THOUGHTS ON HEALTH,

AND SOME OF ITS CONDITIONS.

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PREFACE.

I HOPE these few papers, though of necessity they do but touch the outskirts of the subjects they refer to, may have the one merit of increasing the reader's desire to be better acquainted with them.

I have endeavoured to trace the connection of each special subject with universal laws; and to show it as an instance of an order wider than itself. But I wish in this respect I had done something worthier: I mean something worthier of those glimpses and fore-shadowings of human and spiritual meaning which science, though she gave promise of them from her birth, yet now presents in such increasing multitude and brightness. I am quite sure my own feeling in this respect represents that of thousands; that we seem, when we study nature as science shows her, as if we caught the echo of some distant music—so faint sometimes that we can hardly be sure whether it be not our own fancy merely, and yet so much beyond anything our fancy could have suggested, and, withal, coming so persistently, floating in from every side, shaping itself ever anew, yet in every new form recalling the same strain, that we cannot refuse the glad persuasion that it is a real music which we hear. When shall we hear it fully?

Not so very long, I think. Because already all other voices begin to hush themselves and listen. The world listens: not because it may seem indifferent, is indifference in its heart. Amid the turmoil of its business and its strifes, any one who notes it with an eye not too self-engrossed for sympathy, sees that the world listens. It stands expectant, and its eyes are fixed on science. "We have waited long, have believed often, have often been deceived, but we have one hope yet left, O men of science," it says, "and that is in you. For knowledge we have asked as for bread, and many have given us stones; for solid facts to build our life upon, and many dreamers have beguiled us with their visions. O searchers out of all things, is it for you that we have waited?"

As I believe, it *is* for them. How can it be otherwise. When a man's heart speaks most truly to him, does it not say, "Oh that I were as Nature." When he looks around him, if he dares to wish at all, what is it he can wish but that the fatal discord between man and Nature were resolved? That fateful holder of the key of order that is not restraint; of peace that carries passion in its bosom; of rectitude that needs no law; bears she not in her charmed hands the secret also of his rectitude and peace? Will not those who love her, and devote their lives to her, tell us what it is?

If knowledge puffed them up with pride they would not; if their hard-earned triumphs so filled their souls that they thought nothing was withheld from them. Then we know we should wait in vain. But it is not so. The surest proof of coming knowledge has been given us in the words which own its absence. On all hands from the men who study nature we hear one confession: "We do not know:—what nature *is* we have not found, and shall not find." But in those very words *we* recognize her voice. Our guides have found her, for she speaks in them. They have found her, and they know her not; for she is better than they thought. Seeking assurance of knowledge, they have found consciousness of ignorance; seeking a substance away from them and stranger to their souls, they have found a Power that is known only in its action upon them. They have not found what they sought, indeed; but when did ignorance ever foreknow what would reward her search? A Power known in action, and in action only, this do our guides announce to us: a Power whose *self* they have sought and find it not, are sure they never will find.—Would to God they could say the same of man.

Is nature selfless? Is this what they tell us? They have found the secret of the universe; our secret. It is enough. There is the passion which is rocked in perfect peace; the freedom which no law restrains, yet which fulfils all law; the order which unreason cannot break. O image of Divinity, type and model of all perfectness, a worthy interpreter you have found at last. Your riddle has been guessed, your lesson read, your promise enrolled clear within our hearts. Man shall follow in your footsteps, shall attain your joy: he shall cast out the self.

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CHAPTER I.

HEALTH.

A DEAF and dumb boy being asked what health was, replied, "It is pleasant life." And whether or not the enforced concentration of his thoughts gave them a special clearness, it is difficult to see what other answer could have come much nearer the truth. For a pleasant life is a different thing from a life with many pleasures: of these, if health be wanting, there is not one that may not become the instrument of pain, palling upon a deadened sensibility, or jarring on over-excited nerves. For pleasant life, health is at least the first condition.

And not for pleasant life only, but often for useful or amiable life. How much of the social unhappiness of men arises from deranged system or disordered brain, perhaps we shall never know until that paradise to which all such things were strangers is restored; but we know that a large part of our social grievances has its root in nothing else. How to keep ourselves vigorous in mind and body, so as to be always fit for work and ready for enjoyment—to preserve unbroken that keen sense of life which makes it a luxury to draw our breath, that exhilarating feeling of self-command which makes toil a pleasure, and is itself a sure augury of success, is a problem we should all be glad to solve. Without going so far as the physician who maintained that a man's theological opinions depended on the state of his liver, we yet know very well how our feelings vary with our bodily condition, how dismal the world looks during a fit of indigestion, and what a host of evils disappear as the abused stomach regains its tone. Even in a money point of view, to be always "in condition" would be equal, in the case of most men, to a considerable addition to their fortunes; work would go twice as far, and quarrels would be but half as frequent. I have heard it argued, indeed, that lawyers have quite as large an interest in the ill-health of mankind as doctors.

But health, like virtue, seems more easy to admire than to achieve. Is it not, indeed, the virtue of the body, and only to be attained by compliance with a system of rigid rules, and a life of scrupulous exactitude? No. Its preservation involves no such sacrifice, cannot be purchased, indeed, at any such price.

A certain father of the Church said to one who asked of him rules for living, "Love, and then do what you like." So it might almost be said to any one inquiring how to be healthy. "*Understand*, and then do what you like." It is possible, indeed, for men in certain states of society to fulfil most of the laws of health—which are very simple—without any knowledge on the subject. Circumstances enforce upon them fresh air, exercise, natural rest, temperance, quietude of mind. But under any conditions these cases are not numerous, and in these days they are very few indeed. The time for an unconscious fulfilment of the laws of health is practically past. We must either know or suffer. For not a few of the very refinements and advantages of modern life have a direct tendency to interfere with the conditions necessary to health, unless precautions are taken: gas, for example, especially as introduced into dwelling-houses; papered rooms, of which the walls are thick with arsenic; even the system of drainage itself. Things that subserve our comfort or our pleasure may unsuspectedly undermine our well-being, unless we know the principles on which it depends, and are ever ready to apply them to circumstances as they arise.

Fortunately, as has been said, the principles of health are very simple. As there are few things which are better worth knowing, so there are very few which it is easier to know. And this is especially the case if they are looked at in a common-sense way, and traced to their grounds. That air, exercise, plenty of good food, but not too much, sufficient sleep, but without sloth, temperance, cleanliness, freedom from anxiety, are the great means of health, is known to almost all. But this is not enough, unless the reason be also known. Without that, no hearty application even of remembered truths can be expected, and the simplest principles will be in perpetual danger of being forgotten. Besides, under press of business, or temptations from pleasure, there arises a constant tendency to question facts which are known only empirically, or accepted only on authority. We doubt whether the principle is quite certain, or the practice so very necessary. To make them of their full value to us we ought to know the reason of the laws of health.

Happily this is for the most part quite within our power. The root which the main principles of Hygiene possess in nature, and the manner in which they exemplify the operation of universal laws, are capable of an exhibition as beautiful and satisfactory as the principles themselves are practically important. But we must begin far enough back.

It is curious to reflect how quietly we take our life; how much a matter of course it seems to us that we have all the faculties we possess—the capacity of motion, of feeling, of thought, of executing our designs. All these things we do so naturally, as it were so spontaneously, and by our own immediate power, that the elaborate mechanism by which they are accomplished quite escapes our thoughts. In these days, when a certain knowledge of the animal structure is so widely spread, we can all of us enter somewhat into the feelings of astonishment and admiration which filled the minds of the first anatomists, as the wondrous structure revealed itself in ever-increasing complexity and beauty to their gaze. Of these feelings, indeed, physiology still bears, almost too strongly, the impress. The wonder and admiration have been so great, as to keep too much in check the search after causes. But let us ask ourselves, as they must have done (though less able than we are to give more than a very general answer to the question), what is the meaning of this vast apparatus of muscle, nerve, and gland? Why was this artful mechanism planned, this liberal profusion of contrivances prepared? The reply is obvious—this perfectly appointed body, which we each inhabit, is the proof that we are not the possessors of that independent power of which we seem so conscious. The investigation of our own structure teaches us that we truly employ forces from without, when we seem to act by the mere exertion of our will. The living frame is a machine for placing under our control, and at our use, the powers of nature. So far as our body is concerned, we live and act by *them*.

The laws of health, therefore, are simply the laws of nature. This is the principle on which the intelligent management of the body rests. Our powers, being nature's powers, are subjected to the same conditions which pervade the rest of the world.

It follows, also, that in order to understand the requisites for health, we must not confine our study to life alone. The conditions on which it depends are in some respects expressed more simply, and may be more easily read, in familiar objects around us, than in the hidden and complex mechanism within. In that which we observe without, we may discover oftentimes what seems like an unravelling of the close-woven web of life.

Nature is full of activity. Every particle of dust is the seat of subtle powers. From the gravity which binds worlds together, to the cohesive force which moulds the crystal, there exists, throughout, an unbroken chain of action. Forces are operating everywhere, either in constant energy or intermittent violence, by silent insensible influences, such as those by which light engraves a picture, though our eyes may not discern it, on every object upon which it falls, or in sudden outbursts, like the volcano or the storm. The earth is a magnet ; electric streams circulate continually across its surface ; by marvellous affinities its constituent elements call to each other and they come. Given the problem, therefore, to provide for man, from the dust of the earth, a body full of activity, dowered with capability to respond to nature's infinite appeal, and fit to be the organ of his will, and we see that the means are at hand. Here is matter, rich to overflowing with forces ready to be placed at his command. How should the body then be made ? of all this vast array of powers, which should be chosen for man's service ?

It were hard to have answered, ere the work was done; but we know which was chosen, and can recognize in some degree the wisdom which the choice reveals. The force of *chemical affinity* was raised to this dignity, to be the minister of man; it is made the agent in the realization of his purposes, the fulfiller of his will. For the power of the body arises simply from the chemical changes which take place within it; its life consists in the presence of the conditions which those chemical changes demand; and its health is in the perfectness with which those conditions are maintained, and those changes carried on and regulated.

At once, then, we have the key to the laws of health. They are all summed up in this:—to provide for the due maintenance, and the unhindered performance, of the chemical changes on which the activity of the body depends. To do that is to insure, so far as it is in our power, the perfection of our instrument; to fail in it is to incur inevitable loss. Life has no exemptions, is treated with no favour. We can no more live with the conditions of chemical change within our bodies wanting or deranged, than we can fire a cannon with damp gunpowder, or with none.

I have said we can discern reasons why chemical affinity was chosen as the physical power for man to wield. We can see its eminent and perfect adaptation to that purpose. It is true, indeed, that all arguments of this kind have something of a vicious circle about them. They amount to little more, at last, than that effects follow from reasonable causes, and do not take place in a manner irrational or impossible. Yet it is both pleasant and profitable to trace such relations, and the moral value of the process may outweigh its logical defects. Premising, then, that we do not know, as yet, what chemical affinity is, and have very few hints as to the causes on which it may depend—* premising this, it is evident that matter with chemical tendencies, such as we know it to possess, is a material exquisitely adapted to constitute a living body. What is wanted in such a body? The chief demands are, clearly, that it should be instinct throughout with a capacity for moving; that it should be quick to

* Very few; but not quite none. We see "chemical affinity" evidently imparted to certain bodies by the action of various forces—light and electricity, for instance. The conversion of the chemically passive common form of oxygen into the chemically active ozone, by subjecting the former to electric shocks, is a notable instance. Another is the case of chlorine and hydrogen, which when mixed in the dark remain separate, but after light has fallen on them for a time unite into hydrochloric acid. But in tracing the part played by chemical affinity in life, we take it up as existing in nature, without asking its origin.

respond to a stimulus, from whatever source applied, whether external or internal ; that, while retaining its form and structure unimpaired, it should be capable of manifesting force in any variety of modes, so that, within the bounds of the reasonable desires of man, the will should but need to speak, and the act should follow ; and lastly, that it should have power of self-maintenance and repair.

All these things are provided for in the chemical affinities of matter. Elements endowed with this power, when brought into relation with each other, unite with the manifestation of a force which is perfectly enormous in proportion to their bulk. Oxygen and hydrogen, mixed together, and subjected to an electric spark, unite in water with a loud explosion ; and Professor Faraday has shown that the force which holds together a single drop of water is equivalent to that of a powerful flash of lightning. The explosive gases which cause such fearful calamities in our coal-mines exhibit the power of chemical affinity. Engineers have recourse to it whenever they wish to bring to bear the greatest possible amount of force. But it can also be as gentle as it is mighty, and not least mighty when it is most gentle. It reminds us, though only to show how poorly man's work compares with nature, of the steam hammer crushing iron bars one minute, and cracking nuts the next. Advancing with noiseless step, chemical affinity eats away the stone of our public buildings, and by like action on the mountain rock, it changes the surface of the earth. It is mighty—and weak, yet insuperable in its weakness; it is all-pervading, present in every place, and penetrating into the inmost recesses of every body. It may be brought into play by the slightest stimulus, as in fulminating powders which the touch of a feather will explode, or may remain passive amid incessant change.

A body constructed out of elements thus endowed, is evidently suited to become the organ of a being with wants and desires such as man's. There is provision alike for the exertion of that sudden force which our more energetic actions demand, and for the gentle and continuous processes of secretion or of growth. It is only necessary that these powers should be taken due advantage of. And in the living body this is done; the elements are brought together in that state in which their powers are active, and available for use. They are grouped in modes in which their affinities are unsatisfied, so that they tend to combine afresh. It is no otherwise than as the sportsman charges his gun with elements which tend to recombine, and which can satisfy their affinities only in the formation of new compounds. Such elements, whether within the body or out of it, will give forth their force upon demand.

And chemical affinity is the more perfect as the instrument of life, inasmuch as it has its seat in every particle. Thus the body is not a passive mechanism wielded by forces from without, but one active in itself, and in every part. It is like an army, which also is a whole, or unit, animated by one will, but each constituent "atom" of which is a living agent, and joins his individual forces to the rest. This it is which in great part causes the striking contrast between the living organism and any mechanical contrivance. The latter is a passive mass, containing, or moved by, extraneous agencies; the former is active throughout, and its entire substance contributes to its force.

But a limited use only of chemical power is made for the purposes of life. By no means is the whole range of the affinities which connect the various elements brought into play. The activity of the body is made to depend, so far as we can yet see, mainly upon one process, the union of oxygen with its substance. An animal, physically considered, is mainly a great oxidizing apparatus. By the incessant performance of this process the living frame becomes full of power, which is manifested in the various modes familiar to our experience. Thus, to think rightly of organic bodies, they should be regarded rather from the point of view of their *action* than of their substance; rather as *processes* than as things. "The flame of life," we say, and with a wonderful truthfulness; there is hardly one point in relation to the bodily life which the flame of a lamp does not illustrate. For what is such a flame? Does it not consist in—is it not wholly constituted by—the union of oxygen with the oil? It is an *action* rather than a thing. Definite as is its form, it is not a "substance," but a state of burning. Its particles are never the same for two successive moments; the carbon and hydrogen which make up the oil pass into it, undergo a change (giving off therein their latent force), and pass off again. The flame is a permanent condition of continually changing materials. In this it is wonderfully like ourselves—I mean like the bodies in which we dwell. They also are permanent conditions merely, impressed on ever-changing materials. We live and act in a constant burning. The materials we consume as food, passing into us, undergo a change (giving off therein their latent force), and again pass off. The matter has come and gone, the body remains. That is a state, an active state, a process carried on within fixed limits, and in a definite form—it is a flame.

Some other natural objects place the same conception before us in a form still more simple. I never see one of those spiral pillars of dust which, like a mimic simoon, rush along the road upon a windy day, without thinking, "There is an image of life." Dust and a breath! Observe how the apparent "pillar" is but a condition, an active condition, of the particles of dust, and those particles continually changing. The form depends upon the incessant movement. The heavy sand floats on the impalpable air while it partakes its motion; let that cease and it falls. So the dull clods of the field, smitten by force, take wings and soar into life, partake for a time its rapid course, and then, the force exhausted, fall back into their former state. A whirl, a flux, maintained by forces from without, and ceasing when they are withdrawn;—that is our life.

