various physiological doctrines founded upon chemistry. The opposition of

* "Hints towards the Formation of a more Comprehensive Theory of Life." By S. T Coleridge. Ed. by Dr. Seth B. Watson. Churchill, 1848.

acid and alkali, and the workings of ferments of one kind or another, were supposed to supply the solution of many problems in vitality. Then came the hope, kindled naturally by the splendid discoveries of Galileo and Newton in physical science, that the mechanical principles of the macrocosm would supply the key to all requiring interpretation in the microcosm—a hope which called into existence the so-called iatro-mathematical or mechanical physiologists. The question was of the cohesion, the attraction, the resistance, the gravity, which operate in inert matter, and of mechanical impulse and elasticity, not of powers of a higher order. It was believed that all the various bodily functions were problems to be solved, as so many hydraulic or hydrostatic problems chiefly, partly by gravitation and the laws of motion, and partly by chemistry, which itself, as far as its theory was concerned, was but a branch of mechanics, working exclusively by imaginary wedges, angles, and spheres. The restoration of ancient geometry, aided by the modern invention of algebra, had placed the science of mechanism on the philosophical throne. It was thus, for example, that Borelli dealt with the problem of muscular motion, and after him Bellini.

As far back also as the time of the great Bacon, Gilbert had struck out a new path in the same direction, the following out of which has led to more satisfactory results than any of those arrived at by the intro-mathematical school in their own particular lines of enquiry. He had investigated the phenomena of magnetism with much success, and, by continually poring over this subject, had come to believe that magnetism supplied the key to vital movement, and to vital and physical problems in general; but his speculations bore little or no fruit, and are chiefly of interest as being the first step in an inquiry which did not really begin until two hundred years later, when an event occurred in a house in Bologna which marks the birth of a new epoch in the philosophy of vital motion, and on which it may be well to dwell for a moment or two. The house is in the Via Ugo Bassi, gia Strada Felice. The event is commemorated on a marble slab over the doorway in these words :—

LUIGI GALVANI
in questa casa
di sua temporaria dimora
al primi di settembre
dell' anno MDCCLXXXVI
scoperse dalle morte rane
LA ELETTRICITA ANIMALE
Fonte di maraviglie
a tutti secoli.

The actual event was this. Experimenting with an ordinary electrical machine at no great distance from a plate on which lay a number of frogs' legs prepared for cooking, and noticing that these legs jumped whenever he drew a spark from the prime conductor, it occurred to Galvani that the parts which had been intended simply as a dish for dinner might be made to do good service as electroscopes in some experiments on atmospheric electricity in which he was then engaged. Thereupon, he and his nephew Camillo Galvani, who happened to be his companion at the time, ascended to a belvedere which served the purpose of an electrical observatory, and at once proceeded to put the idea in practice. It was expected that the limbs which had jumped in obedience to discharges of franklinic electricity might also jump in obedience to discharges of atmospheric electricity; and in order to see whether they would do so or not, they were suspended, by means of small hooks of iron wire, upon certain iron bars or stays which stretched horizontally across the chords of the arched openings by which three sides of the belvedere were pierced. The time was a calm and cloudless evening in which there seemed to be little chance of meeting with any of the latter discharges; and yet the limbs were found to jump whenever the iron hooks by which they were suspended were pressed upon by the finger, and not unfrequently when they were let alone. Describing what happened, Galvani says, 'Ranas itaque consueto more paratas uncino ferreo earum spinali medulla perforata atque appensa, septembris initio (1786) die vesperascente supra parapetto horizontaliter collocavimus. Uncinus ferream laminam tangebat: en motus in rana spontanei, varii, haud infrequentes. Si digito uncinulum adversus ferream superficiem premeretur, quiescentes excitabantur, et toties ferme quoties hujusmodi pressio adhiberetur.'* The house, the wooden flight of steps leading from the principal staircase to the belvedere, the belvedere itself, the iron bars upon which the limbs were suspended, are still there, or were there the other day when I made a pilgrimage to the spot; and even the presence of Galvani himself may be recalled by the help of a portrait which hangs in the open landing upon the wall facing the locked entrance to the stairs leading to the belvedere. In this place, and in this way, was the discovery made which is commemorated on the slab in the front of the house as the well-head of wonders for all ages, 'fonte di maraviglie a tutti secoli,' and of which, a short time before the close of the last century, the illustrious author of *Cosmos* wrote, 'le nom de Galvani

* "De Viribus Electricitatis in motu musculari Commentarius," 1791.

ne périra point; les siècles futurs profiteront de sa découverte, et, comme le dit Brandes, ils reconnaîtront que la physiologie doit à Galvani et à Harvey ses deux bases principales.'* At this time, then, and in this place, Galvani saw the contractions he describes, and discovered or rather divined, in them the existence of animal electricity. How, he asked himself, were these contractions to be accounted for? They could not be due to discharges of atmospheric electricity, for the sky at the time presented no indications of electric disturbance: they could not be due to the discharges which gave rise to them within the house, for the electric machine, which remained behind, was then at rest: they could not be due, that is to say, to discharges of either of the two kinds of electricity then known; and having arrived at this point, he jumped from it to the conclusion, that the limbs themselves must have an electricity of their own, and that the contractions were brought about by discharges of this electricity. It never occurred to him to doubt that electricity was the agent at work in causing these contractions: and, in short, he did not hesitate to conclude, not only that the contractions were in themselves abundant proof of the existence of animal electricity, but also that the muscular fibres are charged during rest as Leyden jars are charged, and that muscular contraction is the sign and effect of the discharge of this charge, the discharge, in one way or another, being brought about by an electrical action of the nerves upon the muscles.

From this time until the day of his death, Galvani went on performing experiment after experiment, sacri-

* "Expériences sur le galvanisme, et en général sur l'irritation des fibres musculaires et nerveuses." F. A. Humboldt. Traduit par J. F. N. Jadelot. 8vo. Paris, 1799, p. 361.

ficing hecatombs of frogs, and never wavering in his belief in the existence of animal electricity, or in the conclusion he had come to respecting the action of this electricity in vital motion: but during his lifetime he was destined to be foiled in his hopes to bring others to the same mind with himself, and that too by a weapon which lay hid in one of his own experiments. The experiment in question was one in which a galvanoscopic frog* was thrown into a state of momentary contraction by placing a conducting arc, of which one-half was silver and the other half copper, between the lumbar nerves and the crural muscles. Galvani, as was his wont, explained these contractions by supposing that the conducting arc had served to discharge animal electricity, and that the contractions were the result of the discharge. Volta, on the other hand, was of opinion that the electricity producing these contractions originated in certain reactions between the silver and copper portions of the conducting arc; and he was not shaken in this view by what he did afterwards, for, wishing to confirm it, he began a series of investigations which ended in the discovery of the voltaic pile and battery—a discovery which filled all minds with wonder, and for a long time afterwards diverted attention altogether from the consideration of the claims of animal electricity. In the meantime, however, while Volta was demonstrating the existence of that electricity which originates in the reaction of heterogeneous bodies, and which is now known as voltaic electricity, Galvani continued his search after animal electricity, and made many important discoveries as he went along. He dis-

* The *galvanoscopic frog* was prepared from the hinder half of the animal, by stripping off the skin, and dissecting away all the parts between the thighs and the fragment of the spine except the principal nerves.

covered, among other things, that a galvanoscopic frog would contract without the help of a conducting arc composed of heterogeneous metals. He discovered, not only that these contractions would happen when this arc was composed of a single metal, but also that an arc composed of muscle or nerve would answer the same purpose as the metallic arc. He also discovered that the limb of a galvanoscopic frog, of which the nerve had been divided high up in the loins, would contract at the moment when the end of the nerve below the line of section was brought down and made to touch a part of the trunk of the same nerve. At last, indeed, he hit upon an experiment in which he seemed to have to do with an electricity other than that arising from the reaction of heterogeneous bodies—an electricity which must belong to the animal tissues themselves. He did much, but he did not do enough to win the battle in which he was engaged, for Volta still kept his position, denying the existence of animal electricity, and maintaining that the electricity which produced the contractions in the galvanoscopic frog was always due to electricity arising in the reaction of heterogeneous bodies of one kind or other—silver and copper, metal and organic tissue, muscle and nerve, nerve in one state with nerve in another, as the case might be.*

In 1799, Humboldt took up the question at issue between Galvani and Volta, and published a work† in which he shows by many new and curious experiments that there was error on both sides—that Volta was wrong in ignoring altogether the influence of animal electricity in Galvani's experiments, and that Galvani was not less wrong in recognising nothing but this in-

* "Ann. de Chim.," T. xxiii, pp. 276 and 301.

† Op. cit.

fluence. He, himself, as is proved in the extract already given, was a firm believer in animal electricity; but he failed to supply reasons for this belief which can be regarded as thoroughly satisfactory at the present day. Still, he did something in this direction by making out —first, that the agent assumed to exist, and to be animal electricity, has this in common with electricity, that its action is permitted by conductors and prevented by non-conductors; and, secondly, that it is not to be confounded with voltaic electricity, because the action, which is permitted by conductors, is possible across a gap in the circuit which would allow the passage of franklinic electricity, but which would altogether prevent that of voltaic electricity—would allow, that is to say, electricity of high tension to pass, but not electricity of low tension. What Humboldt did, in fact, was to increase the probabilities of the existence of animal electricity not a little, and at the same time to make it appear that this electricity would prove to be of higher tension than voltaic electricity under ordinary circumstances.

In 1803, Aldini, Galvani's nephew,* published an account of certain experiments which furnish further evidence in favour of the existence of animal electricity, by showing that living animal tissues are capable of giving rise to attractions and repulsions which seem to be no other than electrical attractions and repulsions. 'I held,' he says, 'the muscles of a prepared frog in one of my hands, moistened with salt and water, and brought a finger of the other hand, well moistened in

* "Account of the late Improvements in Galvanism, with a series of curious and interesting experiments performed before the Commissioners of the French National Institute, and repeated in the Anatomical Theatres of London, &c." 4to. London, 1803.

the same way, near to the crural nerves. When the frog possessed a great deal of vitality, the crural nerves gradually approached my hand, and strong contractions took place at the moment of contact.' And again:—'Being desirous to render this phenomenon more evident, I formed the arc by applying one of my hands to the spinal marrow of a warm-blooded animal, while I held the frog in such a manner that its crural nerves were brought very near to the abdominal muscle. By this arrangement the attraction of the nerves of the frog became very evident.'

About this time, however, the discovery of the voltaic battery had given the victory to the opinions of Volta—a victory so complete that nothing more was heard about animal electricity for the next thirty years.

In 1827, Nobili* brought back the subject of animal electricity to the thoughts of physiologists by discovering an electric current in the frog. He made this discovery by means of the very sensitive galvanometer which he himself had invented a short time previously—an instrument which, as perfected by Professor Du Bois-Reymond and others, by Sir William Thomson more especially, ought to be as prominent an object as the microscope in the laboratory of every physiologist. Immersing each end of the coil of the instrument in a vessel containing either simple water or brine, and completing the circuit between the two vessels with a galvanoscopic frog—the fragment of the spine being immersed in one vessel, and the paws in the other—he found that there was a current in the frog from the feet upwards, which current would cause a considerable permanent deflection of the needle—to 30° or more, if brine

* "Bibl. Univ.," 1828, T. xxxvii, p. 10.

were used, to 10°, or thereabouts, if water were substituted for brine. Nobili supposed that this current was peculiar to the frog, and in this he erred; but he did, nevertheless, a great thing, for, by this experiment, he furnished the first unequivocal proof of the real existence of animal electricity.

Twelve or thirteen years later, Matteucci published an essay* which, as M. De la Rive says,† 'restored to animal electricity the place which it ought to occupy in electrical and physiological phenomena.' This essay, moreover, had a great indirect influence upon the fortunes of animal electricity, for M. Du Bois-Reymond, as he himself tells us, was led to undertake the investigations which have made his name famous in this department of physiology by the inspiration arising from its perusal.

The joint labours of MM. Matteucci and Du Bois-Reymond have left no room for entertaining any doubt as to the reality of animal electricity. This will appear sufficiently in the sequel, when many of the experiments which furnish the demonstration will have to be referred to particularly. In the meantime, it may be said that Matteucci has demonstrated in the most unequivocal manner that animal electricity is capable of decomposing iodide of potassium, and of giving 'signes de tension avec un condensateur délicat,'‡ as well as of producing movement in the needle of the galvanometer; and not only so, but also—a fact, the discovery of which will always give Matteucci a place in the very foremost rank of physiological discoverers—that muscular con-

* "Traité des Phénomènes Electro-physiologiques des Animaux." Paris. 1844.

† "A Treatise on Electricity, in Theory and Practice." Translated by C. V. Walker. 8vo. Longman. 1853–1858.

‡ "Cours d'Electro-Physiologie." Paris. 1858.

traction is accompanied by an electrical discharge analogous to that of the torpedo. And as for M. Du Bois-Reymond,* it may be said that he has demontrated most conclusively that there are electrical currents in nerve—in brain, spinal cord, and other great nerve-centres, in sensory, motor, and mixed nerves, in the minutest fragment as well as in masses of considerable size,—that the electrical current of muscle, which had been already discovered by Matteucci, may be traced from the entire muscle to the single primitive fasciculus, — that Nobili's 'frog-current,' instead of being peculiar to the frog, is nothing more than the outflowing of the currents from the muscles and nerves,—that the law of the current of the muscle in the frog is the same as that of the current of muscle in man, rabbits, guinea-pigs and mice, in pigeons and sparrows, in tortoises, lizards, adders, toads, tadpoles, and salamanders, in tench, in freshwater crabs, in glow-worms, in earthworms—in creatures belonging to every department of the animal kingdom,—that the law of the current in muscle agrees in every particular with the law of the current in nerve, and also with that of the feeble currents that are met with in tendon and other living tissues,—and that there are sundry changes in the current of muscle and nerve under certain circumstances, as during muscular contraction, during nervous action, under the influence of continuous and interrupted voltaic currents, and so on, which changes, as I shall hope to show in due time, are of fundamental importance in clearing up much that would otherwise be impenetrable darkness in the physiology of muscular action and sensation.

Before the discovery of the galvanometer the atten-

* "Untersuchungen über thierische Electricität." Berlin. 1849, 1853.

tion of those who cared to meddle in these matters was directed exclusively to the static phenomena of animal electricity. Then the only definite electrical ideas were, charge on the one hand, and discharge on the other. After the discovery of the galvanometer, the original point of view was abandoned altogether, or nearly so, and the attention diverted from the static to the current phenomena of electricity. And herein, as I believe, was an unmixed misfortune. In making out the electrical history of living creatures there is work to be done which, as will be seen in due time, can only be done with the electrometer; and, for my own part, I am disposed to assign to the new quadrant electrometer of Sir William Thomson a position in these investigations which is every whit as important as that which can be assigned to the galvanometer, and to think that the apparatus of any physiological laboratory would, to say the least, be far from complete in which this instrument was wanting.

And thus, by the fact of the existence of animal electricity being now established beyond question, the way is more prepared than it was in the days of Galvani for the adoption of any view of vital motion in which animal electricity has to serve as the basis.

There are also others who must be named as taking what is substantially the same view as that taken by Galvani, and who have a just claim to be commemorated in these introductory remarks, about whose views I would say, what I would also say about the views of Galvani, that I was in complete ignorance of them for long after the time when my own thoughts on the subject had been made public.