Nor should we object to illustrations such as these of sand-pillars or of flames, that they are of simple form and yielding substance, or that they involve a rapid, unintermittent, and, as it were, violent action to maintain them. Forms as simple are seen in the first grades of vegetable or of animal life; forms more simple, indeed, mere cells or shapeless masses, of which we can only say, they live. Many conditions have conspired to mould the frame of the more developed races. Nor does the firmer texture of the living organism than of the flame, imply a less degree of transience in the one than in the other. Gases and a little solid matter in a state of oxidation constitute the flame; gases and a little solid matter in a state of oxidation constitute the body. The mode only is different: the flame is gaseous, the body semi-solid; the one is to the other as vapour is to water. And if we contrast the fierceness of the flame with the mild and almost insensible processes of life, we must remember that we cannot be sure there is any such difference as there appears to be. Life may be like a flame diffused, and each particular combination as energetic in the most delicate structure of the body as in the sevenfold heated furnace. One thing is certain, the force resulting is as great.

But there arises a question which must be discussed before we can go any farther—What is the difference between the living and the dead body? Chemical actions take place in the latter; it is, indeed, given over to the control of the chemical forces, and perishes by their operation. How is this, if its life consists in the use of the chemical powers?

There is apparently separated from the body, when it dies, something which it previously possessed; and this is, perhaps, the chief foundation of the idea that has been entertained of life, as something existing apart from the other physical powers, and capable of being added to, or withdrawn from, an organism, without any other immediate change. But if we look more closely into the facts, we see that the appearance tends to deceive us here. The body is not dead when, as we say, the breath leaves it. It ceases, indeed, to be the instrument of the soul, but that is only because its integrity, as a mechanism of mutually related parts, is destroyed. It is dead as the body of a man, not dead in itself. The life is in each portion still, more or less completely; as is proved by the fact that, for a time, the beard or nails will grow, the limbs move, and the glands secrete. But the offices which the various organs perform can no more be carried out in concert, either through damage inflicted upon one, or by a general weakening of all; and accordingly the actions necessary to maintain the life of the whole cease to be effected. The body first breaks down as a machine, and then only dies as a body. After its individual or active life has ceased, by derangement of the requisite adjustments, the life that pervades every part gradually wears out and ceases for want of support and renewal.* The function of each part is needed for the maintenance of all; and when one utterly fails, and the sooner in proportion as its office is of more essential use, all gradually decay. Thus, if the respiration be diminished beyond a certain point by disease within the lungs, or the heart become unable to maintain the circulation, the body ceases at last to have force sufficient to keep up the necessary actions of the other organs, and these actions cease. The frame lies motionless and insensible, and decay invades it unresisted. It is thus life seems suddenly to leave the body. The actions of which a living organism is the seat form a continuous chain; like a circle, they begin at every point; each dependent upon every other. The external functions of moving and the like, by which the animal provides its sustenance, are maintained by the minute chemical changes which take place within; these latter changes are kept up only by means of the external functions, which supply the food or air, or ensure other requisite changes of condition.

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* The former of these is termed the *animal life*, and consists in the functions by which the creature is related to the external world, and especially in all that comes within the power of its will: the latter is termed the *organic life*, and consists of minute changes taking place within the organism. At the instant of death the animal life only ceases.

We come back, then, to our fundamental conception of the animal body; that it is essentially a state of action—of chemical change—in particles of matter, dependent chiefly on the union with them of the oxygen of the air. From this one idea we can trace the use and the necessity of all the chief functions on which life depends. Food must be taken, regularly and in certain variable quantities, to afford the materials in which this change may go on. And the food must be mainly of a certain kind; it must consist of substances with which oxygen has a tendency to unite, that is, of substances which are prone to decompose. Matters with which oxygen is already combined to its full extent, or which do not readily combine with that element, are indeed necessary as food, but their part, though essential, is subordinate. The mass of the food must consist of organic, that is, of animal or vegetable substance.

Again, air must be inhaled; and this process must be constant. The absolute necessity of a continuous supply of air, though that of food may be taken at intervals, or even interrupted for considerable periods, is easily explained. If those actions within the body which the oxygen maintains, once come to an end (except, perhaps, under some very exceptional conditions), the life is gone. The chain, being broken, cannot be again united. But the oxygen must be supplied afresh for the consumption of each four or five seconds (the interval at which an adult man or woman breathes when in health and at rest), because no store of it can be retained, as in the case of food. It acts immediately it comes into relation with the fitting elements of the body. Its influence is in its presence. But there is also another reason for the necessity of a constant renewal of the air. The products of respiration are poisonous. The particles of the body when combined with oxygen result in compounds which are incompatible with vital action: they choke it, somewhat perhaps as ashes choke a fire; and hence the most injurious of these, the carbonic acid, is carried off immediately by the returning breath. And further, the air must be pure. It is oxygen, and oxygen uncontaminated, that sustains the vital change. Air loaded with the products of respiration, or of artificial lights, is as unfit for breathing as dust is for food; and for the same reason: its chemical capacity is gone—its affinities have produced their effect. Indeed, it is far worse. Dust would but cheat the stomach, affording no pabulum for the blood, but leaving unhindered in its changes whatever of wholesome food there might remain in it. Impure air, in so far as it is impure, not only contributes nothing to the life of the body, but robs it of what life it has, and directly impedes the changes which it should sustain.

And not only must food and air be consumed, but the processes of secretion must be freely carried out. By these, not only are the "dead," or chemically useless, materials which have served their part removed from the body, but changes of the utmost consequence are effected in the blood, raising and intensifying its vital state. The chemical tendencies within the body are exalted by the changes which attend the casting off of its worn-out materials, and the due performance of this part demands the two next essentials for a healthy life—exercise and cleanliness. From active labours in the open air, from the freest possible transudation through the skin, comes Life, and with it, cheerfulness, energy, and peace.

Lastly, for health are needed pleasurable activity of mind, and freedom from depressing cares. The mental operations, like all others, are connected with changes in the material of the body. In all our consciousness the chemical tendencies of the substance of the brain come into play, and thus a chain of action is set up which extends throughout the system. The influence of these brain-changes is felt wherever a nerve travels, and modifies, invigorates, or depraves the action of every part. Experience gives ample proof of this fact to every one, as in the sudden loss of appetite a piece of bad news will cause, or in the watering of the mouth excited by the thought of food. And the history of disease abounds in evidence of a similar kind: hair becoming grey in a single night from sorrow, milk poisoning an infant from an attack of passion in the nurse, permanent discoloration of the skin from terror, are among the instances on record.

CHAPTER II.

FOOD—WHAT IT IS.

CIVILIZATION rests on hunger. Whatever part Mr. Darwin's *Struggle for Existence* may have played in the development of the animal creation, it has certainly had no mean place in the development of man. The recurring and unfailing stimulus which the stomach supplies, lies at the root of those energetic efforts by which men gradually advance from ignorance to knowledge, from impotence to full dominion over nature. Without the necessity of eating, they would probably never have exerted, they would never even have discovered, half their powers. Men *ought*, therefore, to be hungry. Failing appetite, the human race had been a failure altogether.

Accordingly, a continual demand for food has been attained in man's construction. He carries his task-master within him, and, spite of his laziness, becomes a working animal. No inconsiderable achievement this! Nor is it the less admirable because, in the nature of things, it must be. That nature of things itself is admirable.

We must eat, because we are not the possessors, but only the users, of the power which we exercise. We draw from nature at once our substance, and the force by which we operate upon her; being, so far, parts of her great system, immersed in it for a short time and to a small extent. Enfolding us, as it were, within her arms, Nature lends us her forces to expend; we receive them, and pass them on, giving them the impress of our will, and bending them to our designs, for a little while; and then—— Yes; then it is all one. The great procession pauses not, nor flags a moment, for our fall. The powers which Nature lent to us she resumes to herself, or lends, it may be, to another: the use which we have made of them, or might have made and did not, written in her book for ever.

Nature folds us in her arms—and feeds us with *milk.* Scattered through the animal and vegetable kingdoms lie the various substances which are blended in the mother's breast. Man, guided by an instinct, which his highest refinement and most perfect knowledge can but sanction and develop, gathers these substances together, to make from them a sustenance that almost exactly repeats his earliest food. Regarding the essential elements, and overlooking the accidents of form and mode, we may strictly say that man, wherever he is rightly nourished, is fed on milk. And, indeed, in whatever form the food may be taken by the mouth, the blood is fed on milk at all times; the main result of the digestive elaboration which they undergo being to reduce all viands to a milk-like fluid—chyle.

But what then is milk? It is a combination of several very different ingredients, each of which has its own part to play in the living body. Besides water (which constitutes about nine-tenths of it), milk contains casein, the substance out of which the cheese is made; fat, which yields the butter; sugar, which is sometimes extracted, and is then known as "sugar of milk;" and, lastly, various salts, the principal being common dinner salt, and phosphate of lime or bone earth.

Any food on which man can live a healthy life, must contain virtually the same ingredients:—a substance analogous to cheese, and known by the general term *albuminous;* fat; sugar, or starch; earthy matter, or salts; and water. These are not the only essentials of food, but they are the chief.

That we need in our food flesh-like matter, to renew our wasting flesh, and earthy matter, to make strong our bones, is evident. But why should we need also fat, or starch, or sugar, especially the latter, of which our bodies do not seem to consist at all?

We may perhaps obtain a clue to the purpose which sugar serves when taken as food, by observing what occurs in it when placed in corresponding circumstances, external to the body. If a solution of sugar is kept in a warm atmosphere, exposed to the air, and a small quantity of yeast be added, we know that it ferments; the sugar resolves itself into carbonic acid and alcohol, *and the yeast grows.* Here are two opposite processes going on together, and mutually connected—the decomposition of the sugar (which is attended with the absorption of oxygen), and the growth of the yeast. We will not ask at present which of these processes is the cause of the other; it is enough that they take place together, and that, at least, the growth will not go on, if the sugar be not decomposed.

Now the yeast is composed of the same matter of which our own bodies mainly consist. Like them, it is an albuminous substance: and it grows, as we have seen, on condition of the waste and decomposition—in fact, the partial burning away—of sugar. May it not be, then, that our bodies also grow—are made to increase or live—on the same condition? and that the sugar, taken as food, wastes and is burnt away within the system; while by its means, the other, yeast-like, elements of our food develop into more life?

This would be simply the same thing occurring in the body, that occurs without. We may, therefore, well believe that such mutually dependent decomposition and growth take place in the system, though perhaps, as yet, it can hardly be said to be proved. The fact that starch is converted into sugar in the body, before any further use is made of it, renders the idea more probable. It is not meant that the process of digestion, in this respect, is the same as fermentation, but simply that it is analogous. There is nothing in the body that corresponds strictly to the cells of yeast, nor do the sugar and starch of the food *ferment*: although carbonic acid is formed from them, alcohol is not.

But whether this view be true or not, it presents to us an idea, long ago suggested by Liebig, and of the truth of which there scarcely exists any reasonable doubt: namely, that our food consists of two portions essentially distinct—one designed to furnish the materials of our bodies, the other designed to furnish *force*. Liebig fixed his attention chiefly on the heat, which man, in common with the other warm-blooded animals, produces, and which amounts on an average to 38° in temperate climates, and in cold climates to much more; the heat of human blood, in health, being everywhere about 98° Fahrenheit. Accordingly, Liebig divided food into the two classes of tissue-forming and heat-producing substances; the former comprising the albuminous materials, with a certain proportion of the oleaginous, or fatty; the latter, or heat-producers, comprising the greater proportion of the fatty substances, and all the sugar and the starch. All the structures of our body, with the exception of the fat deposited in certain parts (which can hardly be regarded as essential when the animal is considered in respect to its active powers), consist of, or largely contain albuminous materials.

But what, then, distinguishes these "albuminous" materials? Chiefly this: that they contain nitrogen, from which fat, and starch, and sugar are entirely free. Nitrogenous substances are found in all our organs. We can partly see a reason for this in the characters which nitrogen possesses. Of all known bodies, it is that which most strongly tends to the gaseous state, and which constitutes, accordingly, the most unstable compounds. The activity, or proneness to change, of animal bodies, seems to depend chiefly on the presence of nitrogen within them, and its inveterate tendency to escape, and to become free again. "The mobility of nitrogen," says Dr. George Wilson, "makes it pre-eminently the modifier of the living organism. Like a half-reclaimed gipsy from the wilds, it is ever seeking to be free again; and not content with its own freedom, is ever tempting others, not of gipsy blood, to escape from thraldom. Like a bird of strong beak and broad wing, whose proper place is the sky, it opens the door of its aviary, and rouses and flutters the other and more peaceful birds, till they fly with it, although they soon part company." The ordinary cotton, which remains so permanent under all conditions, and even burns so slowly, differs from the explosive gun-cotton, chiefly by the addition of nitrogen to the latter. And this may illustrate the difference between the slow-changing sugar, starch, or fat, and the quickly-decomposing, force-exerting muscle.

It is curious to observe, in respect to nitrogen, how the very same qualities fit one element for purposes apparently the most opposed. As a gas, nitrogen is passive, inoperative, almost entirely free from tendencies of any kind, and fit therefore to be a mere diluent of the too-powerful oxygen. It is the fluid in which the vitalizing air is dissolved, as we mix potent substances with water, to moderate and equalize their force. Combined, on the other hand, into the solid form, nitrogen becomes full of intense activity, and constitutes substances which are fitted, by their extreme liability to change, to become the instruments of sensation or of will.

Nor is it uninteresting to note that, in these respects, oxygen presents characters exactly the reverse. This element is active and prone to change in its free or gaseous state, tending to oxidize every substance that is capable of undergoing that process; it is passive and stable when combined. Surely in these deep relations, and in the adjustment of the living body to their demands, we have glimpses of a profound harmony and a far-reaching adaptation, the full recognition of which might raise to a worthier level our conception of creative wisdom.

The non-albuminous portions of our food—the sugars, starches, fats—are also fitted by their chemical relations for the part they serve. Less prone to change than the nitrogen-containing bodies, they yet have a tendency to undergo changes of their own.

They tend to unite with oxygen, this union being much facilitated by the presence of the albuminous bodies, which, changing more readily, give them as it were a start. Sugar and starch consist of equal values of oxygen and hydrogen (the proportion which forms water), and about the same amount of carbon. They are called, therefore, carbo-hydrates (that is, carbon-waters), and may perhaps be rightly regarded as water containing carbon diffused through it. Thus the carbon readily attracts oxygen to itself, and forms carbonic acid ; carbonic acid and water being the products of their decay or burning. Fat and oils, of every kind, also consist of carbon, hydrogen, and oxygen, but in them the oxygen is in less proportion. They are not merely water and carbon, but if there be any water in them, then both carbon and hydrogen must be considered as diffused through it. Accordingly, these oleaginous substances, in their burning, take up more oxygen, and give out more force.

Thus as the escape of nitrogen seems to give their primary activity to the organs of the body, so the absorption of oxygen gives rise to the force which the subsidiary portions of the food supply. The heat of the body is derived from oxidation ; not, however, of the carbo-hydrates and fats alone, but, in their turn, of all its structures too: for these, either in the act of fulfilling or after they have fulfilled their functions, are partly burned with oxygen as well.

In these processes—the casting forth of nitrogen, and uniting with oxygen, each of them being a source of force within the body—consists emphatically the animal life. And thus we recognize the relation of the vegetable to the animal world, as the great preparer of its food. For the plant performs processes the very reverse of these. It combines nitrogen with its tissues, and forms albuminous bodies;* it gives off oxygen, separating it from carbonic acid, and thus forms starchy bodies and fat. By this means it provides a store of force-containing materials for the animal's use; all the principal elements concerned are placed in their active state; the carbon and oxygen tending to unite, the nitrogen tending to liberate itself. There is a store of force here which the animal needs only to appropriate, to give it power to act.

Food is force. The transference of vegetable

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* This nitrogen, however, is not absorbed from the air. It is derived by the plant only from the chemical compounds which nitrogen forms; and chiefly from the volatile ammonia (the pungent "spirit of hartshorn") in the air, and from the salts of nitric acid in the soil.

matter to the animal, in its eating, is like the placing a tense spring within a watch. The animal structure is the mechanism, and the force which is in the food, operating through it, produces the animal functions as its results. The plants are our purveyors; they gather strength for us from the air and earth, reducing the impalpable and evanescent forces of light and heat into solid and enduring forms, in which we can grasp them with our hands, and consume them with our teeth, appropriate them to our own substance, and make them our immediate servants. The advancing army of animal existence bears in its train a commissariat, whose system never breaks down, and which turns to best account the resources of all lands.

But the non-nitrogenous elements of food have other offices besides that of producing force. Fat is essential to the formation of every structure in the body, especially of the brain and nervous system, which consist in great part of a peculiar fat combined with phosphorus. It is present also, in great quantity, wherever specially active growth and development of cells are taking place. Accordingly it exists largely in the yolk of the egg, one-third of which is composed of oil. This oil gives the yolk its yellow colour and rich taste; it seems to be especially used in the development of the blood cells. Fat is essential also to the right digestion of all food; and there are many facts which prove that an insufficiency of fat or oily matters in the food tends to produce scrofulous disease. Thus, although fat is chiefly consumed in cold countries to act as fuel, and to supply the enormous amount of heat required in them, yet its use is universal. If the inhabitants of the arctic regions gorge themselves with animal blubber, those of the tropics season their lighter dishes with vegetable oils, which those climates yield in especial abundance. It may be that the soft fluid acts as a corrective to the watery, pungent, acid, and cool things which are so refreshing to the frame. So we add oil to salads.

Starch and sugar, too, have other parts to play besides being directly consumed to furnish force. By the separation of oxygen from them in the body, they may be converted into fat; but the presence of a certain amount of fat in the food is essential to this process. Boussingault found, by experiments on animals, that starchy matters (such as potatoes) will not fatten, unless a little fat be also given with them. When this is done, fat is accumulated in a much greater amount than the quantity consumed. Bees, too, if fed upon sugar alone, cannot long continue to form wax; but if a minute portion of fat be added to the sugar, much more wax continues to be secreted than the fat could supply. The instinct, therefore, which leads us to mix butter with potatoes is justified by physiology.

Sugar, also, by forming an acid within the digestive system, acts the part of a solvent upon the other food, and by mixing with the albuminous and earthy matters, causes them to be more easily absorbed. So the egg contains a small proportion of sugar, which aids in the absorption of lime from the shell, to form the bony fabric of the chick. It does not follow from this, however, that the free use of sugar in its separate form is desirable. The ordinary articles of vegetable food contain sugar (or starch, which in the body is converted into sugar), in large proportion; and there is good reason to believe that in its naturally-combined form it is both more easily digested, and more available for the purposes of nutrition, than when crystallized. The ordinary sugar of commerce, moreover, derived from the sugar-cane, is not capable of being directly applied to physiological purposes. Cane-sugar is converted within the body into another kind of sugar, identical with that derived from the grape, before it can enter into the circuit of the vital changes. This modification involves no other change of composition than the taking into combination a little more water. The form of sugar which results is called glucose, and is more easily fermentable than cane-sugar. Their relative composition is — cane-sugar, 12 of carbon to 12 of water; grape sugar, 12 of carbon to 14 of water.

Thus the main current of our life flows on. The organic elements of the food, in their two great forms, supply us on the one hand with the substance we appropriate, and on the other, with the power by which we live, and the heat which makes us glow with vital warmth. But other elements, besides these, are needful. In its highest flights, life does not utterly forsake the ground; the human body, depending upon inorganic salts for its existence, confesses its origin in dust. Common minerals—iron, sulphur, phosphorus, soda, potash, lime, and others—circulate in the blood, or are garnered in the various tissues. And these also are furnished in the food, the various vegetable products containing them in varying quantities. The instinctive choice of certain articles of food, which characterizes, sometimes, whole nations, seems often to be determined by the presence or absence of certain of these elements. The importance of the saline ingredients of food is proved by an experiment made by the French academicians, who fed a dog, daily, on half a pound of boiled flesh that had been previously soaked in water and pressed; in the course of forty-three days the animal had lost one quarter of its weight, and after fifty-five days its emaciation was extreme.

The inorganic materials exist in the body in two forms; partly combined in minute proportions with the albuminous substances, and partly in the form of salts simply dissolved in the fluids. The total quantity of salts contained in the blood is seven or eight parts in the thousand, of which common salt, the chloride of sodium, constitutes about the half. Various of these inorganic materials serve evident uses in the economy. Lime, for instance, united with phosphoric acid, gives solidity to the bones. The alkaline salts also play an important part. Through being alkaline, the blood holds its albumen in solution, and more readily absorbs the digested food, which has been rendered acid by the gastric juice. The alkalies also promote the oxidation and removal of the worn-out materials which the blood carries to the lungs, and there casts off. The chloride of sodium furnishes hydrochloric acid to the gastric juice, while its free soda goes to constitute the bile, and other alkaline secretions. It has been found that cows, with whose food no salt was mingled, after some months lost their hair, and fell into bad condition. And the almost universal desire for this substance, among both men and animals, indicates its physiological necessity. Travellers in Africa have described the intense longing for salt, which a continued use of vegetable food without it induces. Yet it is curious that in certain countries salt is not consumed. Professor Johnston mentions, as instances of this, the South-Western part of Africa, and Berezov, in Siberia. Whether an extraordinary supply of salt is otherwise furnished in these districts, has not been ascertained.

But of all the inorganic elements, none seem to exhibit so striking an adaptation to become a constituent of the organic body as *phosphorus*. The peculiar characters of this substance, fitting it for vital uses, were first described by Professor Graham, the late Master of the Mint; and Dr. G. Wilson has since illustrated the subject with all the acuteness of his searching intellect and the wealth of his graceful fancy.

Phosphorus, in its common and first discovered form, is a soft, semi-transparent substance, resembling wax; it shines even at the freezing-point of water, melts a hundred degrees below the boiling-point of that liquid, bursts into flame in the air at a temperature a little higher, and yields a thick white smoke, condensing into a snow of phosphoric acid. It is so inflammable that it can be preserved with safety only under water or other fluids, and there is scarcely a chemist who has not been in some degree a martyr to its flames. It is so poisonous that not a year passes without some poor child falling a victim to the small portion which it thoughtlessly eats from a lucifer match, and without some incautious lucifer-match-maker suffering the prolonged tortures of slow poisoning which its daily administration in minute doses occasions. It reacts so powerfully upon the air in which it is permitted to fume, that it changes its oxygen into the energetic, oxidizing, deodorizing, and bleaching agent which is known as ozone. In a word, it exhibits in an intense degree an affinity or tendency to combine, alike with metals and non-metals, and strikingly alters each by its union with it.

In so far, then, as mobility, or susceptibility of various changes, is concerned, no one will question the fitness of phosphorus to become an organic element. But till recently we had not discovered that it can change this mobile, restless condition, for one of passive indifference and great stability. Phosphorus is now known to exist in no fewer than five distinct forms, besides that above described, which is called the *vitreous*, or glassy phosphorus.

The most interesting of these other forms is that of a red, non-crystalline solid, the properties of which are in most marked contrast to all that were before supposed to characterize this substance. It does not shine at the heat of freezing water, nor melt even at that of boiling water. It exhales at ordinary temperatures no vapour and no odour, nor does it become oxidized in the air, nor change it into ozone. It is not poisonous, even when directly administered in doses a hundred times greater than those which are fatal with vitreous phosphorus, and it may be handled with impunity. Towards other elements it shows in general a singular indifference; nor is it till it is raised to a temperature of 500° Fahrenheit (or some 470° above the heat necessary to make vitreous phosphorus begin to burn), that it starts into activity, bursting into flame, and yielding phosphoric acid. It appears to owe its peculiarities to the presence in it of much latent heat, so that it differs from vitreous phosphorus as steam does from water, or water from ice; for it is most easily produced by long maintenance of the common phosphorus at a temperature below 490°, and when heated above this point, it suddenly bursts into vapour, changing, with evolution of heat, into the familiar modification of the element.

Here, then, is an element which can imperceptibly and quickly pass from a condition of great chemical activity to one of great chemical inertness. In virtue of this character, phosphorus "may follow the blood in its changes, may oxidize in the one great set of capillaries, and be indifferent to oxygen in the other; may occur in the brain, in the vitreous form, changing as quickly as the intellect or imagination demands, and literally flaming that thoughts may breathe and words may burn; and may be present in the bones in its amorphous form, content like an impassive caryatid, to sustain upon its unwearied shoulders the mere dead weight of stones of flesh. And what is here said of the brain as contrasted with the bones, will apply with equal or similar force to many other organs of the body. All throughout the living system, we may believe that phosphorus is found at the centres of vital action in the active condition, and at its outlying points in the passive condition. In the one case it is like the soldier with his loaded musket pressed to his shoulder and his finger on the trigger, almost anticipating the command to fire; in the other it is like the same soldier with his unloaded weapon at his side standing at ease."

Further, phosphorus forms with oxygen a powerful acid, capable even of abstracting water from sulphuric acid, and yet perfectly unirritating to the organic textures. Taking up varying quantities of water, phosphoric acid assumes no fewer than three distinct forms, which will unite with one, two, or three atoms of alkali respectively, giving an acid, neutral or alkaline reaction. Thus it is available for the most varied uses in the body. "A child is beginning to walk, and the bones of its limbs must be strengthened and hardened; phosphoric acid, accordingly, carries with it three units of lime to them, and renders them solid and firm. But the bones of its skull must remain comparatively soft and yielding, for it has many a fall, and the more elastic these bones are, the less will it suffer when its head strikes a hard object; so that in them we may suppose the phosphoric acid to retain but two units of lime, and to form a softer, less consistent solid. And the cartilages of the ribs must be still more supple and elastic, so that in them the phosphoric acid may be supposed to be combined with but one unit of base. On the other hand, its teeth must be harder than its hardest bones, and a new demand is made on the lime-phosphates to associate themselves with other lime-salts (especially fluoride of calcium), to form the cutting edges and grinding faces of the incisors and molars. All the while also, the blood must be kept alkaline, that oxidation of the tissues may be promoted, and albumen retained in solution; and yet it must not be too alkaline, or tissues and albumen will both be destroyed, and the carbonic acid developed at the systemic capillaries will not be exchanged for oxygen when the blood is exposed to that gas at the lungs. So phosphoric acid provides a salt containing two units of soda and one of water, which is sufficiently alkaline to promote oxidation, dissolve albumen, and absorb carbonic acid, and yet holds the latter so loosely, that it instantly exchanges it for oxygen when it encounters that gas in the pulmonary capillaries. Again, the flesh juice must be kept acid (perhaps in opposition to the alkaline blood, as affecting the transmission of the electric currents which traverse the tissues), and phosphoric acid provides a salt, containing two units of water, and one of potash, which secures the requisite acidity." *

These characters of phosphorus, besides their own immediate interest, are, as we shall see, most suggestive in relation to the question of food in its widest sense. For the nitrogen-containing bodies are characterized also by a capacity for assuming a variety of distinct forms, which serve different physiological purposes, with very slight changes of com-

* Dr. G. WILSON, *Edinburgh Essays*, 1856.

position. They exist in the blood in two chief forms—that of albumen and that of fibrine. The former of these is comparatively little prone to change; the latter readily alters its condition, coagulating on exposure to the air. A great variety also of these substances is found in food, each separate species of plant containing its own peculiar nitrogenous element, distinguished by a slight variety of properties. But we must hasten on. Of the water, which not only forms a part, but is, indeed, the chief constituent of all our food (as it is also of the entire body, constituting three-fourths of our weight), we need not speak further. Although it is the most important of all alimentary substances, and the entire withdrawal of it from the food produces more intolerable sufferings and speedier death than any other kind of starvation, yet so far as we at present know, its office, as a food, is simple. It seems to be a diluent or menstruum only, facilitating changes in which it has itself no share. Perhaps we might say that water is to the body what nitrogen is to the atmosphere, the passive solvent in which the active elements are distributed, and by means of which their activity is at once elicited and controlled. The free use of water, however, greatly promotes various secretions, causing an increase not only in their liquid portion, but also in their solid constituents.

There is another class of substances met with in our natural food, which experience has proved to be of the utmost value, although the mode of their action is not understood—the organic acids, and fresh vegetable juices. The desire for fruits and fresh vegetables, which becomes an intense longing when they have been for some time withheld, as those who have made long voyages at sea can testify, has its root in a real want of the system. Lime-juice, assisted by other rational measures, has almost banished scurvy from the navy; and further proof of the necessity of these substances for healthy nutrition is furnished by facts which still occur. Dr. Carpenter has called attention to the circumstance that during the year that followed the potato-famine in Ireland, when the high price of vegetables interfered with their use as an article of diet, scurvy broke out in many of the English poorhouses. And there is no doubt that too scanty a supply of vegetables, though it may not produce actual disease, undermines the health, and increases the risk of many affections. Not very long ago a patient was admitted into Guy's Hospital with fractured leg. The limb was placed in the most favourable circumstances for uniting. The diet was liberal, and of the most nourishing kind, containing bread, and meat, and porter in abundance. But no union took place. Fresh vegetables were prescribed to the full extent of appetite, and new bone began at once to be deposited.

Nothing is more truly unscientific than the prolonged enforcement of an exclusive diet of bread and meat for weak digestion. It has happened more than once in our own knowledge that a person suffering from dyspepsia, for which a rigid diet has been prescribed, has yielded to temptation, and indulged in a free and varied and most anti-digestive meal; and the dyspepsia has disappeared from that time forth. This fact, however, says nothing in favour of habitual indulgence.

Instinct or natural desire is, generally—perhaps in health it is almost always—a good index to the food that is best. In many cases of disease it is an invaluable guide to the articles best adapted to the patient's state. But this is not always the case. In some instances, as where sugar is found in excess within the system—where the flesh runs away in sugar as it were—the desire for fruits is intense, but its gratification is very hurtful.

It was an idea of Liebig's that alcohol was a food;

that is, that like fat or sugar, it united with oxygen in the system, and supplied it with warmth. Recent investigations, however, have partially modified this opinion. It appears that part of any spirit consumed passes off in the secretions, unchanged. It may be shown, unaltered, in the breath, the perspiration, and other secretions, for as much as ten or twelve hours after the use of even a moderate quantity. It has been long known to possess a special affinity for the nervous tissues. Dr. Percy, many years ago, proved its presence in the brains of persons dying from its use, and of animals to which it was administered; and recent researches confirm his experiments.

When food is entirely withheld, mammals die in from ten to twenty days, and birds, for the most part, much sooner, losing in the course of that time from less than a third to more than half of their weight, according to the amount of fat they had previously accumulated. From some experiments made by Chossat it appears, that while the fat is almost entirely consumed, and the blood reduced to one-fourth of its amount, the nervous system suffers scarcely any loss of weight. Bidder and Schmidt, however, found that in the case of cats, the blood was diminished even more than the fat, and the brain also wasted to the extent of 37 per cent.

The most striking circumstance, however, connected with starvation, is the tendency to decomposition and putridity, alike in the blood and all the organs, which the absence of food occasions. The system, left unnourished, not only wastes away, and is consumed ; its vitality also fails, and putrid emanations cover the surface. This fact furnishes further evidence that part of the office of the food is to feed the *life* of the organism, as well as to supply its substance, and maintain its heat. Thus typhus, and other putrid fevers, follow in the train of famine. Perhaps it is, in part, by counteracting this tendency to putrefaction, that very small quantities of food seem to have so much influence in deferring the fatal effects of abstinence. The usual duration of life in the human subject under complete deprivation of food and drink, is only eight or ten days, yet a case is reported by Dr. Willan, in which a young gentleman, who starved himself under the influence of a religious delusion, lived for sixty days, *taking only a little orange-juice.** In another instance, a patient, under an hysterical affection, for three weeks took only a cup of tea once or twice a day, and on many days not even this was swallowed ; yet the strength seemed rather to increase than to diminish during this period.