The name to be mentioned first in order here is that of the late Dr. West, of Alford, in Lincolnshire. As early as 1832,* in some remarks upon the influence of the nerves upon muscular contractility, this writer maintains, 'that the nervous influence which is present in relaxed muscular fibre is the only influence which the nerves of volition possess over that tissue; that its office there is to restrain or control the tendency to contract which is inherent in the muscle; and that contraction can only take place when by an act of the will this influence is suspended, the muscle being then left to act according to its own innate properties;' . . . and again, 'that nervous influence is imparted to muscular fibre for the purpose of restraining its contraction, and that the action of the will, and of all other disposers to contraction, is simply to withdraw for a while this influence, so as to allow the peculiar property of muscular fibre to show itself.' The co-existence of spasmodic action with nervous debility, the efficacy of stimulants as antispasmodics, and the postponement of rigor mortis until all traces of nervous action have disappeared, are the principal facts which are advanced in support of the probability of this theory.

A similar idea appears to have been also hinted at by Sir Charles Bell in a lecture at the Royal College of Surgeons of England, for, after premising that the question could never be settled, the lecturer said, 'that *relaxation* might be the act, and not contraction, and that physiologists, in studying the subject, had too much neglected the consideration of the mode by which relaxation is effected.' This remark is preserved by Dr. West in the essay to which reference has just been made.

* "On the Influence of the Nerves over Muscular Contractility," "London Medical and Surgical Journal," edited by Michael Ryan, M.D. Vol. i. 1832.

Six years later, in a chapter of his classical work on comparative anatomy,* Professor Dugès, of Montpellier, argues with much clearness that all organic tissues are the seat of two opposite movements—expansion and contraction—and that 'la contraction musculaire ne consiste que dans l'annihilation de l'expansion.' The muscle is supposed to contract in virtue of its elasticity, just as a piece of caoutchouc might contract when set free from a previous state of extension; and an analogy is hinted at between the expanded state of the muscle and the fluid state of the fibrine of the blood, and between rigor mortis and the coagulated state of this fibrine. Analogous in its effects to electricity, the vital agent is supposed to accumulate in the muscles, and to produce expansion by causing the muscular molecules to repel each other; and contraction is supposed to be brought about either by the sudden discharge (as in ordinary contraction) or by the gradual dying out (as in rigor mortis) of the vital agent. And, further, it is supposed that the rhythmical movements of muscle are caused by successive discharges of the vital agent, which discharges are brought about whenever this agent acquires a certain degree of tension; and that the cramps of cholera, or the spasms of tetanus or hysteria, are consequent upon the development of the vital agent being for the time suspended.

More recently still, namely in 1847, Professor Matteucci communicated a paper to the Parisian Academy of Sciences† upon the influence of the nervous *fluid* in muscular action, in which he writes:—'Ce fluide développé principalement dans les muscles, s'y répand, et,

* "Traité de Physiologie comparée de l'Homme et des Animaux." 8vo. Montpellier and Paris. 1838.

† "Comptes Rendus." March 17, 1847.

doué d'une force répulsive entre ses parties, comme le fluide électrique, il tient les éléments de la fibre musculaire dans un état de répulsion analogue à celui présenté par les corps électrisés. Quand ce fluide nerveux cesse d'être libre dans le muscle, les éléments de la fibre musculaire s'attirent entre eux, comme on le voit arriver dans la roideur cadavérique. . . . Suivant la quantité de ce fluide qui cesse d'être libre dans le muscle, la contraction est plus ou moins forte.' Professor Matteucci appears to have framed this hypothesis, partly, in consequence of certain considerations which seemed to show that the phenomenon of "induced contraction" was owing to the *discharge* of electricity in the muscle in which the 'inducing contraction' was manifested—an idea originating with M. Becquerel—and, partly, in consequence of the analogy which he himself had found to exist between the law of contraction in muscle and the law of the discharge in electrical fishes; but he does not appear to have attached much importance to the hypothesis. Indeed, his own comment at the time is—'j'ai presque honte d'avoir eu la hardiesse de communiquer à l'Académie des idées si vagues, et apparemment si peu fondées, et contre lesquelles on pourrait faire bien des objections, mais je pense que, parmi les théories physiques les mieux fondées aujourd'hui, il en existe qui ont débuté de cette manière, et il est certain que des hypothèses, aussi peu fondées que celles-ci, ont quelquefois pu produire ensuite des découvertes remarquables.'

Next in order, and almost contemporaneously with the date of my own first publication on the subject, Professor Engel, of Vienna, wrote:*—'So hat der Nerve die Aufgabe, nicht die Zusammenziehungen des Muskels zu

* "Ueber Muskelreizbarkeit," "Zeitschrift der Kais. Kön. Gesellsch. der Aertze zu Wien," Erster Band, pp. 205-219, and pp. 252-270. 1849.

veranlassen, sondern den Zusammenziehungen bis auf einen geringen Grad entgegenzuwirken. Im lebenden Organismus, in welchem Ruhe etwas unmögliches ist, ist auch ein ruhender Muskel eben so wohl wie ein ruhender Nerv undenkbar, der Muskel in seinem beständigen Streben, sich zusammenzuziehen, wird von Nerven daran verhindert, im Nerven macht sich das fortwährende Streben kund, die Zusammenziehung des Muskels auf ein gerechtes Mass zurückzuführen; das Ergebniss dieser zwei einander entgegengesetzten Eigenschaften des Nervens und des Muskels ist das, was man gemeinhin Zustand der Ruhe, Zustand des Gleichgewichtes, oder an Muskeln auch Tonicität nennt. Das Verlassen dieses Gleichgewichts ist die Bewegung einerseits, die Lähmung andererseits. Die Bewegung wird aber erzeugt, indem entweder der Einfluss des Nervens auf den Muskel herabgesetzt wird, oder indem die Contractionskraft des Muskels unmittelbar gesteigert wird. Lähmung des Muskels findet sich gleichfalls entweder durch unmittelbare Vernichtung der Contractionskraft des Muskels oder durch eine übermässig gesteigerte Einwirkung des motorischen Nervens auf den Muskel. Sollen daher abwechselnde Muskelcontractionen zu Stande kommen, so ist die Gegenwart des lebendigen Nervens im Muskel unerlässlich, und auch bei unmittelbaren Muskelreizen können abwechselnde Zusammenziehungen nur erfolgen, so lange noch die Nerven lebensfähig sind; hört letzteres auf, so zieht sich der Muskel ohne Hinderniss zusammen. Diesen Zustand nennen wir die Todtenstarre.' The chief grounds for this opinion are, first, certain original experiments, some of them very remarkable, which afford additional proof that the muscles of frogs are more prone to contract when they are cut off from the influence of the great nervous centres; secondly, the frequent spontaneous occurrence of cramps and other forms of excessive spasmodic contraction in paralysed parts ; and, thirdly, the supervention of the permanent contraction of rigor mortis when all signs of nervous irritability are completely extinguished.

And, last of all, I find Professor Stannius, of Rostock,* arriving at the conclusion :—'dass es eine wesentliche Aufgabe der sogenannten motorischen oder Muskelnerven sei, die natürliche Elasticitätsgrösse der Muskelfasern herabzusetzen und ihre Elasticität vollkommener zu machen ; dass anscheinende Ruhe des Muskels, zum Beispiele, während des Schlafes, das Stadium solchen regen, den Muskel zu seinen Aufgaben wieder befähigenden Nerveneinflusses anzeige : dass active Muskelzusammenziehung einen geregelten und begrenzten momentanen Nachlass des Nerveneinflusses auf den Muskel bezeichne ; dass endlich die Nachweisung einer Muskelreizbarkeit, in der üblichen Auffassungsweise, ein durchaus vergebliches Bemühen sei.' M. Stannius was led to this conclusion by certain original experiments, in which he found blood to have the power of relaxing rigor mortis and restoring muscular irritability, and these experiments are advanced in evidence. Reference is also made to arguments to be brought forward on another occasion, which will prove—'dass diese Anschauungsweise, so paradox sie immer auf den ersten Anblick sich anlassen mag, mit unserem thatsächlichen Wissen über Nerven- und Muskelthätigkeit keineswegs im Widerspruch steht.' The essay from which these quotations are taken was published towards the end of

* "Untersuchungen über Leistungsfähigkeit der Muskeln und Todtenstarre," "Vierordt's Archiv. für Physiol. Heilkunde." Stuttgart, 1 Heft, p. 22, 1852.

1852—about two years after the date of my own first publication on the subject.

I do not stand alone, then, in thinking that a great change is necessary in the theory of *vital motion*—a change amounting to no less than a complete revolution ; and I am glad that it is so, for, thus supported, I have more courage than I otherwise should have to prosecute the enquiry upon which I have ventured to enter—an enquiry in which the problem of vital motion will be regarded, first, from a physiological, and then, from a pathological, point of view.

II.

Beginning with amæboid movement, and passing thence, through simple muscular and nervous action, to cardiac and other forms of rhythmical vital motion, and thence to rigor mortis, it is seen that all the facts belonging to natural electricity are in harmony with the notion that vital motion is merely a mode of physical motion for which the only key needed is that which is supplied by the natural operations of electricity and elasticity. And so also when the enquiry is extended with a view to see how vital motion is affected by artificial electricity, by blood, by nervous influence, and in other ways, and why vital motion is exaggerated as it is in convulsion, or spasm, or tremor or neuralgia, or the like, there is no occasion to seek for any other key.

Amæboid movements, there is reason to believe, are the simple result of certain natural electrical changes which take place in all terrestrial bodies.

The argument is sufficiently simple. As was pointed out in the last chapter (pp. 106-7), the electrical condition of the surface of the earth is not that of zero, but that of a *charge* which is the seat of regular tidal movements corresponding to those which tell upon the barometer, and of *incessant, irregular oscillations or wave-like movements*. The bodies in which amæboid movement are manifested, as I have shewn by several experiments with Thomson's new quadrant electrometer, are in the same case electrically as water, or sculptor's clay, or any other inorganic substance: and, this being the case, it is supposable, not only that the charge will cause expansion in the charged bodies by keeping their molecules in a state of mutual repulsion, but also that the ever-varying changes in the charge will tell in corresponding changes of expansion. And this too is supposable, that the action of the charge in causing expansion will tell more in some bodies than in others, and more in some parts of these bodies than in others—more in bodies, and in parts of these bodies, which are less solid than in those which are more so, and, *perhaps, only perceptibly* in the bodies, or in the parts of these bodies, which are fluid rather than solid. Hence it may be that the changes in expansion consequent upon changes in the amount of charge may be perceptible in the parts of amæboid bodies which remain in the hyaline state of nascent protoplasm, and not in those parts which have become granular; for it is in amæboid bodies which are in the main hyaline, and not in those which have become decidedly granular, that amæboid movements are really perceptible. And because these hyaline portions are distributed irregularly, it may be that the variation of expansion, consequent upon changes in the amount of charge, may appear in the guise of that irregular protrusion and retraction of processes which is characteristic of amæboid movement. This is all. There is no occasion to call in the aid of a vital property of irritability. Indeed, it is difficult to see how such a property could act so as to bring about the double movement of protrusion and retraction which has to be accounted for in this particular form of vital motion.

Muscular movements, like amæboid movements, are also in the main resolvable into electrical movements, but here the electricity at work is more than that which belongs to all terrestrial bodies equally.

By the galvanometer it is made evident that there is a current, called the 'muscle-current,' in living muscle which is not to be detected in muscle that has passed into the state of rigor mortis, and also that this current disappears in great measure, or suffers a 'negative variation,' when a living muscle passes from the state of rest into that of action. By the electrometer it is made evident that there is in living muscle a *charge* which disappears in great measure when the state of rest changes into that of action, and which is absent altogether in rigor mortis—a double charge which is + in the part from which, and – in the part to which, the muscle-current sets. And further—what may not be so clearly made out either by galvanometer or by the electrometer,—by a 'rheoscopic limb,' or frog's hind leg prepared in a particular way, it is made evident that muscular contraction is, as Matteucci pointed out, accompanied by an electrical discharge analogous to that of the Torpedo. Many experiments with Thomson's new quadrant electrometer, made by myself, justify me in saying what I have said about the electrometric facts, and in coming to the conclusion that the manifold operations of voltaic electricity in muscular motion are to be explained, not by the action of the current, but by that of the *charges*, and *discharges* (instantaneous currents of high tension on making and breaking the circuit) associated with the current. Indeed, the conclusion to which I have come respecting the natural electricity of muscle is that the current phenomena made known by the galvanometer are, not primary, but secondary, the result merely of bringing together, through the coil of the galvanometer, parts which are electrically dissimilar, and which naturally are kept apart and dissimilar by reason of their comparative want of conductibility,—and that the primary electrical condition of the muscle is that which is brought to light by the electrometer—a state of charge during rest, a state of discharge when rest changes into action. Nor is it altogether unintelligible that it should be so. For what is the case as set forth in the argument? It is that the coats and the contents of each muscular fibre and cell are sufficiently heterogeneous to constitute a voltaic element, and that the oxygen in the blood or air passages or elsewhere serves as the developing medium. It is that this voltaic element, owing to imperfect conductibility somewhere, is, while the muscle is at rest, in the state of open-circuit rather than in that of closed-circuit, and that, for this reason, the state of *charge* predominates over that of current—a state of charge in which one half of the element is positive and the other half negative. It is that the charged parts, by reason of the mutual repulsion of their molecules which is set up by the charge, are in a state of expansion, and that the softer parts—the contents of the fibre or cell—may be more expanded than the harder—the coats. It is that the contents of the fibre or cell, as the softer parts, may be the only parts in which expansion may operate *perceptibly*. It is that this expansion of the contents may cause elongation of the fibre or cell, for the simple reason that the shape of the comparatively non-expansible coat, acts upon the contents in the same way as that in which the shape of the tube of the thermometer acts upon the column of mercury within it, or rather as that in which the fine tube of the last new form of electrometer is seen, under the microscope, to cause the thread of mercury within it to lengthen or shorten as the charge imparted to it rises of falls. It is that the failure of this charge, which may be brought about by failure in the due supply of oxygen, and in various other ways, is attended by the development of instantaneous currents of high tension, and that these currents, by traversing the muscle, suddenly discharge the remains of the charge, and so bring about muscular contraction. It is that this contraction is brought about, not because a vital property of irritability has been roused or stimulated into action, but simply because the discharge has removed for a moment the charge which previously counteracted the action of the attractive force or forces inherent in the physical constitution of the muscular molecules. Nor is it to be objected that the electricity of the muscle is too feeble to produce these results, for it may be that the electromotive action of muscle is proportionate to the number of electromotive elements (fibres or cells) in the muscle, and that both charge and discharge are masked, the one by being expended in the production of muscular elongation, the other by being short-circuited within the body. Nay, it is quite conceivable that the instantaneous currents of high tension which produce contraction would prove to be as powerful as those of the Torpedo if they were not so short-circuited. And all that is said of the action of the natural electricity of the muscle is more than borne out by what is said of the action of artificial electricity upon muscle, for in the latter case it is found, not only that charge acts in the same way in causing muscular elongation, but also that the elongation is proportionate to the charge, and that the extra-contraction in electrotonus is only the simple result of the muscle in this particular case having had to return from a state of extra-elongation consequent upon a state of extra-charge.