* Dr. CARPENTER'S *Human Physiology*, 5th Edition, p. 60.

But results similar to those of entire want of food ensue, if the attempt be made to confine ourselves to any single article of diet, however in itself nutritious. It has long been known that gelatine—the substance which forms jelly in all its varieties—could not sustain life. Experiments made on dogs and other animals, by a French Commission, showed that they died almost as soon when fed on gelatine as when kept entirely fasting. But further investigation has proved that albumen itself, the substance from which almost all our structures are directly formed, will not maintain life when exclusively employed. The disgust which a long continuance of one narrow diet excites is therefore justified from the charge of caprice. Dr. Hammond, an American physician, has recently published an account of some experiments made upon himself, with the view of determining the value of certain kinds of food. For ten consecutive days he lived upon coagulated albumen and water. At the end of that time his health was seriously deranged ; the power of the system to assimilate the albumen was impaired, the body was daily losing weight, and an extreme degree of lassitude was felt. On a diet of starch alone, the effects were, as might have been expected, still more severe. The following is the note of his condition on the eighth day of the experiment :—" Violent headache was present during the whole day. The mind was somewhat confused ; an almost constant twitching of the left upper eyelid was experienced, and caused me a great deal of annoyance. There was great oppression of the chest, which was only relieved by frequent, full, and deep inspirations ; palpitation of the heart ; and vomiting of a sour fluid. Several boils made their appearance, and scratches on the hand would not heal. The lips were of a bluish tinge."

From this experiment we may judge what effects are likely to attend the plan of feeding infants on arrowroot and water. Nor can any artificial combination of the various elements of food, however scientifically they may be adjusted, satisfy the demands of the system. The peculiar mode of combination which exists in the various foods so lavishly provided by nature, is as essential to healthy nutrition as the substances themselves. Food must contain not material only, but power : that from which life is to flow, must embody the results o living action ; it must be redolent of sunshine, and permeated with light ; it must have drunk in the virtues of the air of heaven. For all these our food must transfer to us—to glow within our veins, and animate our nerves. Through it, the forces of the universe must work within us, in order that we may live. And therefore, surely, it is that not to one or two—or twenty—varieties of food does nature stint our appetite, or confine our feast. She opens her hand, and pours forth to man the treasures of every land and every sea, because she would give to him a wide and vigorous life, participant of all variety. For him the cornfields wave their golden grain—wheat, rye, oat, maize, or rice, each different, but alike sufficing. Freely for him the palm, the date, the banana, the bread-fruit tree, the pine, spread out a harvest on the air; and pleasant apple, plum, or peach solicit his ready hand. Beneath his foot lie stored the starch of the potato, the gluten of the turnip, the sugar of the beet; while all the intermediate space is rich with juicy herbs.

Nature bids him eat and be merry; adding to his feast the solid flesh of bird, and beast, and fish, prepared as victims for the sacrifice: firm muscle to make strong the arm of toil, in the industrious temperate zone; and massive ribs of fat to kindle inward fires, for the sad dwellers under arctic skies.

"Eat and be merry!" Let the world's various life be marshalled in its ruler's breast.

CHAPTER III.

FOOD—WHAT IT DOES.

It is hard to know whether more to admire the variety of the forms under which food is supplied to the animal creation, or the simplicity of the fundamental plan. The number of nutritious substances baffles calculation, and embraces the utmost diversity of kinds, adapted to every variety of climate, circumstance, or habit. While the living organism, on the one hand, can build up a solid frame from liquid materials, on the other, it can pour iron through its veins, and reduce the hardest textures into blood. There is a squirrel in Africa that feeds on elephants' tusks; and the mark of its teeth is a welcome sight to the ivory-collector. The cunning creature selects —for there is scope for epicurism even in this hard fare—the tusks which are richest in animal matter, and which are therefore the most valuable. But under whatever diversity of form it may be presented, food is in its essential nature always the same. To give us active bodies, it must be an active substance; that is, it must consist of elements which tend to change through the operation of their chemical affinities. To furnish food for animal life is in one aspect a simple problem, though wrought out in infinite complexity. It is to provide matter in unstable equilibrium, as it is said, or constantly tending to assume new forms, like waves raised in water by the wind. Yet it must not be utterly incapable of retaining its existing form, but should be delicately balanced, as it were, so that it will admit of being transferred and moulded in various ways unaltered, and yet will undergo change immediately, when certain conditions are fulfilled. Given a substance thus composed, and there is food. For we must not limit our ideas here to that which happens to be food for us, or for the creatures likest to ourselves. Food is found by some creature or other in substances the most widely diverse. There is hardly a poison known that does not afford sustenance to some form of life. Corrosive minerals, in solution, afford nutriment to peculiar kinds of mould, or cell-plants. Even the gastric juice—the "universal solvent"—will sustain, without losing its properties, its special fungus. The fable of Mithridates, who accustomed himself to eat all deadly things with impunity, is more than realized in nature. Life, in its widest sense, almost refuses to recognize a poison. What is death to one organism supports another. Thus many diseases—an ever-increasing number of them indeed—are found to consist in the development of parasites; a new and hostile life invading the old, and flourishing in its destruction. And some of the most virulent vegetable poisons differ but slightly in composition from perfectly wholesome substances.

Our own food consists simply in that small portion of the substance and the force of nature, which is brought into forms correspondent to our particular life. The plants which prepare it for us add nothing of their own, but simply bring into a special arrangement the elements which exist around them, and the force which comes to them from the sun. So far as their life lies parallel to our own they procure us food; so far as their life diverges from ours they are unavailable for our nourishment, or even fatal to our being. One special form of the action that is everywhere is the life of our bodily frame, and the materials for it are furnished wheresoever, in plant or animal, that action exists in a kindred form. The substances thus akin to our own substance, or subservient to our own life, we have seen to fall into two or three great classes; they are mainly the albuminous or flesh-like, the fatty, and those consisting of sugar or starch. Wherever we find these, we find food.

But in the work of maintaining life, only the first step is taken when the materials are supplied. They need also to be put into us, and this not in the common meaning of the term, according to which a dinner is reckoned to be within us when we have eaten it, but in quite another way, and one which involves a problem of no small difficulty. In strictness, that which is placed in the stomach is not within the body. That internal cavity is as truly outside of *us*, as the cavity contained within the folded hand. The entire alimentary tube is well known to be a prolongation of the skin, which, indeed, changes its character somewhat at the lips, but retains the same essential structure throughout all parts of the digestive system. That structure consists of a layer of membrane, covered with cells which are frequently renewed, and of which each successive generation is in its turn cast off. Both the skin and the lining of the digestive cavities are also studded with minute tubes, which are in like manner lined by cells, and in which the chief process of secretion is carried on. This is, indeed, the character of all the surfaces of the body, whether internal or external; they consist of one or more layers of membrane covered with cells.

There being this connection and resemblance between the skin and the lining membrane of the stomach, it does not surprise us to find that at first, and in its simplest forms, digestion is performed by the skin. The lowest animal known, the Amæba (Fig. I.), takes its food through its external surface, having, indeed, no internal one. It applies itself round the morsel and extemporizes its digestive organs for the occasion, putting out a process of its body, which is at once hand and stomach, whenever it is wanted. The common Hydra again, as is well known, feeds just the same when turned inside out; either part is skin, and either stomach. Now man has no such faculty as this, but it remains true in his case also that the digestive membrane is but an inward skin, and, to a certain extent, similar offices are performed by both. The skin, for example, absorbs certain substances applied to it in a liquid state, and it casts off excreted matters. These are two of the functions of the internal or digestive skin;

Fig. I.

Amæba digesting.

but the latter has also assigned to it the task of dissolving the substances which are consumed, so that they may pass readily into the blood. It is adapted, therefore, to this end, by being more thickly studded with secreting glands. But the materials which are provided in our food, for the most part, cannot be made use of by the system, if they are directly mingled with the blood. It is true the very substances of which the blood consists are presented to us in various articles of diet; but if these be taken in a liquid form, and injected into the veins, they are cast off at once, by the secretions, unemployed. This is the case with the albumen of the egg for instance, which is yet, so far as the chemist can ascertain, almost identical with the albumen of blood. Another task is, therefore, laid upon the digestive organs, besides that of reducing the food to a liquid state; they must impart to it qualities which fit it to join with, and become part of, the vital fluid. This is *assimilation*, or at least the first stage of it. There is a second assimilation whereby each organ and structure of the body is separately nourished from the common blood.

What a problem this is practically to solve: to take the outlying nature and build it up into the human frame, making it fill the place of the materials that are used in its life, and supply the force that is expended in its action. It is no wonder that an elaborate series of organs is provided, and that many distinct processes must co-operate, to achieve the work. And there is surely some value in a result attained at such a cost. That a man may be nourished, as the condition of his conscious life, what a multiplicity of agencies are set to work, what a lavish application of resources is made! We may well regard with a certain reverence, ourselves, what Nature, and the Author of Nature, have thought worthy of so much care, and have purchased at so large an expenditure of means.

The term "assimilation," as expressing the result of the digestive process, is full of significance. It implies a likeness in kind between that which is assimilated and that to which the assimilation is made; a preparedness and adaptation in the one to become the other. As George Herbert says—

> Herbs gladly heal our flesh, because that they
> Find their acquaintance there;

so the food gladly becomes the body, finding there its own kindred. But, further, assimilation implies also a gradual change, a progress from one state towards another, marked by successive stages; and this we find to be eminently characteristic of the digestive process. It is a regular series of successive operations. The food is raised into union with the new organism by definite steps, each of which has its own instruments. Digestion in this is like the act of vision. The one essential for sight is the impression of a ray of light upon a nerve. In the simplest animals this is effected immediately, and without any special apparatus beyond a portion of the nervous system placed at the surface; but as we rise in the animal scale, there is interposed between the light and the nerve an optical apparatus, to modify the rays, and prepare them to fall with perfect adaptation on the more delicate and more complex nervous expanse. The mollusc sees with a mere nerve; the man requires an eye. So he requires also his digestive "eye," to refract, combine, and bring to a focus in his blood his many-coloured food.

For this purpose we carry about with us an entire laboratory: the whole armoury of the chemist is laid under contribution to furnish forth our digestive apparatus. Knives to divide, and mortars to triturate, are provided in our incisor and molar teeth; solvents and delicate re-agents in the secretions which the sight or taste of food calls forth; *baths* of exactly graduated temperature in the various cavities; and filters which strain and separate the elements in the absorbent glands. Digestion is an "organic chemistry," and these are its appliances.

And the means are especially adapted to the work in this respect, that as the food consists of various classes of substances, so the digestive agents are of various kinds. We are accustomed to speak of the gastric juice as if it were *the* digestive fluid ; but, in truth, it is only one among several, and probably it is not the most powerful of them. There are some elements of food over which it has no influence, and all its effects may be apparently produced by other secretions ; it has been calculated, indeed, that scarcely more than half the necessary food is digested within the stomach.

Of the various digestive fluids, some act chiefly on the starch, converting it into sugar ; and of these the saliva is the type. The gastric juice, on the other hand, acts exclusively on the albuminous bodies ; and there are other secretions which have for their part to prepare the fatty matters for absorption.

Further, these various secretions are excited by their appropriate demand. They flow forth on the presence of food, and in quantities proportioned to the amount and need of it ; obeying a vital or human order : the emotions which attend the taking of food, the taste, the sight, the thought of it, call them forth. We are conscious of this in the case of the saliva ; but the same law extends to the gastric juice, and, doubtless, throughout all the series. Enjoyment promotes, loathing suspends them at every stage: they express and wait on the man, not on mere mechanical or chemical conditions. Although by means of the latter kind, such as irritation by tubes introduced into the stomach, or by forcing animals to swallow pieces of sponge, a certain amount of digestive fluid can be obtained, this is always comparatively scanty in quantity, even if it be normal in its quality. Thus already, in this least elevated function, is exhibited the law and nature of the body: that it is the servant, not of circumstance, but of the man. Its destiny is to be not only subservient to, but in every action swayed by, the mental and conscious part. It is true, indeed, that, on its side, the physical rules and controls the mental ; and in a struggle, when the forces are set against each other, so far as the body is concerned, the former must prevail. Neither thought nor will can stand against starvation, intoxication, or disease ; but these are relations that are abnormal. The dominion belongs of right to the higher agent, and is habitually exercised by it. Man rules his body as he rules the obedient horse or elephant, whose powers yet are greater than his own, and before whose rage he cannot stand. Thus also he subdues and uses the natural powers, before the might of which he is an infant. The healthful attitude of the body is that of perfect obedience to, and expression of, the mind ; its momentary state varies, throughout, with the momentary changes of the soul. As we see the shades of emotion write themselves upon the countenance, they write themselves by delicate variations on every inward organ and hidden function too.

Digestion consists of two parts—the solution and transformation of the food, and its absorption into the system. The former of these commences the moment the food enters the mouth, in the outflow of the saliva to meet it. A chief part of the office of this fluid is thoroughly to moisten the food, and prepare it for being swallowed ; and with an evident adaptation to this purpose, it consists of a mixture of three distinct fluids, with different sources and characters. One portion of it is a thin, watery fluid, and this is thoroughly mixed

Fig. 2.

Part of one of the Salivary Glands magnified.

with the food in mastication ; another portion is of a more viscid nature, and serves to lubricate the morsel, and facilitate the act of swallowing. These are poured into the mouth at its anterior and posterior portions respectively. The saliva is furnished partly by large glands situated within or near the mouth, and partly by minute glands lying beneath the lining membrane of the cheeks, which is studded all over with the orifices of these little organs.

The quantity of saliva secreted amounts, in a hearty and well-fed man, to about three pounds (or pints) a day, though it varies greatly with the kind of food ; when that is hard or dry, much more than an equal weight of saliva is mingled with it. Thus it has been found by experiments on horses, that with every 100 parts of hay consumed there were mingled 400 of saliva, but for 100 parts of green stalks and leaves only 49 parts of saliva were furnished. Bernard administered to a horse a pound of oats, in order to ascertain the rapidity with which mastication would naturally be accomplished. It was thoroughly masticated and swallowed at the end of nine minutes. Part of the saliva was then prevented from flowing into the mouth, by dividing the duct of the parotid gland, and another pound of oats was given to the animal; it ate with difficulty, and the swallowed portions were dry and brittle ; at the end of twenty-five minutes it had masticated and swallowed only about three-quarters of the quantity which it had previously disposed of in nine minutes. Our own experience also teaches us how tardily mastication goes on when the saliva is wanting. The dry mouth of fever sufficiently forbids solid food.

But the saliva is also strictly a digestive fluid. The most essential elements of food, indeed, are the albuminous, and the preparing these for reception into the blood, is in some sense the chief end of the entire process. But this is not the first thing done : the saliva has no action on the albuminous portions of food ; nor does it even affect the fat, the substance second in importance. Its operation is confined to one of the subordinate elements ; it converts starch into sugar, fitting it thus both for immediate absorption, and for future changes within the body. The saliva ensures that, on a mixed diet, a certain supply of force-producing matter should be available from the very commencement of the digestive process.

For the conversion of starch into sugar by the saliva commences with great rapidity, if the starch is thoroughly dissolved. A certain amount of sugar thus produced has been detected in the course of half a minute. But though this transformation of starch begins very rapidly, it is carried only to a small extent: the gastric juice interrupts it, probably through its acidity, the saliva being always, during digestion, slightly alkaline. The chief part of the starch taken as food, therefore, when it is consumed in any quantity, passes unchanged through the stomach, and undergoes its final conversion into sugar by means of other fluids, especially that secreted by the pancreas (or sweetbread).

But the use of the saliva is not yet exhausted. Its continued passage into the stomach has been observed to increase the secretion of the gastric juice, so that it appears indirectly to aid the process of stomach digestion. And the sympathy which exists between the various portions of the digestive apparatus, is indicated by the fact that the artificial introduction of starch into the stomach, through an opening in its walls (no food having been taken by the mouth), has been found to excite a larger flow of saliva than the introduction in a similar way of flesh, on which it has no action. The saliva, it is well known, contains air, which gives to it its frothy appearance, and it is possible that its favourable influence upon digestion may be partly due to its conveying a small amount of air into the stomach.

The food, then, reduced to a state of fine division by the teeth, and moistened by saliva, is conveyed by the motions of the tongue and cheeks to the back part of the mouth, and there seized by the muscular bands which form the moving "pillars" (as they are termed) of the throat. Once having reached this spot, its future movements are beyond our control. Swallowing is one of the involuntary actions, which we can excite by bringing food or liquid into contact with the muscles concerned in the act, but are then powerless either to prevent or to direct. Conveyed by successive, wavelike contractions of the œsophagus, or gullet (which may be well seen in a horse while drinking), the morsels of food pass into the next receptacle, the stomach.

In man this organ is a membranous bag of irregularly oval shape. It is furnished at its upper and lower openings with distinct muscular rings, which open or close the cavity in either direction as required. In fact, the stomach in all essential respects may be regarded as a second mouth. It has its lips which open to admit, and close to retain, the food, which the muscles of the throat, like hands, present to it; like those of the mouth, its walls are muscular, and roll the food from side to side, and from part to part, till it is thoroughly mingled with the secretion that is appointed to dissolve it; it is bounded below by another muscle, like the pillars of the throat, which at the fitting time seizes and carries onwards those portions of the food which are prepared for the succeeding stages of their progress. And to make the parallel complete, the stomach of many animals, though not of man—the crab is a familiar instance—is armed with teeth. Its inner coat, in the natural and healthy state, is of a light or pale pink colour, varying in its hue at different times, being darkest during the process of secretion. It is of a soft or velvet-like appearance, and is covered with a thin transparent mucus.

The special function of the stomach is to dissolve and otherwise change the albuminous portion of the food; and for this purpose it pours forth in a truly amazing quantity a fluid of remarkable character. The secretion of gastric juice in a healthy adult man weighing ten stone has been estimated, by careful observers, taking the amount secreted in a given time and under varying conditions as the basis of their calculation, at as much as thirty-seven pounds in each twenty-four hours. Nor is this estimate incredible, although that amount considerably exceeds the entire weight of the blood, when we consider that the secreted fluid is speedily re-absorbed, and that the total quantity may express the result of a rapid circulation, the amount present in the stomach at any one time not exceeding a few ounces. Other observers, however, have placed the quantity at less than half this amount ; and the question is evidently one not easy absolutely to decide.

Indeed, it may well be asked, how any knowledge at all can be gained on such a point, at least in respect to man ; the stomach being an organ hidden from our sight and cut off from our manipulation. However, besides artificial openings made experimentally into the stomachs of animals, accidental apertures have been formed into or near those of human beings. Of the latter, two cases have been carefully observed—the well-known one of Alexis St. Martin, the Canadian, experimented on and described by Dr. Beaumont of the United States army, and more recently by Dr. E. H. Rogers ; and an Esthonian peasant woman, Catherine Kütt by name, who has been under the observation of various physicians in Germany.*

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* Dr. Beaumont's little volume, *Experiments and Observations on the Gastric Juice and the Physiology of Digestion*, was republished in England, with notes, by Dr. Combe, and although all his observations have not been confirmed, and some of his opinions are certainly not true, it is exceedingly interesting to all

By observations thus made, the gastric juice is found to be "a clear colourless fluid, inodorous, a little saltish, and very perceptibly acid. It possesses the property of coagulating albumen in an eminent degree; is powerfully antiseptic, checking the putrefaction of meat; and effectually restorative of healthy action, when applied to ulcerating surfaces." It holds in solution a small amount of a peculiar animal substance, upon which its power of dissolving and otherwise changing the food depends. In this respect, indeed, all the digestive fluids are alike, and the peculiar powers of each seem to be chiefly dependent on the animal matter they contain in solution. These substances may be separated and dried, like yeast, and will exert their powers on being redissolved, even after a long interval. They seem, indeed, to act in a similar manner to what are termed "ferments," exciting decomposition by being themselves in a state of change.

The substance of this class which is contained in the gastric juice is termed "pepsin:" it may be separated as a greyish mass; or by macerating in

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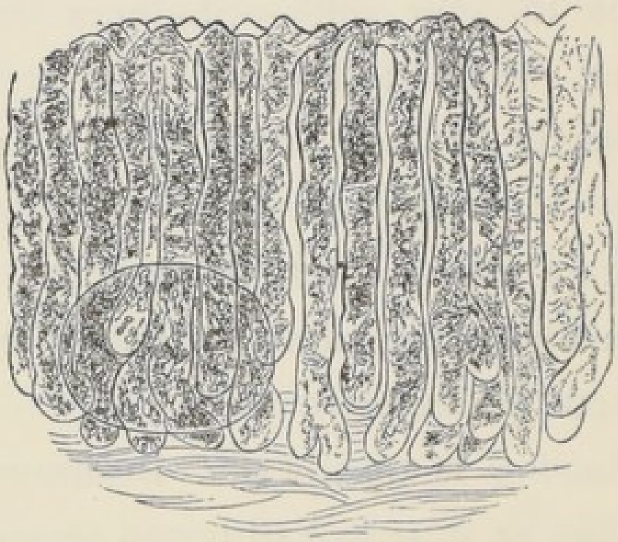
who are desirous of knowledge on the subject of which it treats. In the case of Alexis St. Martin the stomach was laid open by a gun-shot wound, and remained only partially closed, with a valvular aperture.

water the lining membrane of the stomach of a pig, or of the fourth stomach of a calf, a similar substance may be procured. This, when purified and redissolved in water, with the addition of a few drops of certain acids—the acid of common salt, or that which forms in sour milk—produces an artificial gastric juice, which will dissolve meat, or bread, or other articles of food. One part of pepsin dissolved even in 60,000 parts of acidulated water, will have this effect. But it must be kept at a temperature about the same as that of the stomach, or nearly 100° Fahrenheit.

The following is one of Dr. Beaumont's experiments:—After St. Martin had fasted seventeen hours, Dr. Beaumont withdrew from his stomach one ounce of gastric juice, put into it a solid piece of boiled, recently-salted beef weighing three drachms, and placed the vessel which contained them in water heated to 100°. In forty minutes digestion had distinctly commenced over the surface of the meat; in fifty minutes, the fluid had become quite opaque and cloudy, and the external texture began to become loose; in two hours, the fibres of the meat were entirely separated; and after the lapse of ten hours the whole was dissolved. A similar piece of beef was at the same time suspended in the stomach by means of a thread: at the expiration of the first hour it was changed in about the same degree as the meat digested artificially; but at the end of the second hour it was completely digested and gone. Thus the same

Fig. 3.



Section of the Wall of the Stomach, showing the Glands.

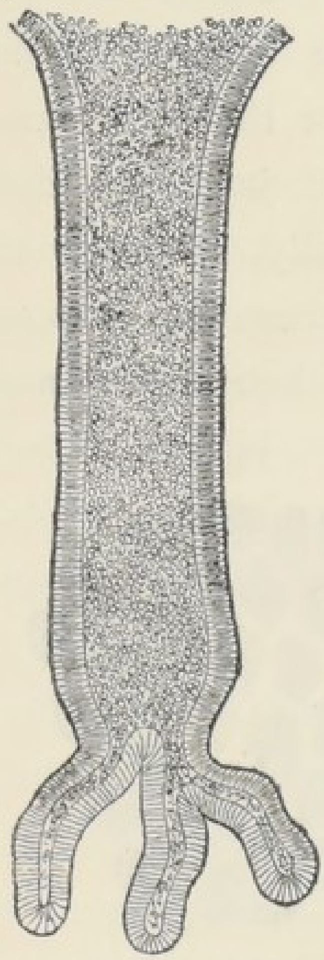
process which takes place within the stomach may be imitated, in part, outside of the body; and that the results are similar to a certain extent is proved by the fact, that albumen which has been thus acted upon is retained when injected into the veins, and is not cast off by the secretions, as it is when injected in its unaltered state.

The gastric juice is secreted from the membrane lining the stomach by minute glands, which are thickly studded over its lower part. These glands consist of tubes, extending through the thickness of the membrane, and lined with cells. They are more developed in some other animals than in man; the woodcut, Fig. 4, represents them in the pig, greatly

Fig. 4.

Gland which secretes the Gastric Juice.

Fig. 5.

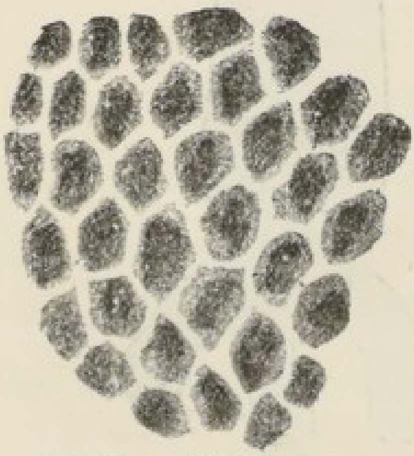


Simple Gland of the Stomach.

magnified. They branch at their lower portion, and contain round cells of a larger kind; and in these it is that the gastric juice appears to be formed.

There is another form of gland contained within the stomach, consisting of branched or simple tubes very similar to the former, except that they are shorter, and do not contain the peculiar larger form of cell. These are situated more at the upper portion of the organ, and secrete not gastric juice, but a simple mucous fluid, which serves to moisten and protect the membrane, and is always present. The gastric juice, on the other hand, is poured out, naturally, only on the introduction of food; the membrane then becomes red and turgid, raised points make their appearance, and the secretion soon begins to collect in small limpid drops upon its surface. The internal aspect of the stomach presents a network of minute ridges (Fig. 6), in the interspaces of which the mouths of the glands are situated; and its entire structure is permeated with minute vessels, which pass into the ridges on its surface, and ramify thickly around its glands.

Fig. 6.



Surface of the Stomach.

The secretion of gastric juice is affected by various circumstances. Impressions on the mouth have an influence upon it, as we have seen that impressions on the stomach in like manner affect the mouth. Thus Blondlot (who first adopted the plan of making artificial openings into the stomachs of animals) observed that when sugar was introduced directly into the stomach of a dog, a very small secretion of gastric juice ensued ; but when the dog had himself masticated and swallowed it, the secretion was abundant.

Cold water introduced into the stomach renders it pale for a time, and diminishes its secretion, but this soon returns more freely. Ice, however, in large quantity, checks it for a long period, as also do all kinds of irritating agents. And the effect of painful mental states in interfering with digestion are explained by their visible influence upon the organ. It was noticed by Dr. Beaumont, in the case of St. Martin, that irritation of the temper, and other moral causes, would frequently diminish, or altogether suspend, the supply of the gastric fluids. The effect was similar to that of febrile action, or of over-fatigue. And anxiety, anger, or vexation occurring at the commencement of digestion, even though themselves but temporary, showed their effect during the entire process. Anger especially caused an influx of bile into the stomach.

The action of the stomach is chiefly exerted upon the albuminous articles of the food. These, or at least a portion of them, it reduces to a liquid form and alters in certain respects, especially rendering them more freely soluble in water. On the starch, or sugar, or other such substances the food may contain, the gastric juice exerts no influence ; nor has it much evident action on the fat, though it is said by Dr. Marcet to effect a change in it which prepares it for digestion by the fluid appointed for that task—the pancreatic juice, and perhaps the bile. As the result of the action of the stomach, the food is reduced to a greyish, semi-fluid mass—the chyme—which gradually passes through the lower orifice of the organ. The muscle which guards this orifice seems to be endowed, during the earlier stages of digestion, with a peculiar sensibility, which enables it to transmit the fluid portions of the contents of the stomach and to refuse the solid ; but as the digestion approaches its termination, this sensibility passes off, and the entire contents of the organ are suffered to escape.

During digestion the stomach is in continual motion, and its movements are essential to the discharge of its office, serving to bring the gastric juice into contact with every portion of its contents. They are effected by means of two layers of muscular fibres, one of which passes irregularly around the circumference of the organ, and the other runs longitudinally from end to end. The motions are intermittent, and pass downwards in regular waves, commencing at the entrance of the stomach, and becoming much more energetic as they approach the lower portion. The result of these movements is, as pointed out by Dr. Brinton, to carry the food in two currents, at once onward in the direction of the movement, and back again, at the same time; the former current occupying the sides of the cavity, and the latter its centre. It is just such a movement as that which would be given to a fluid in a closed cavity by pressing down upon it a piston with an aperture in the centre. Thus a series of revolutions is performed by the food, during which its intermingling with the secreted fluid is perfectly effected.

During the entire period of stomach digestion the walls of that cavity are closely applied, and, as it were, fitted to its contents, contracting as they diminish. When additional food is taken shortly after a meal, the added portion passes into the centre of the mass that already occupies the organ; it soon, however, becomes indistinguishable from the rest.

How long a time does digestion in the stomach occupy? Various experimenters have endeavoured to answer this question, and to determine the relative digestibility of different articles of food, by observing the period at which the stomach becomes empty after they have been taken. Dr. Beaumont's tables on this point have been often quoted. He found that the time required for the complete disappearance of a meal from the stomach of St. Martin, varied from an hour to five hours and a half, according to the kind of food consumed. Pig's feet, tripe, and boiled rice stand at the head of the list, being disposed of in an hour; trout, sweet raw apples, and venison steak follow, occupying an hour and a half; boiled milk took two hours, unboiled a quarter of an hour more; eggs occupied the same time, but the case was reversed—they were soonest disposed of raw; roasted turkey took two hours and a half; roast beef and mutton, three hours and three hours and a quarter respectively; veal, salt beef, and *boiled chicken,* were not disposed of till four hours (longer than potatoes!); and roasted pork enjoyed the bad pre-eminence of demanding five hours and a quarter.

Other observers, however, have come to different conclusions; and one of the last writers on the subject says, very unsatisfactorily—" It is sufficient to quote the opinion of Blondlot, who obtained such very indefinite and unconclusive results, that he was led to express the view that the digestibility of different articles of food depends solely on the state of the stomach at the time of the experiment, and that it is pure waste of time to labour at the determination of the digestibility of individual articles of food."* It is probable that within certain limits this is true, and that we must rely upon experience and good sense for guidance in this respect, rather than on specific rules.

There can be little doubt that variety is better than any kind of theoretically digestible uniformity of diet. It is not unlikely, besides, that the shortness of the time during which an article of food remains in the stomach may be a very unsafe measure of its digestibility. Possibly the less digestible any substance is in the stomach, the more speedily it may be passed on to the succeeding organs, and a longer continuance there may indicate a more complete susceptibility to the action of the gastric juice. Dr. Beaumont himself records evidence of this. He says :—" Vegetables are generally slower of digestion than meats and farinaceous substances, though they

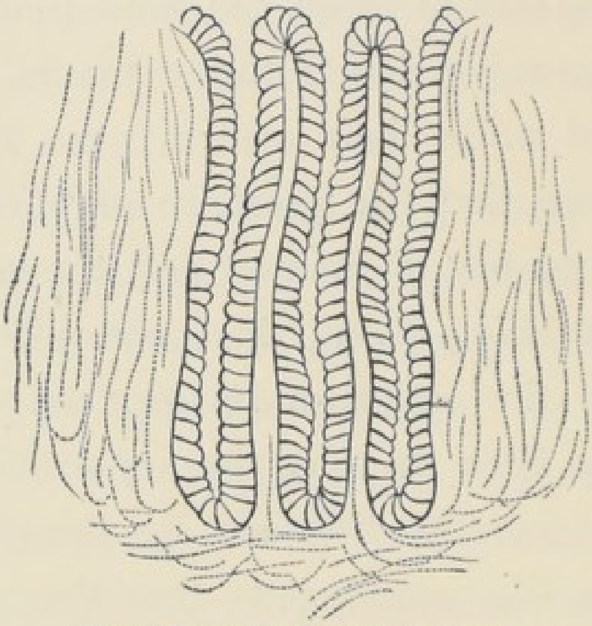
* Dr. DAY, *Physiological Chemistry.*

sometimes pass out of the stomach before them, in an undigested state. Crude vegetables are allowed, even when the stomach is in a healthy state, sometimes to pass its orifice, while other food is retained there to receive the solvent action of the gastric juice. This may depend upon their comparative indigestibility."