Nor does the consideration of rhythmical vital motion as manifested in cardiac muscle or elsewhere lead to a different conclusion. In ordinary muscle, unless the muscle be interfered with in one way or another, the natural charge is kept up steadily: in the muscle which is naturally the seat of rhythmical action, on the contrary, the natural charge, instead of being kept up steadily, fails periodically, and so leads to the development of the instantaneous currents of high tension by which periodical contraction is brought about. The natural electricity is evidently maintained for a longer time in the former case than in the latter. And why? Is it that there is in the two muscles a molecular difference analogous to that by which a piece of paraffin charged by friction will retain its charge for a longer time than a piece of glass so charged? Is it that in the case of the muscular fibres of the heart or air-passages, the state of rest corresponds to the time during which there is enough oxygen in the arterial blood within the vessels of the heart, and in the air within the air-passages, to keep up sufficient charge in the fibres to *inhibit* the contraction which in due time drives out the used-up blood from the vessels, or the used-up air from the air-passages, and, by so doing, prepares the way for the admission of fresh blood and air into the vessels and air-passages, and for the restoration of the state of charge and relaxation which follows, and which continues until it again gives place to discharge and contraction? Is it that the rhythmical vital motion in oscillatoria, in vibratile cilia, in pulsating vacuoles, and in other cases, is to be explained by supposing that the oxygen in the water *near* the rhythmically acting body keeps this body in a state of charge, expansion, and rest until it is used-up, that then the failing charge brings about discharge and contraction by means of the instantaneous currents of high tension which are then developed, and that this motion restores the state of charge and expansion and rest by bringing the moving parts into relation with water containing fresh supplies of oxygen, and so on and on as long as the machinery continues in order and the supply of oxygen in duly kept-up? That it may be so is the natural inference from the premises, and, so far as I know, there is no good reason why it may not be so. At first sight, perhaps, it may seem that there is reason to the contrary in the opposite movement of the auricles and ventricles of the heart, but a little reflection will serve to show that the auricular movements in the case may be resolved *in the main* into passive consequences of the ventricular movements, the auricular diastole coinciding with the ventricular systole because the flow of blood from the auricles into the ventricles is stopped and forced back at this time by the closure of the auriculo-ventricular valves, the auricular systole coinciding with the ventricular diastole because at this time the blood is suddenly sucked away from the auricles into the ventricles.

And as in rhythmical vital motion so also in rigor mortis there is no occasion to change the point of view in order to find the key to the facts. For in rigor mortis the case appears to be simply this—that the charge which counteracted the state of contraction in the living muscle is no longer present, that the soft contents of the muscular fibres and cells have become more or less hardened—a change, in fact, which, by bringing the contents nearer to the molecular condition of the coats, may annihilate the natural electricity of the muscle by putting an end to that heterogeneity of structure upon which it is dependent.

The electrical history of nerve is the exact repetition of that of muscle. There is no occasion to think that "nervous influence," whatever that may be, differs in its action from electricity. There is no occasion to apply to any agent other than electricity in order to explain how it is that nerves act upon muscles in causing contraction, and how muscles in contracting may react upon nerves and give rise to sensation or motion: for the instantaneous currents of high tension which are developed equally in nerve and muscle, when the state of rest passes into that of action, extend beyond the limits of the nerve and muscle, and, by so doing, may reach from the nerve to the muscle or from the muscle to the nerve. Indeed, it seems necessary to believe that the electromotive elements in nerve and muscle form one apparatus in which the action of every part is intensified, both during the time of charge and during the time of discharge, by inter-acting with every other part. Nor is it necessary—in order to establish this parallelism between the electrical histories of nerve and muscle—that nerve fibre should imitate muscular-fibre in elongating during the time of charge and shortening at the time of discharge: for the absence of these changes in nerve-fibre may simply mean—that the contents of the nerve-fibre differ from those of the muscular fibre in being more elaborated, and in resembling, for that reason, the granular bits of elderly protoplasm in which amæboid movements have come to an end.

The same explanation is also found to hold good in convulsion, spasm, tremor, neuralgia, or any other case of exaggerated vital movement. In none of these cases is there reason to believe that any nerve-centre is raised into a higher state of vitality by being supplied with more arterial blood than usual, and that this exaggerated vital motion is the direct result of this change. The facts without exception point in the opposite direction. Where there is supposed to be excess of arterial blood there is really deficiency. Thus, in epilepsy there is, first, a failure of circulation —as is shown in the ghastly pallor of the face which ushers in the fit—and then a state of suffocation—a state in which arterial blood ceases to be formed and supplied to any part of the system. The actual convulsion is coincident with actual suffocation: and even the hard and frequent pulse at the height of the fit is in keeping with this view, for the blood which escapes when an opening is made in the artery at this time is, not *red*, as it is commonly supposed to be, but *black*, as in suffocation it always is—not arterial, that is to say, but venous. So far as the absence of arterial blood is concerned the case of epilepsy is strictly parallel with that of the convulsion which attends upon death by bleeding. And as in these cases so also in other cases of convulsion or spasm or tremor or neuralgia or any other form of exaggerated vital motion, though not always so obviously, the facts when carefully sifted, always showing, in opposition to current notions on the subject, that the exaggerated vital motion is connected, not with a state in which a vital property of irritability is roused into preternatural activity by an excessive supply of arterial blood to one or other of the great nerve-centres, but with a contrary state of things in which, after what has been said, the only conclusion seems to be that the natural electricity has failed in some great nerve centre for want of arterial blood, and that the instantaneous currents of high tension which of necessity attend upon this failure are the immediate agents in exaggerating vital motion as it is exaggerated in these cases.

This, broadly stated, is the conclusion to which I am compelled to come. Everything as it seems to me, is in flat contradiction to the current doctrine of vital motion : everything, as it seems to me, tends to bring phenomena which have been regarded as exclusively vital under the dominion of physical law—to transmute vital motion into what proves to be nothing more than a mere mode of physical motion.

Chapter III.

TRACES OF UNITY IN THE VIVIFYING POWER OF LIGHT AND HEAT.

The life of plants and animals is affected by climate and season in a way which shows very plainly that there is the closest connection between vital force and physical force.

In high northern latitudes, as cold gains the mastery, plant after plant disappears until at last the landscape is almost altogether plantless.

In the sub-arctic zone which succeeds to the temperate region, green pastures, adorned during the short spring and summer with many gay flowers, reach far and wide, and interminable forests of needle trees shut out the prospect in all directions. Oaks have been left behind in the temperate region, but birches and alders and willows struggle on, and their more northernmost outposts are considerably in advance of the lines occupied by the conifers.

In the arctic zone the trees and in great measure the grassy pastures of the last zone have disappeared, the pastures being replaced by tracts, often of wide extent, covered by sedges and cotton-grass and lichens, the trees by prostrate and tortuous shrubs like those met with in high alpine regions—rhododendrons, andromedæ, dwarf beeches, alders and willows, bog-myrtles and others. All trees have disappeared, and the place of grass is almost wholly occupied by lichen. Even shrubs are present in no great numbers. Indeed, the only plants which can be said to obtrude themselves upon the attention prominently are certain low growing perennial herbs which, for the most part, do their best to grace the short spring and summer by dressing themselves in large and brilliant flowers.

In the polar zone no place is found for the smallest shrub. Patches of lichens of various sorts, and clumps of dwarf herbaceous perennials—saxifrages, ranunculi, potentillæ, pyrolæ and others, occur here and there, but the country generally is a plantless waste—a waste so unfavourable to vegetation that even the few flowers which struggle into existence during the few short weeks of spring and summer fail for the most part to bring their seeds to maturity.

In equatorial regions, on the other hand, except in those places where a due supply of water is wanting, the mind is bewildered by the undying richness of the vegetation. On the wooded banks of the Orinoco, for example, enormous trees, with their trunks hidden by countless orchids, aroids, bromellaciæ, ferns, and other parasitic plants, and matted together by passifloras, bignonias, banisterias, paullineas, aristolochias, ipomœas, and other lianes or rope plants, the trailing stems of some of which may be forty feet in length and more, form a tangle which is absolutely impenetrable except by certain lanes made by the passage of wild animals to and from the water—so impenetrable that, as Humboldt tells, these animals, when surprised at the river side, have often to run for a considerable distance before they can find the hole through which to pass back again into the forest. Here the palm, the banana, the heliconium, the ammomum, the strelitzia, are at home. Here, in place of the ordinary fern of the north is the tree-fern, in place of common grass the bamboo, in place of simple moss the Neckera dendroides or some other tree-moss. Here, indeed, where all plants have a tendency to become ligneous as well as arborescent, one or other plant is always in flower, and no plant is ever leafless.

The lesson to be gathered from these facts is plainly this—that plants owe their very existence to the sun, and that their vital vigour is directly proportionate to the degree of insolation to which they are exposed. It is indeed only another version of the annual history of vegetation in the temperate regions of the globe, for here the state of things inclines to that met with in high northern latitudes as the earth turns away from the sun in winter, and to that which is natural to equatorial regions when the earth turns towards the sun again in summer. Moreover, what happens every twenty-four hours may be supposed to convey a hint to the same effect, for the wakefulness of plants in the daytime and their sleepiness at night, as seen in the opening and shutting of flowers, in the rising and falling of leaves, and in many other ways, are in fact only partial manifestations of the more marked summer and winter changes in the life of plants, which are distinguished as æstivation and hybernation.

Nor is the case altogether different when the attention is directed from the world of plants to that of animals.

A few hardy animals, like the polar bear, and wolf, and reindeer, can brave the terrors of the polar cold and darkness, but the majority, like the marmot, must migrate southwards as the winter approaches, or else, if they do not die outright, sink into the death-like sleep of hybernation until revivified by the returning spring.

The devitalizing action of cold and darkness upon animal bodies is not to be questioned; and, as in the case of plants so in this case, the vital vigour is always directly proportionate to the degree of insolation to which these bodies are exposed.

The fact, too, that animals for the most part wake in the daytime and sleep during the night, is not a little significant when taken in connection with the context. It is not enough to refer the state of sleep to the exhaustion consequent upon the state of wakefulness, or to think that wakefulness follows upon sleep because the body has been refreshed by sleep. If it were so the shortest day would not be followed by the longest sleep, and the longest day by the shortest sleep. If it were so, that is to say, the times of repair in sleep and of waste in waking would not be, as they are, inversely related to each other. Indeed, the more this matter is looked into the more difficult is it to regard the sleeping and waking states as standing to each other in the relation of cause and effect, and the more easy it becomes to entertain the belief that sleeping and waking, like hybernation and æstivation, have to do directly with the absence and presence of the sun, and that, for this reason, the varying periods of sleeping and waking in winter and summer *must* in great measure keep strict time with the changes in the length of the nights and days in these seasons. Nor is this conclusion set aside by the fact that some animals, like the bat, wake when others sleep, for in the daytime these nocturnal creatures hide themselves in dark places where night may be said to prevail even during the day. Indeed, after all, these nocturnal creatures may differ from diurnal creatures chiefly in sleeping, not only through the day, but through the greater part of the night also, and in coming abroad only for a short time in the dusk of the evening when hunger compels them to bestir themselves. And this view is not so fanciful as it may seem to be at first sight, for it is a fact that nocturnal animals, confined in menageries, and fed in the daytime, sleep soundly enough through the night and through the day also—are, in fact, always sleeping unless they are awakened by the pinches of hunger.

Whether the life of animals responds to the moon as well as to the sun is a question to which as yet it is not easy to return a decided answer. It is difficult to believe that there is nothing in the notion that the mastiff in the yard is more disposed to bark and howl in the moonlight than in the dark. It is difficult to believe that there is nothing in the Indian notion that wild animals "observe the feast of the full moon" by imitating the noisy behaviour of the yard-dog when he "bays the moon"—a notion of which so vivid an account is given by Humboldt in one of the chapters of his "Aspects of Nature." It is difficult to believe that there is nothing in the old notion that the full moon is in a measure to be blamed for exacerbations of lunacy, and that the persons so affected are rightly called lunatics. And certainly these difficulties are not lessened when the attention is directed to those physiological changes in the human frame in which a monthly, and therefore a lunar, cycle, is more clearly perceptible than in any merely pathological changes. In fact, it can scarcely be doubted that there are tidal movements in animal life in which the conjoined action of the sun and moon would be plainly enough perceptible if the example set by Dr. Mead, and put on record in his treatise, "De imperio solis ac lunæ in corpora humana et morbis inde oriundis," were more frequently followed.

There are also many familiar facts which serve to show that artificial light and heat have a like influence upon plants and animals. Flowers wake through the night in a well-lit room. Many annual plants become perennial under the fostering shelter of the hot-house. An animal that hybernates ordinarily wakes through the winter in cosy quarters, and sleeps through the summer in the contrary case. These facts, and many others like them, are of great interest in themselves, but they are of greater interest as confirming the conclusion already arrived at respecting the relations of natural light and heat to life, for if this vivifying power belongs to artificial light and heat it is impossible to conceive that it does not belong also to natural light and heat.

In a word, the life of plants and animals is so affected by climate and season as to more than justify the notion, not only that light and heat have a vivifying power, but also that vital force and physical force are *united* in the very closest manner.

Chapter IV.

TRACES OF UNITY IN THE PHENOMENA OF INSTINCT.

Many instinctive movements are as automatic as the movements of a watch. The mechanism of the body is constructed so as to "go on" in a certain way, and no other. But the cases of instinctive movement in which many animals act together in concert are not so easily disposed of, and the more they are looked into particularly, the more difficult is it to rest satisfied with any elucidation supplied by the doctrine of automatism.

The swallow, for example, migrates from England to Africa, and from Africa back again to England with strange regularity. Her movements are ordered so as to avoid frost on the one hand and undue heat on the other. She arrives here about the middle of April and departs about the end of September, when the last of her two broods, like the first, is strong enough to bear the journey. If the last brood be late in making its appearance it runs some risk of being left behind, either to perish outright, or else to hybernate until it is awakened in the spring by the chirp of its returning relatives, but the order of nature seldom goes wrong in this way. And certainly the parents would seem to do all they can to avert such a calamity, by making it their business, for many days before starting, to congregate in great numbers and to train their young for the great effort they are about to make, not only by taking long flights together, but also by roosting with them on oziers and other water-loving trees, and so teaching them to forget their nests. One day all are there: the next all are gone. An irresistible impulse has impelled them to go together, and not to rest until they reach the north of Africa. They cannot stay: they have little liberty in the choice of the course they have to take: and, where a wide expanse of sea has to be crossed, not a few, it is believed, are drowned, unless there happen to be within reach ships upon the rigging of which they may rest awhile. In due time also an equally irresistible impulse drives them back by the same route to their old haunts in the north, and great is their distress if, on arriving there, the well-remembered nests are not to be found. Year by year so it happens: as the plants begin to fade, and the insects to disappear, the birds depart: as the plants recover their leaves and flowers, and insects reappear upon the scene, the birds return. It seems to be a matter of circumstance in which the birds are as passive as the insects, almost as passive as the plants—a matter in which the vital movements have to do, not with automatism, but with periodic changes in the position of the earth in relation to the sun, and with other cosmical changes.

So too with the salmon. The eggs of this noble fish are deposited in a trench scooped out by one or both the parents in the gravelly bed of a rapid and rushing stream, and there left, ten days or thereabouts being spent in the process of oviposition and fertilization. Somewhat later the parents, then miserable, lank, scarcely eatable *kelts*, no longer caring for their eggs, betake themselves to the sea, and nothing further is known of them until, after a period varying from six weeks to three or four months, they are again found in the river, taking advantage of each flood or "spate" to make their way from pool to pool, up to their old haunts, and once more deserving to be called *salmon*, until they are again reduced to the state of *kelts* by a repetition of the process of laying and fertilizing eggs. After escaping from the egg the young fish remains in the river for one or two years. Before venturing sea-wards the name given to it is *smolt* or *parr:* on returning to the river it is called, after its first visit to the sea, *grilse* or *salmon-peal*, after subsequent visits, *salmon*. There may, perhaps, be some doubt as to the identity of smolts and parr : but that which has been based upon the fact that parr have been found with perfect milts, or soft roes, is certainly of no moment, for smolts, not more than an ounce and a half in weight, have been found in the same case, with milts so perfect as to be capable of fertilizing the ova of adult salmon. There is also no superabundance of information respecting the salmon, but this is certain, that when the fish is sufficiently developed to deserve the name of salmon it migrates year after year with unfailing regularity from river to sea and from sea back again to river, that it returns from every fresh immersion in salt-water amazingly increased in size—and that, once in the river, it must go on and on, in spite of torrents and waterfalls, from pool to pool, until it reaches the place in which it emerged from the egg. He who has watched the salmon leaping in the rapids of a mountain torrent to the wild music of the rushing waters can scarcely wonder that the Greek of old should have fancied that Pan was within hearing, higher up the stream, calling the fish up to him with his pipes. He will find it difficult, if he think at all, to entertain the notion that a creature so low in the scale of being should, ipso motu, set at nought the power of the cataract to keep it back: and, he is not unlikely, if he listen attentively to hear an echo of the music of the spheres in the rushing of the waters, and to think that the fish is obeying blindly the mandates of a law which rules the river, no less than the living things in the river. The salmon seems to be driven on with as little power of choosing its way as the swallow, or even with less, for in the case of the fish it may be supposed that there is an actual indisposition to pass from the river to the sea and from the sea back again to the river. Nay, the wonder is that, in changing from fresh water to salt-water, and from salt-water back again to fresh-water, the fish does not share the fate of the parasites by which it is infested, dying along with the fresh-water parasites on passing from the river into the sea, dying with the salt-water parasites on passing back from the sea to the river—a wonderful provision by which, among other things, the fish is *clean* and fit for the table when it is most likely to be taken, that is when it has been long enough in the river to lose its salt-water parasites and yet not long enough there to be infested by the fresh-water parasites.

The story of the instinctive movements of the hive-bee, as put on record by blind and patient Hubert, the paragon of all good observers, is even yet more wonderful, and, once taken up, it is difficult to lay aside the book containing it while any page remains unread. It is the very romance of natural history.

The society of the hive consists of one female or queen, with hundreds of males or drones, and thousands of sterile females or workers. On the first fine day the queen follows the drones out of the hive, and before returning, she has contrived, somewhere in the air out of sight, to be fertilized by one of them. Up to this time the workers pay her no attention: now they treat her as a queen. Up to this time the workers have lived on good terms with the drones: now they turn upon them and a massacre commences which only ends in the death of the last male. Sometimes the queen has to leave the hive two or three times before her purpose is accomplished, and in that case the males are allowed to live on sufferance: usually a single journey is sufficient, and the males are doomed to perish without delay. The fertilized queen soon begins to busy herself in laying eggs, and until the time of swarming comes, when the last egg has been laid, she remains at home. For the first twenty days or thereabouts she goes on laying the eggs of workers at the rate of a hundred a day or more: for the next ten days or thereabouts she lays male eggs at the same rate: for three or four weeks longer every second or third day she deposits a single egg which is destined to become a queen. All this while, and for some time previously, the workers are busy enough, some in gathering honey or propolis—the latter material being a transparent, jelly-like, garnet-coloured, resinous gum, secreted by certain plants, and used, along with wax, for building purposes,—others in laying the foundation of the cells. The honey, which is sucked up into the honey-bag or anterior stomach, and so carried, is wanted for their own support, and as material for the secretion of the wax which oozes out between the rings on the abdomen: the propolis is collected ready formed, made into pellets, and carried in the "baskets," which are cavities hollowed out in the inner surface of the thighs of the middle legs. All are in haste to be rid of their wax and propolis as soon as they return to the hive, and, to expedite matters, each helps the other to strip off the wax, to remove the pellets of propolis from the "baskets" containing them, and to pile both in little heaps within easy reach of the workers who are engaged as architects. The smaller cells for the workers are first taken in hand, then follow, in succession, the larger cells for the drones, the still larger and peculiar royal cells, and, last of all, the cells in which honey and polenta have to be stored up. As long as the work of building goes on actively no honey or polenta is stored up: as soon as this work is accomplished sufficiently the honey which is not wanted for the secretion of wax is disgorged into the honey-cells, and, in place of propolis, pollen or polenta is collected, carried home in the "baskets," and transferred to the polenta-cells. The polenta is ready when it is wanted for the support of the brood, but not before: the honey is required as food for the queen and as a winter store for all the inmates of the hive—a store, however, never drawn upon to any great extent, for in the winter the bees—then very torpid, but not exactly hybernating—require very little food. The eggs are deposited in the cells intended for their reception, not by the workers as was once supposed, but by the queen herself; and once *in situ* they are let alone. If, as happens now and then with a belated queen, the eggs are dropped anywhere indiscriminately, the workers may not scruple to make a meal of them: if all goes as it should do, and as it almost invariably does, the workers never go near the eggs until they are hatched, and then only the nurses whose office it is to carry food to the worms—ordinary polenta to the ordinary worms of workers or drones, royal jelly to the inmates of the royal cells. This process of feeding goes on steadily until the worms take to spinning their silken cocoons and are about to change into nymphs, and then the cells, the building of which has been going on steadily all this while, are covered with lids, which are as distinctive as the cells themselves, and sealed down. Before the last cell is closed the hive is so crowded with workers and drones that have escaped from the cells first-formed and first-closed as to make swarming necessary. By this time, too, the queen is ready to head the swarm, for now she is rid of the eggs the weight of which, by preventing her from flying, had kept her at home from the time of fertilization until now. And so it is that on the first fine day the bees swarm, or, in other words, depart in search of new quarters with the queen at their head.

This swarming always happens in the heat of the day when the majority of the bees are abroad. A march is stolen upon the absentees which necessitates prompt action on their part. A queen they must have, and what they want they find in the oldest inmate of the royal cells. To secure the succession is the first thing to be done, and in order to this, after much agitation, a guard is placed over the royal cells. The legitimate successor is the oldest inmate of these calls, and she, as a rule, is quite ready to assume the reins of government. For a time, however, she must remain in her cell under guard, and under guard to some extent she is ever after. Until the bees have given up the hope of seeing their old queen again, that is for the greater part of the next twenty-four hours, she is in strict confinement; and, when released, a constant watch has to be kept over the royal cells to prevent her from breaking into them and destroying their inmates. Once at liberty her one desire is to destroy her sisters, and every other queen that may come in her way. Unable to endure the presence of a rival she must kill or be killed, and the guard has to control the motions of this instinct, always by protecting the queens that still remain in their cells, and sometimes, perhaps, by protecting the queen herself. At all events, it is certain that a stray queen who happens to find her way into the hive while the process of oviposition is going on actively, and while, therefore, the egg-layer is oppressed by her burden, is likely to lose her life, not because she has been attacked by the queen, but because she has been overwhelmed under a mob of workers. For the rest, all that need be said is that from this point the history of the hive goes on steadily in the old way, with this difference only that in this case the cells have to be, not built, but only cleaned out and repaired, the main passages being still intact—the flying of the queen after the drones—the impregnation by one of them before her return—the recognition of the queen as queen after fertilization and not before it—the massacre of the drones by the workers—the laying of eggs in the prescribed order—the storing of honey and polenta in due time—the feeding of the worms—the sealing of the cells—and, lastly, the swarming when the eggs are all laid and the hive is overcrowded by new bees that have already issued from the eggs first laid.

Again and again this process is repeated with the same results. When a queen is wanted a queen is forthcoming; and until they are wanted they are kept in the royal cells under guard, and fed by nurses with food suitable to their age, that is, with royal jelly in the worm stage of their existence, and with honey in the imago-stage, the honey used in the latter case being placed on the lids of the closed cells near a hole through which the proboscis of the insect may pass in and out easily. The interval between the laying of the royal eggs must have effect in preventing a simultaneous development of all the queens, but it is not sufficient to insure the presence of only one adult queen in the royal cells at the same time. Often, indeed, there are many adult queens in these cells at the same time, and now and then, in spite of all the guard can do to prevent it, the prisoners break loose and a battle ensues in which only the strongest remains alive at the end. Nay, it may happen that the hive is left queenless by all the rival queens losing their lives in this way, or by the death of all the royal brood from other causes. In a case like this it might be supposed that the society of the hive would be dissolved for want of a queen, but it is not so. A queen must be had, and very soon the workers provide what is wanted. And this is how they set to work. They extemporize a royal cell by throwing three or four of their own cells into one, and by making sundry other changes which are needful; with one exception, they sacrifice the young worms belonging to these cells; they feed the favoured one with the royal jelly supplied to the royal worms; they close the cell in due time; and, lo! when the perfect insect emerges from the nymph it is, not an ordinary worker, but a queen. The result is constant if the young worm be young enough, that is, if she be not more than three days old. The infant worm of the ordinary worker, so treated, is always transformed into a royal worm, which in due time becomes a queen in every way as perfect as any of the queens which perished in the battle that left the hive queenless. As to the fact of the metamorphosis there can be no doubt. It is *this* fact, often verified, which Hubert speaks of as the great discovery of Schirach. Nor is this the only way in which the place of the queen may be supplied when the royal race is extinct, for there is reason to believe that this place may be taken, without any opposition on the part of the workers, by any stray unfertilized queen who happens to find her way into the hive.

While doing the work which has been mentioned the workers have also other work to do which is scarcely less important. They have to keep a constant guard at the entrance of the hive to prevent the admission of wasps, or hornets, or ants, or moths, or other enemies, and sometimes, in addition, they have to bar the way by certain waxen fortifications which have to be removed when the time for swarming comes; they have, when the air is close, to arrange themselves along the passages in various places, and ventilate the hive by keeping up a fanning action in a certain direction with their wings; they have—no easy matter after the massacre of the drones—to remove dead bodies from the hive, and to act generally as scavengers, and even then they have not done their work. Indeed, the story of the construction of the comb, upon which so much has been said at different times, is almost the least wonderful part of the work done by the sterile female bees or workers; and all that can be said of this story is that it is full of romance from the beginning to the end.

In each of these cases, and in very many other cases like them, it is evident that the manifestations of life of an instinctive character are beyond the skill and will of the individual, but it is not so evident that the explanation is to be found in unconscious cerebration or any other mode of automatism. Very probably each individual is a piece of perfect mechanism arranged to go on in the same manner under the same circumstances; and it is quite supposable that individuals of the same sort are so much alike as to go on in the same manner under the same circumstances without any real connexion between them. But a more simple view, as it seems to me, is to suppose that this real connexion is not wanting—that there is, as it were, an all-encompassing atmosphere of life which is as common to all living creatures as the atmosphere they breathe. And this view is in perfect keeping with all that has been said respecting life so far. For what does this amount to? It is that vital motion is a mode of physical motion—a motion of which the source and spring is, within the individual certainly, but also beyond it—a motion of which the sphere is co-extensive with that of nature herself. It is that there are fluctuations in life which strictly correspond with day and night, with summer and winter, and which, on this account, must be referred to astronomical causes. It is that there is an intimate connexion between vital force and physical force which may be like that which exists between the different modes of physical force, a connexion, it may be, amounting even to correlation. The point arrived at before beginning to speak of instinct, indeed, is one in which, as a matter of course, the search for the key to instinct would have to be made, not in any one living creature singly, but in nature generally. It would be, indeed, as reasonable to go back to the old notion and suppose that the heavenly bodies move because they are actuated by a life of their own as to continue to believe that the life of one of the lower animals, in any of its manifold aspects, is located within the animal exclusively. It would seem as if the key to this life were only to be found in the full recognition of unity in multiety and multiety in unity as an actual fact. And if so, then it is no more wonderful that the instinctive and other vital movements of the lower animals should be regular than that the movements of the heavenly bodies themselves should be regular. The case is too wide to be brought within the scope of unconscious cerebration, or any other mode of automatism, and to account for it in any measure satisfactorily nothing less will serve than to suppose that the phenomena of instinct are effects of a force which is as general as that of gravity, a force which may comprehend that of gravity, a force in which that which is vital and that which is physical may find a common centre. So it may be. And if so, then it follows that traces of unity are not wanting in the phenomena of instinct.

CHAPTER V.

TRACES OF UNITY IN THE PHENOMENA OF MEMORY.

"EVERY man is born an Aristotelian or a Platonist;" so wrote Samuel Taylor Coleridge, so wrote Frederick von Schlegel, the one, it may be, repeating unwittingly the remark of the other. And there is a deep meaning in these words about which it may be well, for reasons which will appear in the sequel, to try and learn something before proceeding to pry into the many dark questions connected with memory or any other mental faculty.

The things of sense, according to Aristotle, are composed of *εἶδος* form, and *ὕλη*, matter. The *εἶδος*, is the formative principle, or energy by which the thing is produced and constituted and actualized. It is connatural with the First Cause, which is one in essence, indestructible, immaterial, at once immoveable and the spring of all movement: but it is not in any way subject to this First Cause. It is, indeed, wholly free and independent, except, perhaps, in the case where it is associated with matter, *ὕλη*. Mind, *νους*, is pure *εἶδος*, peculiar to man, which abides with the body during life and departs at death, whither is not distinctly stated. Soul, *ψυχή*, differs from *νους*, in being dependent upon body, which is a compound of *εἶδος* and *ὕλη*, and in belonging to plants and animals as well as to man. It is possessed of several energies or faculties, *δυνάμεις*—the faculty of appropriating nourishment, *δύναμις θρεπτική*; the faculty of sensation, *δ. αἰσθητική*; the faculty of motion in place, *δ. κινητική*; the faculty of impulse or desire, *δ. ὀρετική*; the faculty of intelligence, *δ. διανουτική*: and in more than one of these points it is difficult to see wherein it differs from *νους*. It would seem also as if the *εἶδος* entering into the formation of the *ψυχή* had lost some of its purity by being associated with *ὕλη*: and in short, the relations of the *νους* to the *ψυχή* are involved in much obscurity. In many points, certainly, there is a distinction without a difference. Indeed nothing is said to show why the *νους* has to do with pure imperishable *εἶδος*, and the *ψυχή* with the perishable compound of *εἶδος* and *ὕλη* which constitutes the living body, *ζῶον*: and the general impression left upon the mind is that the things of sense are more real than the things which do not come within the range of sense, and that in the *ζῶον* the *ὕλη* is quite as important a constituent element as the *εἶδος*. It is scarcely just to speak of Aristotle as a materialist in the modern sense of the word: it is certainly not right to speak of him in any sense as a spiritualist. His First Cause is little more than an abstraction, which for all practical purposes is extra-mundane. His *νους*, is very little more of a reality. His *ψυχή* is a shadowy entity which ceases to be when the *εἶδος* and *ὕλη* constituting the *ζῶον* separate at death: and all that can be said about it is that it is something contingent upon body, something which can be no more than a bodily function. There is no room in the system for the idea of immortality. At death the man is disintegrated: and what applies to man applies equally to all other living creatures. There is no room for the idea of perfection even. On the contrary, while alive, the body is supposed to have an inherent capacity for self-improvement or development which may, perhaps, have led to the gradual evolution of man from lower types of being, through that of woman it may be. There is no distinct realization of the idea of unity in diversity and diversity in unity, for the constant aim is, not to bring together, but to define and differentiate, except it be in the case of the living body, *ζῶον*, where the constituent elements, *εἶδος* and *ὕλη*, are often more or less confounded, by speaking of *ὕλη* as if it were all but actually *εἶδος*—as if matter, *ὕλη*, were potentially everything—and of *εἶδος* as if it might be so far materialized as to come within the range of the senses.