There are, however, some experiments, made by Büsch on the woman before referred to as having an accidental orifice near the stomach, which throw some further light upon the question. In her case it was found that boiled eggs began to pass from the stomach in from twenty to thirty-five minutes ; flesh, in from twenty-two to thirty minutes ; cabbage, in from fifteen to nineteen minutes ; potatoes, after fifteen minutes ; and parsnips, after twelve. On examining the proportion of matter that had been absorbed in each case, it was found that flesh was more digestible than eggs, that parsnips were more digestible than potatoes, and potatoes than cabbage. But, whatever may be the nature of the food, the more thoroughly it is masticated, the more readily it is digested. The facility with which it is dissolved is regulated by the readiness with which, by its minute division, the solvent fluid can obtain access to every part.

The gastric juice, as may be supposed, will dissolve the stomach itself, if there be any present in it at the time of death. But it will digest living substances as well as dead ones. This has been put to the test by means of frogs, the hind limbs of which have been introduced into the stomachs of animals, and digested while their owners were alive. It is clear, therefore, that the presence of "life" is not a preservative against digestion; and the mere fact of the stomach being living does not account for its resistance to the action of its own secretion. The difficulty has been met by the supposition that the organ *is* continually dissolved by the gastric juice, but is continually reproduced—that the growth compensates for the loss. Perhaps, however, it is not absolutely necessary to take this view, which implies a destruction and renewal, in this organ, of immense and unparalleled rapidity. Different parts of the body have a different susceptibility to various influences; and it may be that the changes which the stomach naturally undergoes, during life, are of such a kind as to counterbalance those which its own secretion would otherwise excite within it. Its vital changes may *stop* digestion, as the action of the gastric juice *stops* putrefaction. The possible growth of a fungus in the gastric juice itself, shows how this may be. The stomach may have a mode of vital action to which the gastric juice may act as a stimulant rather than as a destroyer.

Fig. 7.

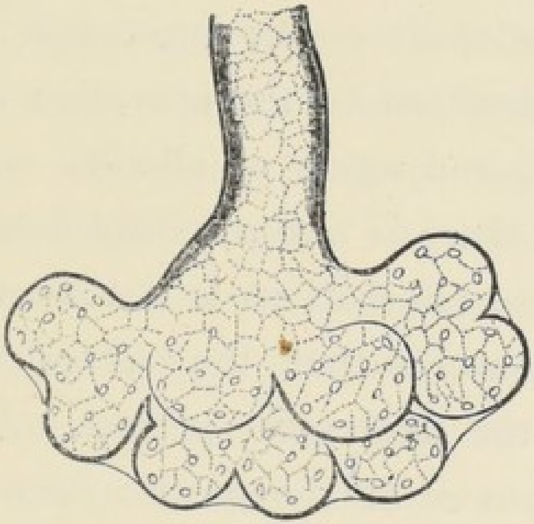


Glands lining the Intestinal Canal.

The food is not only dissolved more or less completely in the stomach, it is partly absorbed into the blood also ; liquids being rapidly taken up by the vessels which ramify upon its walls. But by far the larger portion is transmitted from the stomach for further elaboration. The whole extent of the digestive canal is lined with glands, which pour out a secretion hardly less powerful than the gastric juice itself, and which seems, unlike that fluid, to affect *all* the elements of the food.

By means of this secretion the solution and elaboration of the digested matter are brought to their final completion; but two special organs also bear a part in the process. These are the pancreas (or sweet-bread) and the liver. The former, which is placed immediately beneath the stomach, in its structure, and partly in its office, resembles the salivary glands.

Fig. 8.



Glands found in the neighbourhood of the Stomach.

Like them, it converts starch into sugar; but it also reduces the fat into a state of minute division, which prepares it for being absorbed. The peculiar milky appearance of the chyle is due to the fat contained in the food being thus brought into the condition of an emulsion, by the secretion of the pancreas. Whether that organ has the power of dissolving albuminous substances is not yet quite decided. Its characters seem to connect it much more closely with the salivary glands than with any others, and it seems

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also to have an intimate sympathetic relation with them, so that in disease of the pancreas a profuse flow of saliva is a common symptom. The quantity of the pancreatic secretion has been estimated at about ten pounds a day, but this is probably an extreme amount. It is curious to observe that while the gastric juice is decidedly acid, the fluids with which the food next comes into contact are alkaline. It is thus submitted to the operation alternately of alkaline, acid, and again of alkaline secretions. In the herbivora there is also a second acid juice. The reason of these alternations is not known, but it can hardly be doubted that they serve to make the digestion of the food more perfect. And although the solvent power of the gastric juice is placed in abeyance when its acidity is neutralized by the alkaline fluids, yet it appears to be the case here, as in respect to the saliva, that effects are produced by the mixture of the various secretions which are poured together into the digestive tube, that would not result from either alone.

It remains to speak of the part taken by the bile in digestion; and this is a matter of no little difficulty to determine. An admixture of the bile with the gastric juice seems to put a stop to the action of the latter; nor has the bile itself any evident solvent action on any portion of the food. Probably, however, it materially assists in the absorption of the fat, since it is found that oil will rise much higher (by "capillary attraction") in minute tubes, when they are moistened with bile than when moistened with any other fluid. Beyond this the bile seems to have no obvious digestive action; but it plays, notwithstanding, a very important part in nourishing the body. It is taken up again into the system, undergoing changes which may, perhaps, be considered as a digestion of the bile itself. The effects of preventing its entrance into the digestive canal, which is done by opening the gallduct and causing the bile to flow externally, are thus described by Dr. Dalton:—"Two dogs were the subjects of the experiment; both of them died, one at the end of twenty-seven, the other at the end of thirty-six days. The symptoms were constant and progressive emaciation, which proceeded to such a degree that nearly every trace of fat disappeared from the body. The loss of flesh amounted, in one case, to more than two-fifths, in the other, to nearly one-half the entire weight of the animal. There was also a falling off of the hair, and an unusually disagreeable odour in the breath. Notwithstanding this, the appetite remained good; digestion was not essentially interfered with. There was no pain, and death took place at last without any violent symptoms, but by a simple and gradual failure of the vital powers."

May we not reasonably believe, therefore, that the bile should be classed with the force-producing substances, having, for part of its office, to undergo decomposition, and so to furnish a power for the development, and elevation in the scale of life, of certain portions of the food? For this must never be lost sight of in considering the problem of digestion, that the food is to be conveyed into the system without loss of the force which it contains, and which, under similar circumstances out of the body, it very speedily does lose. It is not suffered to *fall* or decay, but is incorporated with the body still in its living state. The ball is kept in the air during the whole process. Nay, more, in digestion the food has to be *raised*, and carried up to a higher vital level: the blood is more living than the substances from which it is formed. And for this purpose force is needed, which can be derived only from the decomposition of some substance within the body. It is probable, therefore, that the bile which disappears within the digestive tube is consumed in *raising* the food, or making it more living. If this be so, the languor and debility which attend derangement of the biliary system receive in part an easy explanation. The daily quantity of bile secreted in an adult man is estimated at three or four pounds.

Through the agency of these various secretions the food, of whatever materials it may have consisted, is reduced to the form of a thin fluid of uniform appearance. At the same time, there goes on a process of remarkable character, and of which the perfect explanation cannot yet be given—that of absorption, by which the contents of the alimentary tube find entrance into the blood. To effect this, a beautiful law is called into operation—the law that if two fluids of unequal density be separated by an animal membrane, they will, with few exceptions, pass through the membrane and mingle with each other. Thus, for example, if a solution of sugar be divided from pure water by a portion of bladder, the water enters into and dilutes the syrup, while a little of the syrup also passes into the water; and this interchange will take place with considerable force, so that a column of fluid may be raised by it to a height of several inches. It is evident that this law (called by its discoverer, Dutrochet, the law of endosmose) is susceptible of a wide application to the vital actions. It furnishes the explanation of a large part of the process of absorption, both in animals and vegetables. Professor Graham has shown that a decomposition of the interposed membrane is an essential step in the process when it occurs out of the body, and probably minute changes of structure are concerned in it in the living organs also. Thus we see one use of that tendency to change which is universal throughout the animal structures. The vital interchange of fluids depends upon it.

Further, in this law of endosmose may be seen a reason for the vast quantity of the fluids which are poured into the digestive cavities after every meal to effect the solution of the food. The passage of fluids through animal membranes is usually most free on the part of that which is the less dense. Water, for example, passes much more readily into syrup, under these circumstances, than the syrup passes into the water. Accordingly, the great dilution of the digested food directly favours its entrance into the blood.

But whatever material enters the system from the stomach, or other part of the digestive tube, is submitted to still another process of elaboration before it is counted fit for the nourishment of the body. It passes through "glands" of peculiar character, the operation of which, though not yet understood, is evidently of the utmost necessity in the preparation of the new matter for its work. Part of it passes through the liver, part through a series of small glands resembling those which occur in the arm-pit or the neck. How far the influence exerted on the absorbed matter by these small organs, and by the liver, is of a similar kind, it is hard to say; different portions of the food are submitted to the action of each. That which passes through the liver is conveyed to it by the blood-vessels, and consists mainly of the albuminous materials and the sugar; that which passes through the small scattered glands contains the chief part of the fat, and is taken up by minute vessels distributed throughout the whole length of the digestive tube, and known by the name of "lacteals." This name they have received from the milky appearance given by the minutely divided fat to the chyle which they convey.

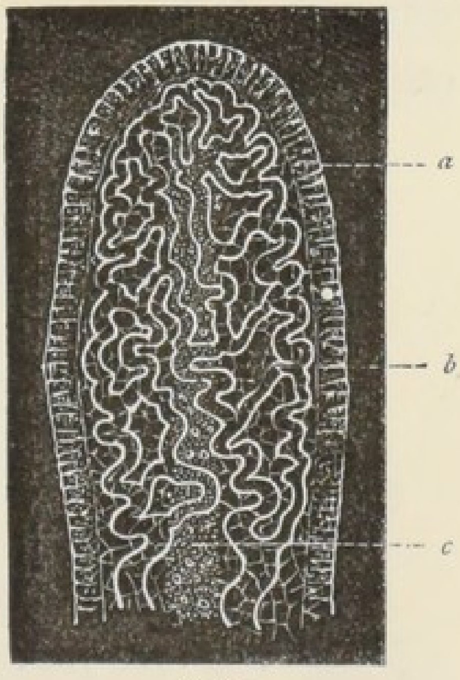
Through these two channels, then—the veins and the lacteals—the dissolved and digested food is carried; first to certain glands, then into the general blood, and passed on through the heart into the lungs, there to undergo further changes, into which it is not our present business to inquire. In the work of absorption, the veins are the chief agents; the lacteals, though apparently the specially appointed instruments, play a less considerable part.* The veins begin to take up the liquid portions of the food from its first introduction into the stomach, and their action continues as long as any part of it is presented to them in a fluid form. These veins, thus charged with new material, unite to form a large trunk, which enters the liver at its lower part. From the blood thus supplied the bile is secreted; and other processes, yet unexplored, are carried on within the same organ, one result of which is the formation of a large quantity of sugar (or, at least, of a substance that rapidly changes into sugar after death), although neither sugar nor starch may have been contained in the food. What effect these processes have upon the newly formed blood, we cannot be said to know, yet surely we can hardly doubt that their result is to intensify and perfect its life—to raise it into a condition in which it embodies more force, and therefore is more living. In the giving off of bile and in the production of sugar, alike, we may see evidence of changes adapted to produce this effect. One part of the blood sinks, or falls, into bile or into sugar;

* The lacteals only *seem* to be specially contrived instruments for the absorption of food; they are, in truth, simply a part of a system of minute absorbent vessels distributed almost universally through the body.

these are less living than the blood—they contain less vital force; then, must not the remaining portion of the blood be rendered more living, made to possess a greater tension of the vital force, by their formation? One part may grow by the decay of another part, as we see is the law of nature everywhere around us. Is it not also the law within? The child's see-saw embodies the same law—one part falls, the other rises.

But quitting that portion of the food which enters the blood through the veins and the liver, we come back to that other part which finds its path through the absorbent or lacteal vessels, and the small glands scattered along their course. These vessels commence in minute conical projections, termed *villi*, which are thickly set over the whole length of the digestive tube, and give it its velvety appearance. Fig. No. 9 is a magnified representation of one of them. These villi are covered with cells, and within them are contained numerous small blood-vessels, with the commencement of the lacteal lying in the centre. This

Fig. 9.



Villus.
a. Layer of Cells. *b.* Vessels.
c. Commencement of Lacteal.

latter vessel is not open at its mouth, but commences in one or more closed extremities.

Small as they are, the villi contain muscular fibres, arranged around the central vessel, which give them a distinct contractile motion, and doubtless assist in the absorption and propagation of the chyle. To this end, also, the movements of the digestive tube itself largely contribute ; these movements are of a regular and rhythmical kind, proceeding by a gradual creeping contraction, at intervals, throughout its entire length. They are produced by two layers of muscular fibres arranged, as in the case of the stomach, one around, the other in the length of, the canal.

Absorption is effected by means of the cells by which the villi are covered. During digestion these cells may be seen to contain minute particles, probably of fat, in transit towards the lacteal vessel within. Fig. No. 10 represents them in their empty state, and when absorbing food. Connected with the lacteals are numerous roundish bodies occurring either separately or in groups. These are found throughout the entire digestive tube, though they are fewest in the stomach, and seem to be the first of the series of glands through which the

Fig. 10.

a. The Cells empty.
b. Absorbing Food.

chyle passes on its way into the blood. They are about a thirtieth of an inch in diameter, and consist of a mass of cellular pulp freely permeated by vessels.

Fig. 11.