Aristotle always regards the things of sense as being really what they seem to be: Plato, on the other hand, regards them as mere phantoms, *εἴδωλα*, except so far as they derive reality from things transcending sense, to which he gives the name of ideas, *ἰδέαι*, the things of sense being, in fact, only copies or adumbrations of these ideas—a view according to which the world of appearances, the material world, holds from the ideal world which shines through it "its entire existence in fee." Everywhere, Plato is bent on recognizing a principle of unity in multiety and multiety in unity, by which all things are bound together in *one*, not only with each other, but with a Divine Being, who is at once the true centre of unity and the only source of being—who is not merely that which is divine, but divinity personified. not merely *τὸ θεῖον*, but *ὁ θεὸς*. "When," says Maurice, "we use personal language to describe the God of whom Plato speaks, we find that we are using that which suits best with his feelings and principles, even though, through reverence or ignorance, he forbears to use it himself. When we use personal language to describe the deity of Aristotle, we feel that it is improper and unsuitable, even if, through deference to ordinary natures, or the difficulty of inventing any other, he resorts to it himself. Theology can have no connection with the system of Aristotle." Theology, on the contrary, is the very marrow of Platonism. Without being inconsistent with his principles as a philosopher Plato could not be other than religious in one way or another. Without thinking that he was doing anything irrational he may have fulfilled the last wish of Socrates by offering in person a cock to Aisklepios. This he may have done with perfect sincerity: but not so Aristotle, who only escaped being put to death at Athens for atheism by escaping to Chalcis, and remaining there ever after, even until his death in the year 322 B.C. Plato, indeed, is always looking beyond the present. Realities, to him, are not the things of sense, *εἴδωλα*, but the ideas, *ἰδέαι*, underlying them. The idea of the Divine Being is the substance of every other idea and, therefore, of every *εἴδωλον*. The case is one of unity in multiety and multiety in unity, with the Divine Being as the centre, and not one of independence and separation in which every creature is its own centre. The case is one in which any energy, mental or other, is an imperfect manifestation of an energy of the same sort which is manifested in perfection only in the Divine Being. The case is one in which the limitations of within and without, of here and there, of now and then, merge, without confusion, for the *ἰδέα* which is the basis of every *εἴδωλον* is like the *ἰδέα* of the Divine Being in being free of space and free of time—in being, that is, ubiquitous and immortal. The case is one which agrees with the premises, for these, so far, both as regards form and force, point only to multiety in unity and unity in multiety: Life in all its aspects, mental and others, according to this view, is more than a mere bodily function, for its only foundation is in the ἰδέα which underlies the εἴδωλον, or rather in the ἰδέα of the Divine Being which is the substance of all ἰδέαι. Death attacks the εἴδωλον, resolving the partial into the general, the transient into the permanent, transforming it into the ἰδέα perhaps, but it does not reach the ἰδέα, which, by virtue of its Divine original, remains imperishable, immortal. Nor does death result in disembodiment, for, instead of being mere formless energy, the spiritual *form* of the εἴδωλον always remains in the ἰδέα—a form which may or may not be revealed to the senses. Indeed, Plato would have no difficulty in believing that the gods might appear among men, and again disappear, and that man, without any miracle, might undergo corresponding changes, because he believed in the material world as something which was capable of being idealized or spiritualized so as to be rapt away from the senses, and in the ideal and spiritual world as something not insusceptible of that transformation by which it could be brought within the reach of the senses.

Aristotle and Plato, in fact, represent two irreconcilable schools of thought. That which is divine, τὸ θεῖον, is to Aristotle no more than an impersonal First Cause, or energy, which is really extra-mundane rather than intra-mundane, and which works only in creation. That which is divine to Plato is a personal God, ὁ θεὸς, who may or may not be revealed to the senses, who is all in all in a system of nature in which a law of unity in multiety and multiety in unity is the law of laws, and who is the upholder as well as the creator of all things.

The εἶδος of Aristotle is independent force or energy, connatural with the First Cause, and becoming manifest to the senses only when it is associated with matter, ὕλη, The ἰδέα of Plato is something which is beyond the senses ordinarily but which, without the addition of any foreign element, ὕλη or other, may be revealed to the senses, something which is connatural with the Divine Being, on whom it is dependent for its very existence,—something to which the εἴδωλον stands in the relation of a dead crust or veil, rather than in that of a constituent element. Aristotle talks about νοῦς as pure εἶδος which enters the body at birth and remains in the body until death, but he chiefly concerns himself with the ψυχή, which in all its higher manifestations is undistinguishable from mind, and which is no more than a function of that compound of εἶδος and ὕλη which constitutes living being, ζῶον. As regards the ψυχή, which is the whole life of plants and animals, and the greater part of the life of man, the view taken by Aristotle is most cheerless. It is not lit up by a gleam of immortality. And even as regards the νοῦς the case is not much better, for this vital principle vaporizes, so to speak, into formless εἶδος at death, and so leaves the man to whom it belonged for a time—*nowhere.* Death, in short, is the end of man no less than that of every other living thing if this system be carried out to its legitimate consequences. Plato, on the other hand, does not concern himself with these differences between νοῦς and ψυχή, between εἶδος and ὕλη. The ἰδεα may be instinct with any and every vital attribute, and this life is unending, because it participates in the life of the Divine Being. Death dissolves the εἴδωλον, or terrestrial body, and sets free the ἰδέα, or spiritual body, the action of death being to remove an impediment to the manifestation of life rather than, as

Aristotle believes, to destroy life by killing a living body. And this setting free of life by death extends not only to time but also to place, for the simple reason that the *ἰδέα* of life must be as free of time and place as its Divine Original. In a word, the difference between Plato and Aristotle is substantially that which exists, and will ever exist, between the so-called spiritualists and the so-called materialists—a difference which Coleridge and Von Schlegel had in view when they said "every man is born a Platonist or an Aristotelian," and which every one who ventures to speculate upon the dark phenomena of mind, will do well to keep in view also.

The view of memory which is in favour at the present time is undoubtedly Aristotelian in its character. It takes in little or nothing beyond that which is subject to the senses. Memory is looked upon as contingent on the life of certain brain-cells—as a function of these cells. Let these cells die, and utter oblivion is the instant result. That is all, or nearly all, that physiologists now-a-days venture to say on the subject. It is impossible, however, to let the holders of this view pass unchallenged, or to allow that reason is on their side when they answer to the challenge. Nor is there any real difficulty in making good this statement.

There are several facts which make it difficult to believe that memory has no surer foundation than that which is supplied by perishable brain-pulp, and, so far as I can see, this difficulty is insuperable.

A case supplying one of these facts is related by Coleridge in his Biographia Literaria. "It occurred in a Catholic town in Germany a year or two before my arrival in Göttingen, and had not then ceased to be a frequent subject of conversation. A young woman of four or five and twenty, who could neither read nor write, was seized with a nervous fever, during which, according to the asseverations of all the priests and monks of the neighbourhood, she became possessed with a very learned devil. She continued incessantly talking Latin, Greek, and Hebrew, in very pompous tones, and with most distinct enunciation. This possession was rendered more probable by the known fact that she was a heretic. Voltaire humorously advises the devil to decline all acquaintance with medical men, and it would have been more to his reputation if he had taken this advice in the present instance. The case had attracted the particular attention of a young physician, and by his statements many eminent physiologists and psychologists visited the town and made cross-examination on the spot. Sheets full of her ravings were taken down from her mouth, and were found to consist of sentences coherent and intelligible each for itself, but with little or no connection with each other. Of these a small portion only could be traced to the Bible; the remainder seemed to be in the Rabbinical dialect. All trick or conspiracy was out of the question. Not only had this young woman ever been a harmless, simple creature, but she was labouring under a nervous fever. In the town in which she had been resident for many years as a servant in different families, no solution presented itself. The young physician, however, determined to trace her past life step by step, for the patient herself was incapable of returning a rational answer. He at length discovered the place where her parents had lived, travelled thither, found them dead, but an uncle surviving, and from him learnt that the patient had been charitably taken by an old Protestant pastor at nine years old, and had remained with him for some years, even until the old man's death. Of this pastor the uncle knew nothing but that he was a very good man. With great difficulty, and after much trouble, our young medical philosopher discovered a niece of the pastor's, who had lived with him as a housekeeper, and had inherited his effects. She remembered the girl; related that her venerable uncle had been much too indulgent, and could not bear to hear her scolded; that she was willing to have kept her, but that after her patron's death the girl herself refused to stay. Anxious inquiries were then, of course, made concerning the pastor's habits, and the solution of the problem was soon obtained; for it appeared that it had been the old man's custom for years to walk up and down a passage in his house into which the kitchen door opened, and to read to himself with a loud voice out of his favourite books. A considerable number of these were still in the niece's possession. She added that he was a very learned man, and a great Hebraist. Among the books were found a collection of Rabbinical writings, together with several of the Greek and Latin fathers; and the physician succeeded in identifying so many passages with those taken down at the young woman's bedside, that no doubt could remain in any rational mind concerning the true origin of the impressions made upon her nervous system."

"This authenticated case," continues Coleridge, "furnishes both proof and instance that reliques of sensation may exist for an indefinite time in a latent state, in the very same order in which they were originally impressed, and contributes to make it even probable that all thoughts are in themselves imperishable: and that if the intellectual faculty should be rendered more comprehensive, it will require only a sufficient and apportioned organization—the body *celestial*, instead of the body *terrestrial*—to bring before every human soul the collective experience of its whole past existence. And this—this, perchance, is the dread book of judgment in whose mysterious hieroglyphics every idle word is recorded! Yea, in the very nature of a living spirit, it may be more probable for heaven and earth to pass away than that a single act—a single thought—shall be loosened or lost from that living chain of causes, to all whose links, conscious or unconscious, the free-will, our only absolute *self*, is co-extensive and co-present."

As bearing directly upon these remarks, De Quincey also writes:—"I was once told by a near relative of mine (a woman of masculine understanding and unimpeachable veracity) that, having in her childhood fallen into a river, and being on the very verge of death but for the assistance which reached her at the last critical moment, she then saw her whole past life, clothed in its forgotten incidents, arrayed before her as in a mirror, not successively, but simultaneously; and that she had at the same time a faculty developed as suddenly for comprehending the whole and every part. This, from some opium experiences, I can believe. . . . . And of this I feel assured, that there is no such thing as ultimate *forgetting;* traces once impressed upon the memory are indestructible. A thousand accidents may, and will, interpose a veil between our present consciousness and the secret inscriptions in the mind. Accidents of the same sort will also rend away this veil. But alike, whether veiled or unveiled, the inscriptions remain for ever; just as the stars seem to withdraw before the common light of day, whereas, in fact, we all know that it is the light which is drawn over them as a veil, and that they are waiting to be revealed whenever the obscuring daylight itself shall have been withdrawn."

To the same effect, also, is the story told in a letter to the celebrated Dr. Wollaston by a former hydrographer to the navy, Admiral Beaufort, of his own experience in drowning—a letter which has, I believe, found its way into print before, but which I transcribe, as far as is necessary to my present purpose, from a manuscript copy in the possession of my friend Sir Thomas Watson, who, in fact, called my attention to it.

"Many years ago," writes the Admiral, "when a youngster of the 'Aquilon' frigate, after sculling a boat about Portsmouth harbour, I was endeavouring to make her fast alongside the ship, but, the tide being strong, and the boat sheering off, I foolishly stepped on the gunwale in order to reach the ring of one of the scuttles. The boat of course upset, I tumbled into the water, and, not knowing how to swim, all my efforts to lay hold either of the boat or of the floating sculls were fruitless. The transaction had not been observed by the sentinel on the gangway, and it was not until the tide had carried me some distance from the ship, that a man on the foretop saw the splashing in the water and gave the alarm. The first lieutenant (the present Rear-Admiral Oliver) instantly jumped overboard, the carpenter followed his example, and the gunner hastened into a boat and pulled after us. With the violent attempts to make myself heard I had swallowed a good deal of water, my struggles to keep myself afloat had exhausted me, and before any of my gallant preservers overtook me I had sunk below the surface. All exertions having ceased, all hope having fled, I *felt* that I was drowning.

"So far the facts were either partially remembered, or else supplied to me by those who had witnessed the scene, for during an interval of such agitation, the mind is too much absorbed by alternate hope and despair to mark the succession of ordinary events very accurately: not so, however, as regards the circumstances which immediately followed. From the moment exertion had ceased, which I imagine was immediately consequent upon complete suffocation, a feeling of the most perfect tranquillity superseded the previous tumultuous sensations. It might be called apathy. It was certainly not resignation; for dying no longer appeared to be an evil, and all thought of rescue was at an end. Nor was I in any bodily pain. On the contrary, my feelings were rather of a pleasurable cast, comparable, perhaps, to those of that dull, but satisfactory, state which precedes the sleep produced by fatigue. Though the senses were thus deadened, the activity of the mind seemed invigorated and excited in a ratio which defies expression, and thought succeeded thought with a rapidity which is not only indescribable, but probably inconceivable, by any one who has not himself been in a similar situation.

"The course of these thoughts I can now in a great measure retrace. The event that had just taken place, the awkwardness that had produced it, the bustle it had caused on board (for I had observed the two persons leap out of the chains), the effect it would have on my most affectionate father, the manner in which he would disclose it to the rest of the family, and a thousand other circumstances associated with home—these were the first ideas which occupied me. But my thoughts now took a wider range, and the events of the last cruise, a preceding voyage, a former shipwreck, the school where I had been educated, my boyish adventures and earliest exploits, every past incident in my life, glanced across my mind in retrograde succession, not in mere outline, as here stated, but with the picture filled up with every collateral detail. In short, my whole life seemed placed before me in a sort of panoramic review, and each act of it was accompanied by a consciousness of right and wrong, or by a reflection on its causes and its consequences; indeed, many trifling affairs which had long been forgotten then crowded into my mind with a sort of recent familiarity.

"It is remarkable that the innumerable ideas which thus crowded into my mind—with one exception at the outset about the feelings of my family—were all retrospective. Yet I had been religiously brought up; my hopes or fears of the next world had lost nothing of their early strength, and at any other period the most intense interest, or the most awful anticipation, would have been excited by the mere probability that I was standing on the threshold of eternity. Yet in that inexplicable moment, when I had a full conviction that I had crossed this threshold, not a single thought wandered into the future. I was wrapped entirely in the past. . . . .

"Whilst life was returning my feelings were painfully the reverse of those which immediately preceded the loss of consciousness. A single, miserable, confused belief that I was still drowning dwelt upon my mind—a hopeless and doubting anxiety, a kind of horrid nightmare, pressed heavily on every faculty and prevented the formation of a single distinct thought, and it was with extreme difficulty that I could at length convince myself that I was really alive. Instead of being free from bodily suffering, I was also tortured by dull, but deep pains; and though I have since been seriously wounded in all parts of my body, and subjected to severe surgical discipline, I consider my suffering to have been far greater at that time, if not in intensity, at least in general distress."

With such experience, it is no wonder that, in the course of this letter, Admiral Beaufort should put the question: "May we not infer that in the 'prolonged instant' in which the past was so marvellously opened out there is no faint indication of the almost infinite power of memory with which we are to awaken hereafter, and thus be enabled, or compelled, to contemplate our past life? Or, might it not almost warrant the startling idea that death is only a change or modification in our existence, in which there is no real pause or interruption."