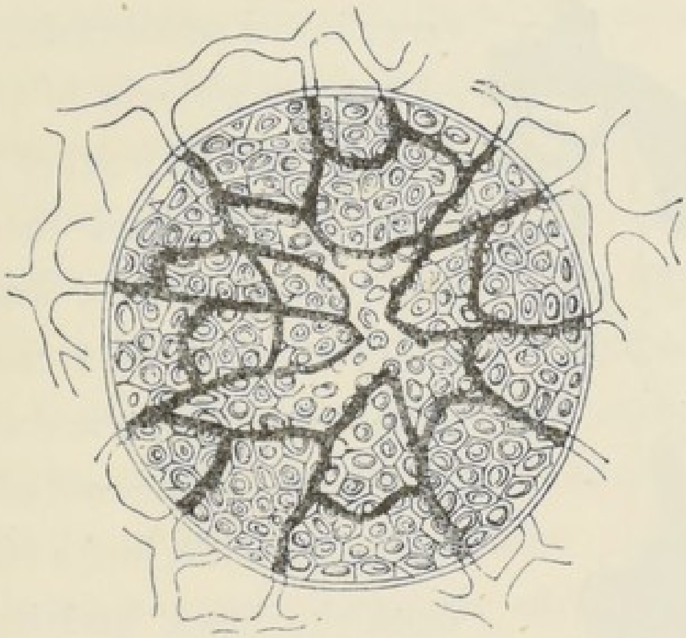
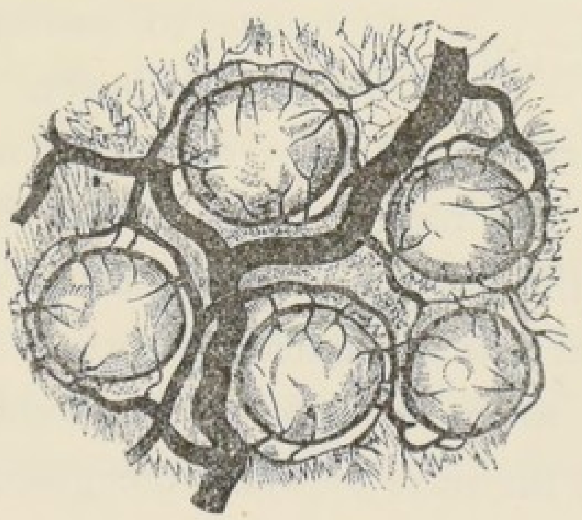


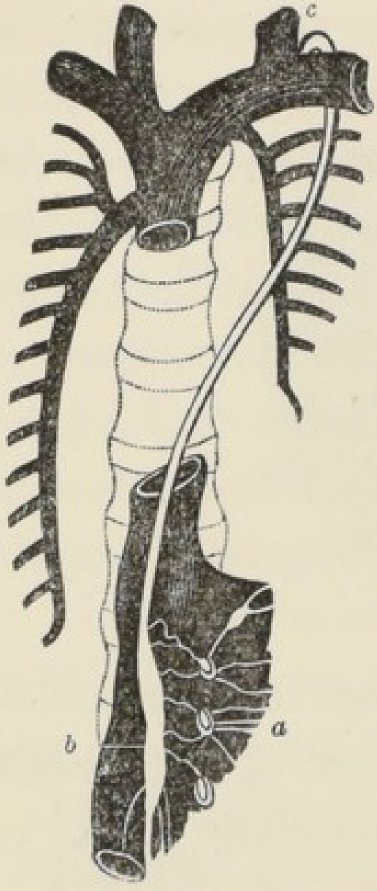
Fig. No. 11 is a representation of one of these bodies, and No. 12 shows the arrangement of the vessels among the groups in which they frequently occur.

Fig. 12.



Passing onwards, the various lacteal vessels are carried through another series of glands (essentially resembling those above described) in which they subdivide and reunite. Thence they converge into a small expansion, called "the receptacle of the chyle," situated on the front of the spinal column, and from thence there proceeds upwards a larger vessel, about the size of a crow's quill, called the "thoracic duct." This duct opens at the root of the neck, on the left side, into a vein coming from the head, and its contents are thus soon carried to the heart. The course of the thoracic duct is represented in Fig. 13. As the chyle passes along this vessel it continues to undergo changes; the fat diminishes, cells make their appearance, and grow more and more like the globules of the blood. And before it enters the circulation the chyle becomes so far blood-like in its qualities that it will coagulate slightly if withdrawn.

Fig. 13.



Course of the Thoracic Duct.
a. Lacteals.
b. Receptacle of the Chyle.
c. Entrance of the Duct into the Vein.

This is what becomes of the food. Variously changed by the secretions and the glands appointed for that purpose, it is poured into the blood. It has become part of that river of Life from which the body ever rises afresh ; shaming by reality the ancient dream. The lowest facts lay hold of the loftiest truths. The food is buried in the blood, and raised to a new life in every organ of the frame.

It must be raised. Entombed, a living corpse within a living sepulchre, the life that is hidden in it must break forth in visible and active forms. Not more surely is the Divine promise pledged to raise up again His dead, than the Divine law stands bound to restore, in active life, to nature the power she renders up to nourish living things. Written on tables of stone wherever a particle of matter may be found, written on fleshy tables wherever life rejoices, this law stands paramount and fixed : Whatever thing is given up shall be restored again ; nor shall any say, I have made the Maker rich. Value for value, force for force, all shall be rendered back. Flaw or defect, here, no man has found ; nor shall find. The perfect law of justice sways the quivering beam of life, changing with every breath, thrilling with every thought. Life trembles—as the balance trembles. The strong law that is in it sports in the disguise of weakness ; but he that would bend it measures his strength against the universe.

The food *must* nourish the body. There is that within it which compels growth, and makes action a necessity. We err when we think of ourselves as appropriating, using, living upon, that which we eat. We take, indeed, the active part in procuring and consuming it, but not beyond ; in the added life which follows, we are passive. We do not "live upon" the food, but the food lives in us. The body is but a theatre on which it may exhibit its latent powers ; powers stored up by patient chemistry, day by day, from warmth and light, and vagrant currents of electric force. Brought into union with the animal structure, these forces, thus bound up in the food, pour their energy through new channels ; but they are the same forces still, and they constitute its life. Through these it lives and grows ; through these it is strong to act. The materials wherewith the House of Life is built need not to be laboriously moulded by extraneous force ; *they* place their powers at our bidding, and gather themselves to our substance. The food actively builds itself into our frame, and brings its ready service to our need. It is thus the body grows ; a temple—meet image of the highest Temple —made without hands, and built of living stones.

CHAPTER IV.

FOOD—HOW TO TAKE IT.

THE health that is purchased by a rigorous watching of the diet, thought Montesquieu, is but a tedious disease; and indeed, if health were to be obtained in any such way, this would be a true description of it. We may very heartily congratulate ourselves, in this case at least (as, perhaps, we might in many others, if the truth were known), on failure rather than success, and count it one of our felicities that whenever science hitherto has attempted to lay down dietetic laws, it has but exposed its own incompetence. On this subject experience, and not theory, has given us all the rules of any practical value that we possess; and in truth science itself has grown wiser, gaining modesty with maturity, and has accepted an humbler part than that of dictating laws to nature. In respect to food, it declares for liberty, and concedes the rule to instinct. The physiologist now is well content with the subordinate part of explaining or supplementing our natural desires. He recognizes that a deeper wisdom than his own utters itself in these, and acknowledges, in the perfect conformity of his inductions with that which they declare, the ultimate seal of truth.

It is pitiful to think how often, in trying to escape from the bondage of ignorance, men have merely subjected themselves to a worse yoke of pedantry. Certainly, in their digestive "struggle for existence" they have often been as unfortunate as the poor Britons were when they called on the Saxons to help them against the Danes; exchanging the sharp attacks of indiscretion for the leaden tyranny of routine. But this is no more the case. To apply the present principles of physiology to diet, is not to forfeit, but to confirm, and by understanding its conditions, to enlarge, our liberty.

To see how truly science has become in these matters the servant and interpreter of instinct, we need only listen to what Dr. Edward Smith, who has recently made some very extensive experiments on the influence of various modes of living, says, in reference to the inclination or dislike to special articles of diet. "It is known that whilst there is a general correspondence among men in the food which they desire, there are many exceptions both in the healthy and diseased system. In my inquiries I found that with a disrelish for an article of food there was less influence from it than under ordinary circumstances; so that in reference to milk, the effect of every element of it was less on another gentleman who took part in my experiments than on myself, and neither he nor any member of his family can take milk or cheese. Hence, appetite for food is the expression not only of desire, but of fitness. Moreover, it was found that in the same person the various substances which were disliked had a common mode of action; also that with this disrelish there was an unusual enjoyment of some other article having a similar mode of action. Thus, one disliking milk and sugar was very fond of tea. It is, therefore, very questionable how far it is proper to induce a person to take that which he disrelishes. An important meaning is shown to exist in that which is commonly regarded as irrational or capricious."

If we reflect, we see at once how reasonable and how significant these facts are. Nutrition thus appears not as a mere appropriation of material effected by some overruling force, but as an exact interlinking of powers without with corresponding powers within. The inexhaustible variety of life is maintained by an equally inexhaustible variety of means. And nothing can exhibit in a more striking light the mutual subservience of mind and matter, and the wonderful exactness of the relations which exist between them, than the mode in which the problem of nutrition is thus worked out. For the support of healthy life the natural forces must be brought into union with the living frame, not grossly, but in detail ; each organism demands its own special nutriment distinguished by the minutest shades of difference, by shifting and evanescent qualities which no analysis could detect. To fulfil these demands might well seem a task impossible, but the instrument is provided in this piercing instinct, which like a chemic affinity searches out its own ; and if it be not overborne by force, or ruined by abuse, selects and rejects with unfailing accuracy. Lowest of all our faculties as it seems, mere appetite, or discriminative desire, becomes invested with a strange dignity when we reflect upon it. Appetite reveals to us deep and wide relations, links and affinities of things, to which we should otherwise be entirely blind ; more deeply than all our other faculties together it carries us into the recesses of the material world, and is the revealer of hidden harmonies. As the eye sees more than the light-picture can present—colour as well as form ; so can the appetite discern what the chemist misses and must miss—a *colour* in our food.

Recognizing thus the function of our instincts in respect to food, science invests them with a significance and value that can hardly be exaggerated. Indicating as they do the existence of relations the most important, yet revealed to us only in this way, they are demonstrated to be our natural and rightful guides. Accordingly, the fundamental law in the kingdom of the stomach is, to fulfil the instinctive impulses and legitimately to gratify the natural desires.

An easy rule to follow does this seem? In some respects it is so, doubtless; yet there are a few conditions which cannot be overlooked. Thus, to gratify our instincts we must, at least, preserve them, suffering them neither to be blunted nor perverted; and we must give them fair play, by a certain simplicity of living. Being guided by nature, implies so much as this: we must have natural tastes to gratify; we must give them opportunity to indicate their real preferences. The habitual use of strongly-seasoned dishes, of artificial flavours, of modes of cooking which conceal the natural taste of the substance, or even of a great variety of dishes at a single meal, are all opposed to this fundamental rule. Probably the old-fashioned

English "joint" enjoys a supremacy, in this respect, over the more elaborate modes of cooking which so seriously threaten to displace it. At least it has the advantage of challenging and clearly eliciting the expression of the natural taste of the consumer. It is more than probable that some men lead languid and unenjoyable lives in the midst of every advantage, chiefly for want of some little article of food which nature needs, and which, under a simpler regimen, their tastes would decisively demand. Nor is this an extravagant idea, for there is ample proof that the importance of special portions of our food cannot be estimated merely by the value of their direct contribution to the system. The yeast is small in quantity, but it is all important to the loaf. And there is every reason to believe that certain portions of our food act a part that may be compared to that of yeast in respect to bread. Digestion is by no means a simple transference of so much matter into the body, but a long series of changes, in which certain elements are subservient to others. The repair of the substance of the body by one part of the food, is dependent upon forces derived from the changes which other parts undergo. No mere quantity, although ample, and every portion unexceptionable in its way, will give the true result, unless there be present the complementary substances in due proportion to supply the needful stimulus. The addition of half a pint of milk a day to the diet at Wakefield gaol, in 1853, diminished the sick list from 22 to 14 per cent.: an effect much beyond that which could be attributed to the amount of nourishment contained in the milk. It supplied elements which aided the appropriation of the rest. We must all have experienced how a feeling of indifference or repugnance to a certain article of diet may be converted into desire, if it be united with, or follow, another to which it may have no obvious relation.

But though the actual demands of the system as indicated by appetite constitute the chief claim of our likings to rule our food, there is a second reason, scarcely less potent, in the influence which enjoyment has in promoting the digestive process. Thus these two laws work most admirably together: that what is most relished is at once most needed by us and best digested. In truth, the great duty of the dietetic code is to enjoy. Pleasure is made the judge and ruler in the cause: and that is the best diet which gives the most genuine and permanent satisfaction.

The natural limitations of this law of liking are, for the most part, obvious. Children, of course, need controlling; and, in disease, the stomach may get a sort of twist which makes its preferences most perverse. But even in such cases, though the indications of appetite have not authority, they are never without a certain significance. The sick man's longings are the physician's sign-posts; and the youthful love for sweetmeats reveals an adaptation of sugar-containing food to the early stage of life.

To gratify the natural inclinations, then, is the first rule in taking food. The second might be, to have a natural inclination to gratify. In other words, if we eat what we have an appetite for, we should, as a rule, have an appetite before we eat. What the cause of the feeling of hunger may be, the best authorities cannot quite decide; but there is no doubt that its presence indicates the proper condition for eating, and that, except in certain cases, such as disease, exhaustion, or great mental excitement, its access should be waited for. For thus the proper interval is secured which should always intervene between successive meals. There is no more prevalent cause of indigestion than burdening the stomach (even with small quantities) before it is ready for its work. And the necessity of a regard to this point is demonstrated by ascertained facts respecting the mode of the secretion of the gastric juice. For that is a result of *growth*, and depends upon the development of cells within which the secretion is formed. As a process of growth, therefore, it requires time; the digestive fluids, once exhausted, can be furnished again only after certain intervals. In adults, these intervals can be scarcely reckoned less than five or six hours. They are shorter in children, in whom all the vital processes are more rapid, and the need of food proportionately greater. Children accordingly should eat, as parents well know, more frequently than their elders. One of the most needful cautions in respect to diet arises from the greater demand for food in early than in mature life. The relative diminution of quantity, which is indicated at the period when growth ceases, is easily ignored when everything invites to a contrary course.

In respect to the number of meals, there are three plans which are sanctioned by experience and conformable to our knowledge. Two meals a day: a substantial breakfast at nine or ten, and dinner from five to seven, with or without a light lunch, comprising salads, fruit, or soup, but without meat: this is suitable for strong digestions. Or three meals a day: an earlier breakfast, dinner towards the middle of the day, and a solid tea in the evening. Or, lastly, four meals: tea being taken as a liquid meal, about four hours after dinner, and a slight supper an hour or two before retiring. There are some strong constitutions for whom one meal a day not only suffices, but seems to answer best: a plan which was more common among the Romans than it is with us. Theoretically, the most perfect way is the three moderate meals at nearly equal intervals; but the great point is to allow time for the perfect digestion of each before the hour arrives for the next, not passing the limits of over-fatigue. A meat lunch, followed in a few hours by a hearty dinner, probably with little bodily exercise between, is a frequent source of evil. In this case, the best plan often is to make the lunch (perhaps postponed to a little later hour) the dinner.*

Dr. Paris suggests, as an additional reason for the necessity of a good interval between the successive meals, that the assimilation of food into the blood goes on alternately with digestion, properly so called, so that the latter should have ceased in order for the former to be well performed. The period at which digestion is succeeded by the assimilating processes is marked by a feeling of lightness and disposition to bodily exercise, which should be gratified, if possible.