In a note accompanying the copy of this letter, Sir Thomas Watson writes: "Many years ago a Mr. Impey, whom I met at dinner, told me that James Boswell (son of Dr. Johnson's Jemmy Boswell), who was a contemporary of his at Brazenose, Oxford, and was once nearly drowned, had afterwards declared to him (Impey) that he then felt a drowsy, sleepy, undulating sensation, and that in a very short space of time the minutest circumstances of all his former life appeared before his mind in rapid succession. The present Lord Romilly, and his deceased brother Edward, also knew of similar cases; the former of a gentleman rendered insensible by immersion in the Lake of Geneva; the latter of an acquaintance of his, a Mr. Ashmore (?), who was near being drowned in this country."

With facts like these to deal with it is more than difficult to be satisfied with any materialistic view of memory. How can anything that is so far imperishable find a home in perishable brain-cells, or in any other part of "the clay cottage in which man is tenant for life!" The brain-pulp is in the main made up, not only of water, but of water in motion: and if there were no surer foundation than this for memory the only result must be that which the poet Keats had in mind when he chose for the epitaph on his tomb (close by the pyramid of Caius Cestius at Rome) the words "whose name was writ in water." No doubt these brain-cells have some all-important office to discharge in relation to memory and all other mental faculties: but it does not follow that this is that which is taken for granted. They may have to help in keeping up that electrical state of the brain, and of the nervous system generally, without which any bodily manifestation of mental action would be impossible—that the brain and the rest of the nervous system is a wonderful telegraphic apparatus by which different regions of the body are put into communication. It may be that different parts of this apparatus are so set that certain parts of the grey matter of the convolutions have to do specially with particular movements, one part with speaking, another part with handling, and so on. Or it may be that they have work to do which has yet to be discovered. But do what I may I cannot bring myself to think that these perishable brain-cells have to serve as a record office for memory, and that the work of remembering is carried on within them. And certainly this difficulty is not lessened when the facts to which I have been directing attention are taken along with those about which I have next to speak—facts among which the first in rank, and the most significant, is the identifying power of memory.

The identifying power of memory is a fact upon the reality of which no question can be raised. Without this power there would be nothing but the consciousness of present existence—nothing to be remembered: for every time that any unnoticed object or subject came under notice again it must appear as another object or subject. Without this power, for example, the *days and years* of my own personal life must be broken up into disconnected *moments*, for there would be no means of bridging over the intervals of forgetfulness which recur every moment. Nay, there must be a continual confounding of my own identity with that of other persons and things whenever my thoughts roamed away from myself. If the power of identifying were destroyed it could not be otherwise. What then? How is it that I know that I myself am at all times I myself, and not another person or thing about whose reality I am equally convinced? Is it enough to suppose that this knowledge is conveyed through the senses to the sensorium, and there stored up for the use of the memory? The senses have much to do in the matter—too much perhaps: but they cannot do all that has to be done. The sensorium has much to do, but less in all probability than is commonly supposed. The senses have much to do in the primary acquisition of many facts and fancies, but when this knowledge is once acquired the memory would seem to have little or no occasion for their service. And, without question, the help of the senses is not more necessary in respect of memories which are beyond the reach of the senses, for in this case the senses can have nothing to do even with the primary acquisition of that which is remembered. Be this as it may, however, there is more in the remembrance of another person or thing than can be accounted for by cerebration or any reaction between the sensorium and senses, and this is the conviction of the identity of that person or thing. For how is this conviction to be acquired except by assuming an actual transaction between the person remembering and the person or thing remembered—a transaction which seems to imply a continuance of the interaction by which the memory took cognizance of the person or thing remembered in the first instance, or else a transference, so to speak, of the mind of him who remembers so as to allow a comparison of the copy in the brain with the person or thing copied. It cannot be enough to look at the copy: and, if it be necessary to compare the copy with that which is copied, then it seems to be necessary to believe that the power of identifying another person or thing implies a wider mental presence than that which is limited to body, a presence which is transcorporeal as well as corporeal, a presence which is in a measure superior to place, a presence which is altogether inconsistent with the notion that memory is no more than a mere function of certain brain-cells. The case, indeed, is one for a Platonist to deal with rather than for an Aristotelian. For a Platonist the senses and the sensorium alike must be impediments rather than helps in the acquisition of the *ideas* which underlie the things of sense, and which are the only realities. For him, instead of disconnexion, there must be universal unity in diversity and diversity in unity, with the Divine Being as the living centre of all things. For him, by reason of this all-pervading unity, all these ideas must be so far spiritual as to be superior to place. For him, memory must point to mind as something which is not to be confined within any corporeal limits—as something which is quite as much transcorporeal as corporeal. For him, the seat of memory will be, not in the sensorium exclusively, nor yet in the sensorium together with the senses, but anywhere and everywhere, wherever the mind has chanced to roam: and the act of remembering will take place wherever the mind was acted upon originally, no matter where. For him, it will be easy to dispense with the notion that the sensorium is a record office for memory, for, by reason of its ubiquitousness, the mind can have no difficulty in finding access to the original documents outside the sensorium. For him, once to know anything is always to be in the same case, and the act of *recognition* ceases to be separable from the act of *cognition.* Upon this view a thing once apprehended mentally from that time forth becomes part and parcel of the being who apprehends it, and it must be recognized if again brought under notice in any way without any question being raised as to its identity. Once held it is never let go: and by ever holding it the mind is satisfied as to its identity. Nor is this conclusion invalidated when the thoughts are turned from the mind to the body of which the senses take cognizance. For what is the actual case then? It is that this very body is inseparably bound to other bodies, to the universe at large, by the force of gravity. It is—as will one day be better known, I trust—that it is not less firmly held in this position by "the electric chain wherewith we are darkly bound." It is that it cannot claim more than a momentary tenure even in the matter of which it is made, for, in fact, this matter is in a state of perpetual flux. And thus even body may be generalized until it ceases to be a serious obstacle to the adoption of that generalization of mind which arises naturally out of the premises—a view according to which mind is to be looked upon, not as the result of cerebration, or of any other similar action, but as something which is common to nature generally—as something of which the substance, without any confusion as to identity, is *one* with that of the Divine Being who upholds nature.

Again: if mind has to be looked upon in this way it is no wonder that the records of memory should be indelible. In point of fact, the reasons for concluding that mind is superior to space necessitate a similar conclusion with respect to time. The *εἴδωλον* is time-bound as well as space-bound; the *ἰδέα*, from being connatural with the Divine Being who is everywhere present as the eternal Now, is neither space-bound nor time-bound. This is the Platonic doctrine. And so it may be that the records of memory are indelible because they are inscribed, not on the changeable *εἴδωλον*, but in the changeless *ἰδέα*, and the only wonder is—that they should ever seem to be erased.

Again: the view here taken of mind sheds not a little light upon the association of ideas. For if the ground once occupied by the mind be never vacated, does it not follow that the subjects or objects appropriated must ever remain in that particular relation to each other which they occupied in the first instance, so that for the memory to go back along any one chain of thought to any one link in that chain is of necessity to bring to the mind's eye the overlappings of the adjoining links?

Again: in this view of memory there is what would seem to be a sort of explanation of the strange backward way in which memory fails in old age, or under the ravages of certain brain-diseases. In this failure recent events are forgotten first, then those which are less and less recent in turn, until at last all that is remembered has to do only with early life. Some years ago, for example, I saw a french widow lady whose case supplies a memorable instance of the way in which these results are brought about by disease, the case being one of relapsing mania, with epileptiform symptoms, rapidly passing into dementia. Until she reached her sixteenth year this lady lived in France, and spoke only french; after this time she came to live in England, and began to speak english. When about twenty she married an american, and from this time, for about twenty years, she lived sometimes in America, sometimes in England, speaking english habitually, and french scarcely ever. When I saw her first, her mind was feeble, and that was all: when, after an interval of about two years, I saw her last, she had forgotten everything connected with her married life, her english not excepted; and if asked who she was, and where she was, she gave her maiden name, and mentioned the street where she had lived in Paris when a girl. So completely had she forgotten her english, and gone back to her french at this time, that it had become necessary to change an english for a french maid. What happened in this case, and happens to a greater or less extent in all cases of the kind, as well as in old age, is the very reverse of what might be expected to happen. It might be expected that the memory of early events would be the first to fade, and that of recent events the last; but in reality this is no necessary inference from the facts. If mind be spirit, indeed, it is possible that it may, as it were, go on widening through a series of concentric circles until it reaches its maturity, that, so long as it retains its full vigour, it may keep hold upon all the memories in each of these circles, inner and outer, and that afterwards, when a contrary movement to that of development is taking place, the mind may fall asleep, as it were, in circle after circle, until at last it only remains awake in the innermost circles of all; for if it be so it will follow that the memories of recent events, which are in the outer circles, will be the first to fade, and those of early events, which are in the inner circles, the last. That would happen, in fact, which is really found to happen, so that what seems to be exceptional at first may after all prove to be exactly in order when the law of mind is better known.

In speculating upon the phenomena of memory, therefore, I cannot prevent my thoughts from soaring to a region where the limitations of time and space are unknown, where, without loss of identity in either, body and spirit are substantially *one*, where unity in diversity and diversity in unity is the one thought which remains uppermost in the mind. I can find nothing in the mechanical conception of cerebration which may serve as a firm foundation for memory. I must seek far and wide beyond my actual corporeal presence before I find what I want for this purpose. I must even discard the notion that various bodies act and re-act upon each other from a distance through the instrumentality of simple *force*, and adopt in place of it the notion that these bodies, instead of being separate, as they appear to be to the senses, *commingle*, and act and re-act upon each other, not indirectly, but directly, by participating, as it were, in an atmosphere, *not of mere force but of actual being*. It would seem as if my mind keeps hold of any object or subject upon which it has ever taken hold, whatever it be, wherever it be, becoming one with it in no merely imaginary sense. It would seem as if I might find in my memory the proof that I myself, body and mind together, am bound to the universe and the universe to me by numberless indissoluble ties—that the sphere of my trans-corporeal presence is co-extensive with that of this universe—that I can only be fully myself when I recognise this relationship—and that the manifold mysteries of memory only begin to be disclosed when the doctrine of unity in diversity and diversity in unity, as paramount in nature, is made to serve as the key to them. And thus a further revelation of unity in diversity and diversity in unity is indeed the end of the whole matter—"only this and nothing more."

CHAPTER VI.

TRACES OF UNITY IN THE PHENOMENA OF IMAGINATION, WILL, AND INTELLIGENCE.

THE history of the memory is substantially the history of the imagination also, any difference being no greater than that which is produced in one and the same song by altering the key and words. And so likewise with the histories of the will and the intellect.

About the *imagination* it is difficult to think at all without becoming bewildered. A faculty which intermeddles with all things, past, present, and to come, ever spurning the bounds of time and space, and never ceasing to exercise a power which may be rightly regarded as *creative*, can scarcely be earth-born. Nor is the wonder lessened by supposing that the phenomena have to do with a dreaming rather than with a waking state of mind. Too often dreams are merely disjointed repetitions of waking thoughts and feelings, but they are not always so. They may sink to the level of lunacy or rise to that of prophecy. They are always too wild and disorderly to admit of being brought into subjection to any kind of physical rule. In the waking state the body always asserts itself with sufficient emphasis, but not so in the dreaming state. The dreamer, in fact, for the time, forgets his body as much as if he were actually disembodied. And why? Is it that in dreaming there *is* a partial escape from the world of appearances, the world of the senses, which is emphatically the world of the waking state? Is it that then, more clearly than in the waking state, man realizes, as belonging to himself, a *trans-corporeal presence*, the revelation being not altogether unlike that by which the relations of the earth to the universe are made known on a starry night "by the withdrawal of the *veil* of light"? Is it that then "a ladder reaching from the earth to mysterious altitudes above the earth" is set up for every man as it was once for the Patriarch Jacob? Is it that sleep, like death, is the gateway to a fuller life, because then the chain is loosened by which man while awake is fettered to a 'body of death?' So it may be; and, if so, then the story told by the imagination is the same as that told by the memory, with additions that give it greater emphasis and wider scope—a story of which the chief burden is still this, that, so far, the phenomena of mind point to *trans-corporeity*, and through trans-corporeity, to unity in diversity and diversity in unity, as the very foundation of these phenomena.

What holds good of the imagination and the memory would also seem to hold good of the *will*. How is it that I am *free* to say *yes* and *no*, and to act accordingly? How is it that the will of one man may control or be controlled by the will of another man? Not, surely, by taking a lower view of will than that which would seem to be necessitated by the history of the imagination and the memory. Indeed, the more the matter is looked into the more it becomes evident that the will requires a wider field for action than that which is to be found in cerebration, or any other mode of bodily action, as wide even as that required for the manifestation of the imagination and the memory.

In his Sylva Sylvarum (Century X., 945, 946), Bacon has said something which is much to the point here. "The problem," so runs the text, "is whether a man constantly and strongly beleaving that such a thing shall be (as that such an one will love him, or that such an one will grant him his request, or that such an one shall recover a sicknesse, or the like) it doth help anything to the effecting of the thing itselfe. And here againe we must warily distinguish, for it is not meant (as hath been partly said before) that it should help by making a man more stout, or more industrious (in which kind a constant beleafe doth much), but mearely by a secret operation, or binding, or changing the spirit of another. And in this it is hard (as we began to say) to make any new experiments, for I cannot command myselfe to beleave what I will, and so no triall can be made. Nay, it is worse, for whatsoever a man imagineth doubtingly, or with feare, must needs do hurt, if imagination have any power at all. For a man representeth that oftener that hee feareth, than the contrarie.

"The helpe therefore is, for a man to work by another, in whom he may create beleafe, and not by himselfe, untill himselfe have found by experience that imagination doth prevaile, for then experience worketh in himselfe beleafe, if the beleafe that such a thing shall be, be joyned with a beleafe that his imagination may proceede it.

"For example, I related one time to a man that was curious and vaine enough in these things, that I saw a kinde of juggler that had a paire of cards, and would tell a man what card he thought. This pretended learned man told mee, it was a mistaking in mee, for (said hee) it was not the knowledge of the man's thought for that is proper to God, but it was the *inforcing* of a thought upon him, and binding his imagination by a stronger, that hee could thinke no other card. And thereupon hee asked me a question or two which I thought hee did but cunningly, knowing before what used to be the feats of the juggler. Sir (said hee), doe you remember whether hee told the card the man thought himselfe, or bade another to tell it? I answered (as was true) that hee bade another tell it. Whereunto, hee said, so I thought, for (said hee) himselfe could not have put on so strong an imagination; but by telling the other the card (who beleaved that the juggler was some strange man and could doe strange things) that other man caught a strong imagination. I hearkened unto him, thinking for a vanitie hee spoke prettily. Then hee asked me another question: saithe hee, doe you remember whether hee bade the man thinke the card first, and afterwards told the other man in his eare what hee should thinke, or else that hee did whisper first in the man's eare that should tell the card, telling that such a man should thinke such a card, and after bade the man thinke a card? I told him, as was true, that hee did first whisper the man in the eare, that such a man should thinke such a card. Upon this the learned man did much exult, and please himselfe, saying, loe you may see that my opinion is right: for if the man had thought first, his thought had been fixed; but the other imagining first, bound his thoughts. Which, though it did somewhat sinke with me, yet I made it lighter than I thought, and said, I thought it was a confederacie between the juggler and the two servants, though (indeed) I had no reason so to thinke, for they were both my father's servants, and hee had never plaied in the house before. The juggler also did cause a garter to be held up, and tooke upon him to know that such an one should point in such a place of the garter, as it shoulde be neare so many inches to the longer end, and so many to the shorter. And still hee did it, by first telling the imaginer, and after bidding the actour thinke."

In the case in which one person is said to be "unable to refuse anything" the will would also seem to be affected to a certain extent in the same way. As the stronger person chooses the weaker person must needs say yes or no in words or deeds. The case, as it would seem, is not remotely akin to that about which Bacon speaks, or to the cases which are referred to mesmerism, or electro-biology, or hypnotism—cases to which one day a good deal more attention must be paid than is paid at present. Possibly, a time will come when the story told by Bacon will be found to have an important bearing upon the interpretation of all these cases. Possibly, when the matter is more carefully looked into, the *tongue* will be found to be continually testifying to the same effect, not only in saying *yes* or *no*, with little or no choice on the part of the speaker, but in much more lengthened utterances. I once knew, for example, a bright little english girl about five and a half years of age who could speak english or french or german with equal readiness, but who was unable to choose the language in which she had to speak. If spoken to in english she answered in english, and so also for french or german. She had a nursery governess, a german, who spoke french and english as well as her native language, and she it was who directed my attention to the curious fact in question and gave me more than one opportunity of verifying it. Again and again I heard the child addressed in each of the three languages named, and pressed to reply in one or other of the remaining two, and invariably without success. If pressed beyond a certain point she would cry, and that was all. On the part of the child there was no unwillingness to obey, and no inability to obey in any other case. Indeed, what puzzled the nursery governess and caused her to speak to me on the subject was that the child should be, as it seemed to her, perfectly good and obedient except in this one matter. Nor was the result different when the conversation was carried on by others. More than once I myself tried to prevail, and all I could do by coaxing, and by bribing as well, I did, but I failed as completely as the nurse. Whether the result would have been different if the child had been spoken to by another *child* I do not know. There were no other children in the house, and no polyglot children within reach; and, honestly, it did not occur to me to try this experiment while there was the chance. Nor do I know whether the peculiarity in question passed off as age advanced. Indeed, all that I know more is that this child was never strong, and that she died about eleven from some head-affection, which was supposed to have been brought on by pressing her education injudiciously; and this, also, is all that I would say upon the subject now, except this, that I have heard of more than one case in which, as in it, the words of a child would seem to have been prompted by another person in a way which is scarcely intelligible except upon the supposition that there is an actual commingling of *being* in the two.

And thus it is possible to discover traces of unity in the phenomena of the will no less than in those of the imagination and the memory, for this commingling of being may be looked upon as itself unintelligible unless it be assumed that different people are — by being subject to the law of unity in diversity and diversity in unity—substantially *one.*

So likewise with the intellect. The mighty power which speculates, not only upon the world of appearances, but upon such abstract mysteries as infinity, eternity, absolute goodness, absolute truth, absolute justice, unity, cosmical law, Deity—which is ever asking *why*, and never doubting that it is entitled to a satisfactory answer in every case,—which is as free of time and space as are the powers of memory and imagination, —is surely something more than cerebration or anything of the kind. And, as surely, this impression is only deepened by looking into the facts a little more particularly.

As it seems to me, the notion that the intelligence is something which is hemmed in within the bounds of the body or subjected to any kind of limitation, is flatly contradicted by the simple presence in the mind of any abstract idea. It is to me inconceivable that the idea of eternity, for example, can have a lodgement in a brain-cell. I might, *perhaps*, allow that impressions of a certain sort upon this cell may "by myriad blows" give rise to the notion of time; but that any multiplication of these impressions should cause the idea of time to change into that of eternity is altogether beyond my powers of comprehension. These two ideas have nothing in common; and to think that the idea of eternity should arise in this way, would seem to be almost as absurd as to suppose that a clock, by dint of continual clicking, should, instead of wearing out, come to be, not only a better timekeeper, but also a teller of what happens when time ends in the timeless eternal Now. In order to the conception of the idea of eternity, as it seems to me, there must be an intelligence which is in itself eternal,—a something which may belong to an eternal entity, but which cannot by any probability belong to mere temporal brain or body; and, deal with it as I may, I cannot think otherwise than that this conception of eternity is in itself an argument for supposing that in intellect, no less than in memory and imagination and will, there is something which points to *trans-corporeity* as a paramount reality in man. And as with the idea of eternity, so also with the idea of infinity or any other abstract idea, I cannot find room for that which is universal in that which at best is only partial; and thus it is, that in order to accommodate these abstract ideas, it is necessary to get outside the brain and outside the body, and to believe that the true sphere of the intelligence is co-extensive with that of the memory and imagination and will. Indeed, to do otherwise, and suppose that an idea like that of God, or eternity, or infinity, can be lodged in a brain-cell, requires, as it seems to me, a far greater stretch of credulity than that which would be needed in order to believe it possible that all the waters of the ocean could be gathered up in the hollow of a cockle-shell.

Evidence to the same effect is also to be found in the strange way in which, without any help from the senses, one person will often divine the thoughts of another person, or in which the same thought will often occur to two or more persons simultaneously; but it is not necessary to dwell upon these facts, or to cast about for any others, for enough has been said to show that the phenomena of intellect, no less than those of memory, imagination and volition, point beyond the body to a state of trans-corporeity, and, by so doing, make it all the more easy to entertain the idea that the doctrine of unity in diversity and diversity in unity is the only real key to the interpretation of these phenomena.

Chapter VII.

TRACES OF UNITY IN THE PERSONAL, SOCIAL, AND RELIGIOUS LIFE OF MAN.

Much remains to be done before it is possible to arrive at a satisfactory conclusion respecting the modes of life to which attention is directed in this chapter. And why? Would more have been done if more heed had been paid to the teachings of Plato? Would still more have been done if these teachings had led on, as they naturally do, to those of the inspired writers? An Aristotelian may sneer at such questions, a Platonist cannot do so. Indeed, Plato himself, if he were to re-visit the earth, would, in all probability, be most eager to recognize in these writers men whose vision was clear and far-reaching where his own was dim and purblind, and whose spirit was in all points congenial with his own spirit. Be this as it may, however, I cannot hope to advance far in the devious way which now lies before me if I refuse to accept the guidance of the so-called inspired writers, and choose to trust only to the *lumen siccum* of my own reason.

A great demand is made upon the reason in adopting this course, but, after all, this is not so great as that which is made by the evolutionist when dealing with the same matters. I am required to believe that man was created in the "image of God" and endowed with a god-like dominion over nature, and that he is *now* in a state of *death* with the chance of recovering all he has lost, and more. I am required to believe that man in his perfect state must love his fellow man and his God so as to be actually *one* with both. I am required to believe that the God in whose image man was made is perfectly good and true and just and loving, and at the same time the eternal, immutable, omnipresent, omniscient, omnipotent, self-existent, personal, I AM, in whom man lives and moves and has his being, and by whom all things consist. I am required to believe that man is almost the exact opposite of what he seems to be: and yet I dare not set aside the demand as unreasonable. On the contrary, I can dimly perceive that man is more, much more, than what he seems to be—that he may be, even as regards body, all that I am required to believe him to be—and that, in fact, no lower view than this will apply exactly to the actual case.

What has been already said about *body* makes it not altogether unintelligible that S. Paul should say that there is a body celestial and immortal as well as a body terrestrial and mortal, the one in every way real, the other comparatively unreal, the one "a house not made with hands, eternal in the heavens, and present with the Lord," the other an earthly tabernacle, burdensome in every sense, *naked*, and "absent from the Lord," the body terrestrial being something which is to be, not put off, as by a process of unclothing, but *clothed-upon*, mortality being swallowed up in life. "For we know that if our earthly house of this tabernacle be dissolved we have a building of God, a house not made with hands, eternal in the heavens. For in this we groan, earnestly desiring to be *clothed-upon* with our house which is from heaven, τὸ οἰκητήριον ἡμῶν τὸ ἐξ οὐρανοῦ *ἐπενδύσασθαι ἐπιποθοῦντες*: if so be that being clothed we shall not be found naked, *εἴ γε καὶ ἐνδυσάμενοι, οὐ γυμνοὶ εὑρεθησόμεθα.* For we that are in this tabernacle do groan, being burdened: not for that we would be *unclothed, but clothed-upon,* that mortality might be swallowed up of life, *ἐπειδὴ οὐ θέλομεν ἐκδύσασθαι, ἀλλ' ἐπενδύσασθαι, ἵνα καταποθῇ τὸ θνητὸν ὑπὸ τῆς ζωῆς.* . . . . Therefore we are always confident, knowing that whilst we are at home in the body we are absent from the Lord (for we walk by faith, and not by sight): we are confident, I say, and willing rather to be absent from the body, and to be present with the Lord."

Here, without question, the doctrine is that the body is, not always what to the senses it now appears to be, but sometimes this, and sometimes that which may be transfigured or translated—*transfigured* as it was in Moses when he had to veil his countenance, or in Ananias, Azarias, and Misael in the midst of the fiery furnace, or in the disciples at the day of Pentecost (when, perhaps, it was not upon the head merely that the tongues of fire rested), or in Stephen when his countenance shone like that of an angel, or in Christ when he underwent that change of which in aftertimes the vision inspired Fra Angelico to paint the fresco which still illumines the wall of the cell in the convent of S. Mark at Florence in which he lived and died, and Raphael to begin the wondrous picture, now in the Vatican, which he did not live long enough to finish—*translated* as it was in the evangelist Philip when he was caught away from the side of the eunuch and found at Azotus, or in Christ, when he hid himself from the angry crowd at Nazareth, or when he took bread and brake it at Emmaus. The present body, indeed, is represented, not as something which is to be cast aside as vile and worthless, but as something which may, without disembodiment, be spiritualized and glorified—as something which, like the body of angels and other celestial beings, may at one time be not unlike an ordinary human body, and at another transfigured or translated—as something which is changeable in a way which will appear natural to every child, and which cannot appear altogether unnatural even to the most matter-of-fact man. The child turns towards this view instinctively, and if the man does not do so it is because his instincts are blunted and not allowed to have free play. In other words, there is an imaginative faculty in both child and man which compels the reason to listen believingly, not only to what is revealed about the body terrestrial and the body celestial, and the mutual convertibility of the two, but also to what the poets have had to say upon the subject at all times and in all places. And, after all, there need not be any grave disagreement between the imagination and the reason in this matter, for after what has been said upon unity in diversity and diversity in unity, in form and force, the reason must allow that the transitory earthly body is associated with a form which is not transitory, and which, for anything that appears to the contrary, may be the very spiritual body of which the Scriptures speak so plainly.

What is revealed respecting God is also consistent with what is revealed respecting man in this matter. The God of the Scriptures is made known as walking and talking with Adam before his fall, as talking and eating with Abraham, as wrestling with Jacob, as appearing in glory to Ezekiel and S. John, but nowhere as mere disembodied Spirit. There is, so to speak, a distinct anthropomorphic element in the revelation of the Divine Being which is not to be explained away. In the vision of the four cherubim and four wheels, and of the glory of God, which Ezekiel saw in the land of the Chaldeans by the river Chebar, there was "the appearance of a throne, and upon the likeness of the throne the likeness of the appearance of a man above upon it," from the loins upward and from the loins downward irradiant with amber-coloured fire and light, and "this was the appearance of the likeness of the glory of the Lord." In the vision in the Isle of Patmos, S. John saw, still more distinctly, in the midst of the seven golden candlesticks, "One like unto the Son of man," glorified beyond measure, who declared Himself to be "the Alpha and Omega, the First and the Last, alive for evermore." And what S. John saw on this occasion was in keeping with what he had seen at the transfiguration on the mount, and again and again after the resurrection, for it is scarcely to be supposed that the form in which the Saviour then appeared was *only* that of man. Indeed, it seems to be in accordance with the general tenor of Holy Scripture to believe that there is, as I have said, an anthropomorphic element in the Deity, and that perfect divinity as well as perfect humanity was manifested at all times in the person of Christ, even before the resurrection.

Without disembodiment, therefore, man may be the "image of God." His present body, by resurrection, must be changed from the body terrestrial to the body celestial, as the body of Christ was changed by resurrection: and then, even as regards body, the Divine likeness, which is now marred so terribly, is not wanting in man. This is all. And if so, then there can be little difficulty in advancing further, and seeing more clearly at every step that man may, nay must, be "the image of God" in other respects also.

If the view set forth in the last chapter but one be correct, there can be no difficulty in finding a mental likeness to the Divine Being in memory. For what other meaning is to be attached to that superiority to time and place to which the memory testifies except this —that there is something in the mind of man which reflects the image of the Divine Being who is immortal and omnipresent. And if so, then it follows that the mind of man may find, as it would seem to do, a seat anywhere, and keep it, even in a stone, as in the case where Joshua took a great stone, and set it up under an oak that was by the sanctuary of the Lord, and said unto all the people, "Behold, this shall be a witness unto us: for it has heard all the words of the Lord which He spake unto us: it shall therefore be a witness unto you, lest you deny your God."

There is also in man a power to will and do which may well belong to one who is the image of Him who is all-powerful. I know that I may say yes or no, and defy any power, human or divine, to make me say otherwise unless I am so minded. I cannot account for the way in which I coerce the movements of my own mind and body, or am coerced by others, except upon the supposition that the will is supremely powerful. Indeed, after what has been said already, I am more than half compelled to regard my will as heaven-born rather than as earth-born—as indicating that I am nothing less than the image of Him who is all-powerful, and to believe that there is nothing really inconsequent in what is revealed about the dominion over nature which man had before the fall, or about the power to remove mountains which he may again have, if he have "faith as a grain of mustard seed."

As it would seem, also, all is confusion if the imaginative and intellectual faculties of man are regarded from any lower point of view than this. The work of the imagination is *creative* in the true sense of the word. It lies outside the world of appearances, but it is not the less real on that account. In every case it is real enough for the memory to take hold of it and keep hold of it as firmly as if it had been enacted in this world; and—as more than one passage in the Sermon on the Mount will serve to show—it were well if it were not so in very many instances. In every case it is difficult to find wherein the memorial record of a *fancy* differs from that of a *fact* either as regards vividness or persistency. And in very many cases it may be questioned whether the latter record has not much more to do with fancy than with fact—whether the fact itself is not so much dressed up by the imagination as to run no small risk of not being recognized if this dress were removed—whether the fact would assert itself at all as such without this dress. At all events, the creatures of the imagination are sufficiently real to warrant the conclusion, not only that the imagination is *creative* in the true sense of the word, but also that the power which may be exercised in this direction is altogether beyond measure. Nor is a different conclusion to be drawn from the history of the human intelligence. It is short of the truth to say of man, with Hamlet, 'in understanding how like a god,' unless it be understood that this god is The God to whom omniscience must be attributed. Indeed, the more the history of the imaginative and intellectual faculties is looked into the clearer it becomes that here man is, potentially, the image of the All-wise Creator, and that illumination comes to him, 'not by penetration, microscopic inspection, and syllogistic groping from one syllable of the book of nature to another, *whereby one* *gets its words indeed, but not their sense,*' but 'by soaring and surveying,' or rather by patiently receiving the 'inspiration of the Almighty which giveth understanding,' 'the creeping and touching processes of the understanding and reason belonging not to the *finding*, but to the *proving* and *confirming* of truth.' Be this as it may, however, of this there need be no doubt—that in one way or another the imagination and intellect of man are powers which may justly lay claim to the very highest parentage, even though this be that of the All-wise Creator himself. So that here, no less than in the points which have been already under consideration, man may be rightly regarded as the 'image of God.'

And even on that side of humanity which lies most in shadow there are features which seem to belong to a Divine Being who is perfect in goodness and truth and justice, and who at the same time is loving to all his works. The likeness here, no doubt, is terribly marred, but it is not to be mistaken. It is far from being that of a fiend—very far. Willingly or unwillingly, man is compelled to recognize the rightful supremacy of goodness and truth and justice and love, and to see, more or less clearly, that he can only be at peace with himself when he acts up to his convictions in this respect. His conscience will not be silenced. In reading the words, 'Thine ears shall hear a voice behind thee saying this is the way, walk ye in it, when ye turn to the right hand and when ye turn to the left,' he knows full well what is meant. He not only hears this voice, but he recognizes it as the voice of a Ruler to whom he owes allegiance. Nay he is not without hope that brighter days are in store for him in which he will hear the voice more distinctly and obey it more willingly—days in which the law in his 'members' will cease to be at war with the law of his mind—days 'after which, saith the Lord: I will put my laws into their minds, and write them in their hearts; and I will be to them a God, and they shall be to me a people: and they shall not teach every man his neighbour, and every man his brother, saying Know the Lord; for all men shall know me, from the least to the greatest.'

And, lastly, I am driven to the same conclusion by the conviction of my own personality. I know that I have a perfect right to say *I am.* And why? Surely by no lower right than that which is conferred upon me as the image of Him whose name is I AM! On this ground my right is indefeasible; on any other ground I am in the same predicament as "the beasts that perish." And thus, in my name no less than in my nature, I am constrained to believe that man *is* literally what he is revealed to be—the "image of God."

Nor need the keen sense of my own shortcomings prevent me from reasoning in this way. On the contrary, these very shortcomings may be nothing more than the necessary consequence of the state of *death* in which, according to the Scriptures, I now am. I am required to believe that Adam *died* on the day on which he fell, and that thenceforth his state and that of his descendants, has been a state of *death*—a state which, for anything that appears to the contrary, may mean obscuration to any extent of the divine image in man, obscuration to the extent at present met with even. And if so, then, instead of being a stumbling-block in the way of receiving what is revealed respecting man, the very imperfections at present met with in man only serve to attest the trustworthiness of the sacred record.

Taking this view of the personal life of man it is easy to advance a little further and see why the philosophy of Plato should lead, step by step, from the individual man to the idea of a republic of men under the personal superintendence of a Divine Being, and why a higher philosophy than that of Plato should bring men together in a church with Christ for its head—it is easy, that is to say, to find a key to much that would otherwise be very unintelligible in the social and religious life of man.

Sociology, with self as its centre, is, to my mind, no key at all to the social life of man. Instead of tightening it loosens the bonds which bind husband to wife, parent to child, friend to friend, man to man, and all men to home and country. Man cannot, if he would, altogether shut himself up in self. He dimly perceives that self-sacrifice must be the paramount law of his being. He feels himself disgraced if he does not risk his own life to save that of another person. He shudders at the mere thought of an execution; he cannot look upon a dying person, even when death comes in his most peaceful guise, with indifference. He feels, in these and a thousand other ways, that Jean Paul was speaking quite soberly when he said "the heart of man takes more into itself than his head, and the better man must needs despise himself if his arms should reach only round a single planet." And this feeling must gain upon him just in proportion as he realises more clearly the boundless capacity of that something belonging to him which is called the heart—which finds expression not in selfishness, but in selflessness,—which strives unceasingly to enter into communion with all mankind and with nature generally, and which may be nothing less than one of the many ways in which man is made to know that the doctrine of unity in diversity and diversity in unity, of which so much has been said, is no empty dream. And if this doctrine of unity be the only true foundation of sociology then it ceases to be matter of wonder that the social and personal life of man are not to be disjoined, and that the second great law should be "thou shalt love thy neighbour as thyself," for how can it be otherwise if the being of man is connatural with that of Him whose name is Love?

Nor is this conclusion at variance with that which may be drawn from certain passages in the religious life of man to which I am at liberty to refer here. In these passages man is represented as imperfect now, and as remaining imperfect unless he become the recipient of certain divine gifts which are at his disposal if he seek for them in the right quarter and in the right way. This seems to be the main purport of these passages; and it is not at all surprising that it should be so. It is certainly true that man is imperfect now. It is certainly true that man is not content to remain in this state, and that a way has been already opened out by which he has been able to effect a partial escape from it. How this way has been opened out is not so certain, but the facts would seem to point to superhuman rather than to merely human means. Much genius and talent has been at work, but it is difficult for man to claim sole credit on this score. It is usual to speak of genius and talent in every form as imparted—as *gifts*—as *divine gifts:* and, to say the least, it is very difficult to say that it is not right to say so. Do what he will, man cannot get rid of the feeling that the *divine gifts* which, for instance, are symbolized in the cap of Hephaistos, in the winged sandals and diamond-bladed weapon of Hermes, and in the shield of Pallas Athené, are real necessities, and that he must be endowed and empowered, as

Perseus was, before he can hope to get the better of the Gorgon, or spirit of evil in one shape or another, whose will it is to prevent him from gaining the object of his hope, his Andromeda, *by turning him to stone.* Nay he can not quite get rid of the fear that he is already punished in this manner in some measure for failing to secure these gifts, for may it not be that he *is* partially devitalized, materialized, *turned into stone,* whenever he persists in mistaking, as he does do continually, matter for spirit, death for life, a dead idol for the living God? And if he can arrive at this point he has not to go much further in order to be able to accept as true what is more clearly revealed in Holy Scripture about faith and prayer and spiritual gifts and the necessity for self-sacrifice, for he will be quite prepared to allow that the many deficiencies in human nature of which he is so painfully conscious can only be remedied when that is imparted by which human nature is assimilated to the Divine Nature —when, in fact, the prayer of Christ for His disciples is answered, even this—"that they all may be one: as thou, Father, art in me, and I in thee, that they also may be one in us—that they may be one, even as we are one: I in them, and thou in me, that they may be made perfect in one." Instead of being staggered by these words, he will cling to them as containing the fullest assurance of the truth of the doctrine about which so much has been said, the doctrine of unity in diversity and diversity in unity, with the Divine Being as the centre of unity. Instead of looking upon faith and prayer generally as of necessity opposed to *law,* he will recognize in these acts the natural means by which he is to attain to his full stature as the "image of God." Step by step along a firm pathway he will arrive at this conclusion, and at every step he will feel less disposed to yield to the temptation of making use of faith and prayer in opposition to *law*. Indeed, it is not too much to say that along with the power of faith and prayer there will ever be a strong disposition to say "not my will, but thine be done," and that, for this reason, the man who is full of faith and prayer will be as little likely to interfere with the natural workings of *law* as the most unbelieving and prayerless Aristotelian.

And certainly I know of no evidence in favour of the doctrine of evolution which ought to lead to a different conclusion.

It is taken for granted that the fossil remains of the plants and animals which are entombed in the cemetery of the rocks supply such conclusive evidence, but, as it seems to me, upon very insufficient grounds. It is quite true that the remains of dicotyledonous plants are confined to the cainozoic or more recent fossiliferous rocks: that those of monocotyledons are met with, not only in the lower mesozoic rocks (palmæ in the trias), but also in the upper palæozoic rocks (aroideæ in the coal measures); and that remains of gymnosperms (conifers) vascular plants (lycopodiaceæ, ferns, equisitaceæ) reach down far into, and cellular plants (algæ) almost to the bottom of, the palæozoic series of rocks. It is quite true that the remains of mammals—with the exception of those of marsupials, which are met with in the mesozoic rocks—are confined to the cainozoic rocks; that the remains of birds reach down to some depth in the mesozoic rocks; that those of reptiles over-pass those of birds and reach the upper palæozoic rocks; that those of fishes (ganoids and plagiostomi) are met with in the latter rocks; and that the remains of invertebrata are buried deeper down still, the more simple forms the deepest of all. To some extent also, the more simple plants and animals reach deeper down than the less simple. But, in fact, these forms, plant and animal, more simple and less simple, extinct and non-extinct, are mixed together—for example, the conifers and cycadaceæ with the algæ, the crustaceans and brachiopods and annelids and cephalopods with the sponges and polypes—in such a way as to make it more than difficult to believe that the more simple had precedence of the less simple in the order of development. Indeed, I do not see why the plants and animals may not represent the spoils of *different* districts at the same time rather than those of any *one* district at different times—why the plants and animals of different districts should not have differed as they differ now, say in Australia and India, and why, for this reason, the rocks formed from the *debris* of these districts should not differ in their fossil remains as much as they do in their inorganic constituents, and this all the more as the difference in their inorganic constituents would seem to point conclusively to difference of district. And, most assuredly, many difficulties will have to be cleared away before it is possible to follow the latest and most uncompromising of the evolutionists, Professor Häckel, in the path along which, by dint of much pushing and leaping, through many intermediate forms, many of them purely imaginary, he tries to make his way from the monera to man—a path of which the following brief and pithy itinerary, given by my friend Dr. Elam in a remarkably interesting work just published *, is not a gloss or caricature, as it may seem to be, but a simple abstract of the text. Thus:—" 1. The *Monera* is the earliest

* "Winds of Doctrine: an Examination of the Modern Theories of Automatism and Evolution."

form of life. It arose in the Laurentian epoch by spontaneous generation from inorganic matter. Its acceptance as our earliest ancestor is *necessary* 'on the most weighty general grounds.' 2. The *Amœbæ;* and 3. The *Compound Amœbæ* come next. They are to be accepted on embryological considerations; as also are 4. The *Planœada*, represented by some ciliated animalculæ. 5. The *Gastræa* (Urdarmthiere) are a purely imaginary class of animals. They are placed here because required as ancestors for the *Gastrula*, itself an imaginary order, derived from embryological exigencies. 6. The *Archelminthes*, or earliest worms, represented now by the *Turbellaria*. 7. The *Scolecida*, the actual annelidan representatives of which are not known. 8. The *Chordonia*, also a purely imaginary type, having no extinct or living representatives, but being '*undoubtedly*' the progenitors of all the Vertebrata, through the Ascidians. 9. The *Acrania*, represented by the Amphioxus, the lowest form of vertebrate animal, a rudimentary fish, having certain resemblances to the Ascidians. 10. The *Monorhina* which was the parent stem of the sharks, through the Amphirhina, represented by the modern lampreys. 11. The *Selachii*, or skark-tribes, from which sprang—12. The *Dipneusta*, or Lepidosirens, from which originated—13. The true *Amphiuma*, and 14. The *Sozura*, another order of Amphibia, interpolated here, 'because required as a necessary transition stage between the true Amphibia,' and 15. The *Protamniota*, or general stem of the mammals, reptiles, and birds. "What the Protamniota were like," says Professor Huxley, "I do not suppose anyone is in a position to say," but they are *proved* to have existed because they were the necessary forerunners of—16. The *Pro-mammalia*, the earliest progenitors of the

Mammalia. The nearest living genera are the Echidna and the Ornithorhynchus. 17. *Marsupialia*, or kangaroos. 18. The *Pro-simiæ*, or half-apes, as the indris and loris. 19. The *Menocerca*, or tailed apes. 20. The *Anthropoides*, or man-like apes, represented by the modern orang, gibbon, gorilla, and chimpanzee, amongst which, however, we are not to look for the direct ancestors of man, but amongst the *unknown* extinct apes of the Miocene. 21. The *Pithecanthropi*, or dumb ape-men—an unknown race—the nearest modern representatives of which are cretins and idiots!! They '*must have*' lived, as a necessary transition to—22. The *Homines*, or true men, who 'developed themselves from the last class by the gradual conversion of brute howlings into articulate speech,' &c., &c." *Ohe, jam satis est.*

Nor is a different conclusion to be drawn from the manifold modifications which so many plants and animals undergo under the fostering care of man and in other ways, and which are often regarded as improvements upon nature. Thus: the rose may be *improved* from the wild rose of the hedges into the queen of the garden. Thus: the dog may be *improved* from the wolf-like wild dog into the tame, friendly, noble St. Bernard dog. But the manifold changes producible in these and countless other plants and animals are never so great as to constitute *species*, never more than those which go to make up the differences called *varieties:* and, in fact, constant care on the part of man is needed to prevent these varieties from speedily reverting to the original type. And what other conclusion can be drawn from the infertility of mules than this—that there *is* a barrier between different *species*, even between those which are most closely akin to each other, by which they are kept apart most effectually. Nay, it is even difficult to find any evidence in favour of evolution in the history of the rudimentary creatures whose very vitality may be somewhat doubtful. *Bacteria*, the simplest of all living units, *may*, as Dr. Bastian points out so cleverly, be developed (possibly from inorganic elements) almost at the will of the experimenter into monads, and amœbæ, and paramæciæ, or into the lowest forms of fungi—into forms of animal life, that is to say, or into forms of vegetable life: but not much is to be built upon this fact in favour of evolution. For what follows? Simply this—that, instead of passing on into higher forms of being, these forms are unstable in the highest degree, and always in haste to break up again into bacteria. The tendency to retrograde is, to say the least, quite as marked as the tendency to advance; and, as respects evolution, the conclusion to be drawn here is even that which has been drawn from the history of the rose and dog—this and no other.

Nor can I find any evidence of a contrary sort in the doctrine of unity upon which so much has been said. According to this doctrine, each *εἶδωλον* has a *firm* foundation, through its own *ἰδέα*, in the Divine Being, Who is "the *same* yesterday, to-day, and for ever." According to this doctrine, what is involved is, not only unity in diversity, but diversity in unity. I am not at liberty to think that any one difference can merge in another, or that diversity can ever be lost in unity; and, to my mind, the doctrine of unity in diversity and diversity in unity has little or no bearing, direct or indirect, upon the doctrine of evolution.

In a word, there is, so far as I can see, nothing to be said in favour of evolution which need prevent me from concluding that each creature was created as a necessary part of a great whole, perfect in itself, and perfect in its relations to other creatures, and to the universe to which it belongs—so perfect as to deserve to be spoken of as "very good"—and that man originally was no brute-descended savage, living in a wilderness, and fighting his way upwards, step by step, to a higher level, but a demi-god, walking and talking, as a child with his parent, with the God in whose image he was made, until for some fault of his own he was driven out into the wilderness, 'wretched, and miserable, and poor, and blind, and *naked*,' and so far oblivious of everything relating to his high descent as to put Moloch in the place of God—nothing to prevent me from adopting the conclusion already arrived at that man is in the full sense of the words the "image of God," and that his life, personal, social, and religious, only ceases to be enigmatical when this old-fashioned doctrine is used as the key to it.

Nor is the dignity of the Godhead in any way compromised by regarding man as the "image of God." For what is the conclusion to which I have been compelled to come respecting man? It is that he is more than that "mortal man, immersed in blood, encased in flesh," and "lapsed in time and passion," about which the senses speak so loudly. It is that he has, in addition to this "body of death," not only an undying corporeal presence, which may or may not be made manifest to the senses, but also a trans-corporeal presence, which is no less than immortal, ubiquitous, god-like spirit. It is that he is a being, not apart and alone, but *one* with all men, and with nature as a whole, and with Him who is the author and upholder of nature. The view taken, indeed, is one in which man, in order to be wholly himself, must enter fully into this wide and high and deep communion. It is impossible to stop short of this conclusion. In other words, the sphere of humanity—by being thus more than co-extensive with that of nature—is wide enough to include the very widest conception of divinity, even though this should go on widening for ever: and, therefore, without at all lowering the idea of the God-head, it is quite conceivable that man may be the "image of God," and also that "the *invisible* things of Him from the creation of the world are *clearly seen*, being understood by the things that are made, even His eternal power and Godhead." Nor does the idea of the Godhead become indefinite by so regarding it. On the contrary, among the invisible things of Him which are clearly seen in the things that are made may even be a glimpse of Unity in Trinity, and Trinity in Unity, for this, to my mind, is the most distinct vision which remains when the eye, dazzled by the contemplation of unity in diversity and diversity in unity, as revealed in nature, is raised from nature to the God of nature.

Δόξα μόνῳ τῷ Θεῷ.

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