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* Dr. Leared gives the following as a fair type of the diet suitable for impaired digestion, supposing a moderate amount of exercise taken :—

If to digest our food we should enjoy it, it should, of course, be taken leisurely, and in a pleasant frame of mind. The cheerful society of friends should not be absent. Chatted food, the proverb says, is half digested. And the longer time spent over the meal thus socially enjoyed has its part in the benefit. Next to anxiety, the worst foe to digestion is hurry; and this for several reasons. The stomach, in its normal action, contracts on each morsel as it is swallowed, and relaxes again to receive the next. Insufficient time allowed for this interferes with the rhythm of its movements and disorders the play of its muscles. Cramps and painful feelings of distension could have no more likely cause. That haste cuts short mastication is obvious, and on the perfection of that process chiefly depends the rapidity

	oz.		oz.		pt.
		Breakfast.			
Bread (stale)	4	Mutton chop, or other meat (cooked), free from fat and skin.....	3	Tea or other beverage	¾
		Luncheon.			
Bread (stale)	2	....		Liquid	¼
		Dinner.			
Bread (stale)	3	Meat (cooked) free from fat and skin.....	4	Liquid	½
Potatoes and other vegetables	4				
		Tea or Supper.			
Bread (stale)	2	....		Tea or other beverage	½
Total	15		7		2

with which the solution of the food can be effected. Again, it creates an artificial thirst, partly by not allowing time for the due admixture of saliva; and, above all, it deprives us of the natural guide to the proper amount of food, and remits almost to chance a decision than which scarcely any is more important to our wellbeing. For the natural indication of a sufficiency of food is the feeling of satisfaction; not *satiety*, which is always a symptom of excess, but a feeling of perfect comfort, the true luxury of eating. This feeling the hurried eater cannot know; it never exists for him. Either the unnatural violence to the stomach induces a premature feeling of repletion, and stints him of his due supply, or he eats on until the warning (which ever comes too late) of satiety arrests him. But perhaps it is in vain to protest, to hurried men, against hurry in their eating; and it is well, therefore, that there exists a means by which its ill effects may be, to a great degree, escaped. *Meat* may be eaten rapidly; if cut small, even with very little mastication. Animal food, if well divided, may be, without much risk, almost *bolted;* but vegetable food may not. The reason of this difference is that the digestion of the former is carried on entirely by the secretions of the internal organs; that of the latter depends in considerable part upon the action of the saliva. If, therefore, little time can be secured for a meal, a chop may be swallowed rapidly, and bread, fresh or dried fruit, &c., taken afterwards at leisure, at such intervals as may occur. By acting on this plan a tolerable digestion may be secured, even by those whose avocations compel them to compress their set times for eating into the most inadequate compass. The rapidity with which the carnivora consume their prey, and the slow feeding of the vegetable eaters, confirm this rule. And perhaps in the omnivorous character of man, rightly taken advantage of, provision is made alike for his social development in the prolonged and cheerful meal, and for the imperative subordination of all pleasures and all needs to the inevitable call of duty. If perfect mastication be from any cause impossible, the various instruments which perform that office artificially cannot be too highly commended. Some of them are admirably suited for domestic use. But it is always advisable that the act of masticating should be well performed, since the motions concerned in it are important stimuli to the secretions of the mouth.

The temptation to ravenous haste is one reason for avoiding too long intervals between the meals. But, in addition, such intervals debilitate the digestive power, and render the stomach less fit to receive even a reasonable quantity of food. If this were not sufficiently proved by ordinary experience, it would be demonstrated by the extreme instances of prolonged starvation, in which it is well known that the greatest caution is necessary in administering food. Restraint, therefore, should be put upon the appetite after unusually long abstinence, and the same rule applies after very great exertion. Prostration from toil impairs the digestive powers, and is to be met, not by large supply, but by small quantities of highly nutritious and somewhat stimulating food ; at the head of which stands the concentrated juice of meat prepared by heating beef in a closed earthen jar. This preparation, also, is an admirable substitute for stimulants.

If, after great exertion, though short of exhaustion, appetite fails, it is best to take a very little food, and follow it by perfect rest. The usual amount, followed by activity, in such circumstances, would be almost sure to do mischief.

Drinking, in so far as unstimulating liquids are concerned, if the habits are otherwise reasonable, should be regulated by inclination. For some constitutions, however, it is decidedly preferable not to drink during a meal ; but, if thirst be felt, to take liquid two or three hours afterwards. The habit of washing down almost every mouthful, however, is always objectionable, and great benefit often arises from its abandonment. It cannot be said, on experimental grounds, that the addition of liquid hinders digestion ; on the other hand, it is found that, after the gastric juice has ceased to act, the solution of the food will recommence on the addition of a moderate amount of water. Perhaps, it is thus that water is useful at a late period of digestion. For those who can take it without disturbance, a glass of pure spring or filtered water, taken immediately on rising, is of great advantage. It should be followed by gentle exercise, but not to a great extent, except by those who are accustomed to it. Much unaccustomed exertion before breakfast is apt to be followed by languor through the day.

By regularity in the periods of eating, digestion is brought within the sphere of that great law of periodicity which characterizes all the processes of life, animal and vegetable alike, and of which the succession of sleep and waking is the chief instance. At the habitual periods the digestive system is prone to the actions demanded of it. But there seems to be a counterbalancing advantage in the stimulus given by an occasional change. A deviation from the accustomed hours will sometimes seem to endow the jaded organs with a fresh vivacity, while the change of season itself operates as a pleasant charm. In a similar way, if the ordinary food be ample, an occasional fast, or partial fast, even though not specially made necessary, is a great preservative of health. On this point the art of "training" gives confirmation to ordinary experience. "It is well known," says Dr. Paris, "that race-horses and fighting cocks, as well as men, cannot be preserved at their *athletic weight*, or at the 'top of their condition,' for any length of time; and that any attempt to force its continuance is followed by disease. A person, therefore, in robust health should (occasionally) diminish the proportion of his food, in order that he may not attempt to force it beyond the athletic standard." Some celebrated men have taken nothing more solid than an egg on Sundays; some, although Protestants, have fasted on Fridays. In truth, the human body seems attuned to variety; it rusts in sameness, and has wonderful power of accommodation to circumstances. We find, in point of fact, that the most robust and long-lived men are by no means those who have passed the most regular lives. A new spring seems often to be taken by the entire vital machinery from some unusual shock. And the pleasantness of variety (for a time) to the eye and mind, perhaps, are the fruits of the freer play and healthful stimulus it gives to the bodily processes. The animal frame is not a fixed and unvarying machine, but a channel for the forces of Nature, ever adapting, and meant to adapt, itself anew.

On the vexed question of suppers, theory must be silent in the presence of experience. As far as any rule can be given, it would seem to be that at the hour of sleep the stomach should have nearly finished its task, but that the blood should be well supplied with new materials. This, at least, seems the wisest plan in the perhaps somewhat irritable state of constitution which at present prevails ; it can hardly be reckoned a natural requirement. Sleeping after food is general throughout the animal creation ; and, so far as we know, the condition of the brain during sleep is such as would be every way suitable to the carrying out of an active process of digestion. It is certain that sound and refreshing, or at least restoring, sleep is not to be obtained by abstinence. So far as we can judge, the very purpose and end of sleep is that the system may build itself up and restore its waste, and for this purpose it is necessary that materials should be at its disposal. Sleep, with an impoverished circulation, would be sleep thrown away. Every one who has had to do with children knows that they cannot be got to sleep with an empty stomach ; and herein, doubtless, the demands of nature are indicated. Sound sleep is often obtained, after sickness, only by means of a substantial supper. And if disturbed slumbers follow a meal taken shortly before retiring, they are probably caused by some indiscretions which a little caution would prevent.

In respect to the quantity of food required to support life in the best way, some reliable information has been obtained by experiment. The precise amount which in the adult maintains the weight of the body unchanged during a life of moderate exercise is theoretically the right average quantity. Of course, it varies with the kind of food employed; some articles furnishing much more nourishment in an equal weight than others. On a diet of fresh meat, bread, and butter, with coffee or water for drink, Dr. Dalton found the entire quantity required during twenty-four hours by a man in full health, and taking free exercise in the open air, to be —of meat, 1 lb.; of bread, 1 lb. 3 oz.; of butter or fat, $3\frac{1}{2}$ oz.; water $3\frac{1}{3}$ lbs. That is to say, rather less than $2\frac{1}{2}$ lbs. of solid food, and rather more than 3 pints of liquid. These weights would of course be exceeded if less nutritious substances, such as rice, potatoes, or fruits, formed any considerable portion of the diet. Dr. Hammond found that he maintained his exact weight by a daily consumption of 1 lb. of meat, 18 oz. of bread, 6 oz. of soup, 4 oz. of beetroots, 1 oz. of butter, with salt, drinking at the same time, 3 pints of water and 10 oz. of coffee, with cream and sugar. Any excess above this caused an increase of weight, any diminution caused a loss. Remembering that the doctor is 6 ft. 2 in. in height, and weighs 14 stone, we may take these quantities as a fair average for a strong man somewhat beyond the ordinary stature.

Generally speaking, the average amount of food necessary for healthy men is estimated at 12 oz. of beef, 20 oz. of bread, with about ½ oz. of butter. These articles contain a force, capable, if applied by a machine, of raising fourteen million pounds weight to a height of one foot; that is, the oxidation of the elements contained in them would give rise to an amount of heat equivalent to that effect. But in the human body, though it far surpasses all machines in economy of force, the utmost amount of power attainable from them is not more than equivalent to three and a half millions of pounds raised to the height of a foot; and an average day's labour does not exceed two millions of pounds thus raised. The difference is mainly due, doubtless, to the number of internal actions which are carried on in the living body; such as the circulation, the movements of respiration, and the production of animal heat. These consume a great part of the force of the food, and leave only a remainder to be disposed of in muscular exertion.

But no average is of much practical avail, in respect to amounts of food required; for individuals in this respect differ very widely, as much as different breeds of cattle. Some can be kept in health only by continual abundance; with others, a small light diet will alone agree. But as a rule, a good and liberal diet is the right thing for health—liberal diet and plentiful exercise in the open air. Mr. Chadwick, in a paper published in the *Journal of the Society of Arts* (1856), has adduced striking evidence to prove how intimately the amount and value of the work that can be performed by a labouring man is connected with ample nourishment. Repeated and unvarying experience has proved that well-fed labourers, working under the stimulus of high wages, do better and cheaper work than those whose wages are low, and whose living is correspondingly scanty. Mr. Chadwick says:—" I have ascertained in England, that in highly-cultivated districts, where agricultural labour costs 14*s*. and 16*s*. a week, the work is, for quantity, as cheap as in districts where agriculture is lower, and where wages are only 8*s*. or 9*s*. a week.

Nay, we have in my county—Lancashire—a class of workmen strangely called navigators, or 'navvies,' it is supposed from having been originally employed in digging canals and works for serving inland navigation. These Lancashire men work in gangs of five, and will admit no man into their gangs who cannot, as his minimum task, load twenty cubic yards, or twenty single horse-loads, of earth in a day. I have known instances of men of this class, as a feat, doing even double that quantity. A mile of road made by labourers of this superior class, earning 3*s.*, 3*s.* 6*d.*, or 5*s.* 6*d.* per diem, has been executed in a much shorter time, and has been finished as cheaply, as a mile of precisely the same sort of road done in Ireland by pauper labourers whose wages were only 1*s.* per diem. Common agricultural labourers, when they have been allowed to join these gangs of navvies, and have been 'alimented' and seasoned to their tremendous discipline, on their return have astonished the farmers by doing an ordinary day's agricultural work before noon, and by putting their spades on their shoulders, and going away for the rest of the day. My noble friend, Lord Shaftesbury, brought down to his estate in Dorsetshire a foreman accustomed to superior labour at piecework. Judging what would be his answer, I said to this foreman, 'Will you not get this work done more cheaply; here the labourers are got for only 8*s.* per week?' 'But *they* would be dear at 6*s.*,' was the reply. 'How is it here with your other classes of artisans?' I inquired,—'your journeymen bricklayers, for example, what sort of workpeople are they?' 'Such as, from their wages, you, sir, would expect,' was the answer. 'And what wages are those?' 'About 12*s.* per week.' 'And how many bricks do they lay in a day?' 'Not more than between three and four hundred.' 'And how many do your town bricklayers lay, to whom you pay double wages?' 'More than a thousand a day!' was the answer."

Similar evidence is given by Dr. Letheby. The navigators who performed the task of making the railroad in the Crimea were daily supplied with 20 oz. of bread, 20 oz. of meat, 2 oz. of peas, 2 oz. of rice, 1¾ oz. of coffee, and 4 oz. of rum, per man. This was much more than the full allowance of the soldier, and the results are seen in the following statement:—"In the Crimea, under the directions of our army administration, the ordinary labour and tasks of earthwork required from soldiers—raised chiefly from those same districts from whence the best navvies have been obtained, and acknowledged by impartial observers to have in physique no superiors amongst all the troops in the field—were only to remove ten cubic yards a day in a loose soil; that is to say, that at least two soldiers were required to do the work done with an interest and a will by one navvy—the navvy very often the brother or relation of the soldiers, or coming from the same villages."

The bearing of these facts on the prospects of the agricultural labourer is full of hope. It has been shown, too, by researches into the health of towns, that all other causes of disease together are insignificant when compared with want.

But in order to derive benefit from ample consumption of food, ample exercise is necessary—exercise of the limbs, and in the air. For only that part of the food which is made to participate in those energetic processes of change in which life consists, contributes to the strength; and for these processes muscular exertion and plenty of oxygen are essential. Without them, the excess of food oppresses the stomach, or if it gets farther, it is distributed through the body as masses of fat, or, worse still, converts into fat, and spoils, the very organs of life itself. Abstinence is better than good feeding without exercise. Thus the prize-fighter's training, by which he is put into the highest condition of health and vigour, consists in eating largely of animal food and undergoing enormous muscular exercise; drinking the while only a little weak beer, but any amount of water.

Essentially the kind of living best fitted for the athlete, is that which is most suited to those whose exertions may be hardly less in amount, though of a different character. Work of brain exhausts, and needs supply, though not in exactly the same way. The fact seems to be, so far as we can penetrate these somewhat obscure relations, that while in mental work there is no less expenditure of force and substance, there is not given by it an equal stimulus to reconstruction; probably because the secretions are not brought into activity to the same degree as by muscular exertion. For life consists in the balance of two opposite actions, the formation and the decomposition of the frame, and in the vigorous performance of these operations, each in due proportion, consists the vigour of the man. Now, neither of these can be well performed if the other is languid. On the nourishment of the body depends the possibility of its action; on the activity of every organ again depends its nourishment. The energy disengaged in vigorous exercise is restored in part to the body itself, and adds an impetus to the forces which are engaged in absorbing and uplifting the new materials. Accordingly, there should be a certain difference in the kind of food taken by workers with the brain and with the muscles. If vigorous exercise cannot lend its impulse to the vivifying of the new materials, then a more considerable portion of the food itself might be of a kind to serve this office. For the sedentary, the subordinate class of food (that which contains no nitrogen) is fitting in larger proportions than for the powerfully active. A less vigorous life may thus result indeed, but it may be the best attainable, and the most truly balanced. The sedentary man should be largely a vegetable feeder; farinaceous articles, with milk, might constitute a valuable portion of his food. Speaking, however, of the exercise which the head worker should take, there is one caution to be remembered. Such exercise may be carried to an extreme. Great physical and great mental exertion combined, will often exhaust too much, and leave no power for vital uses. The mental labour must be moderated, for the most part, by those who are accustomed to hard thought, when active bodily exercise is undertaken.

There are many instances on record of great temporary abstinence during a specially severe strain upon the mind. How Newton, during the birth-throes of his great discovery, took only a few biscuits and a little wine, is well known. During the siege of Gibraltar, Lord Elliott for eight days "took only four ounces of rice per day as solid food." But it is probable that not a few hard workers in these days take on the whole too little food. It is certain that some so-called bilious headaches, for which fasting is commonly supposed to be a proper remedy, are signs of the need of better living.

The question of the use of animal or vegetable food may well be remitted to the arbitrament of nature, as expressed in the desires; by which it would be victoriously decided, in all such climates as ours, in favour of the flesh-eater. But the sufficiency of vegetable food, if widely varied, to maintain health and even strength, is not to be questioned, for those who like it. When we hear that the ancient Persians lived a good deal on water-cress, we naturally connect in our minds their physical inferiority with the poverty of their diet; but finding, on the other hand, that the Romans, in the best period of the Republic, largely sustained themselves on turnips, and that degeneracy came in as turnips went out, we are compelled to reconsider our opinion. In brief, an exclusively vegetable food may be best suited to those by whom it really is preferred. Children in this respect exhibit the greatest difference; some, with manifest advantage, eat meat in large quantity—others can hardly be prevailed on to taste it, and yet retain perfect vigour. Similar differences, in all probability, exist among adults; but a vegetarianism self-imposed against the promptings of desire, would tend, as a vigorous writer says, to make us "not the children but the abortions of Paradise." *

For those who cannot, or not without repugnance, eat meat, there is one caution necessary; that the food which is substituted should be such as to contain the elements essential to perfect nourishment. This is a caution made necessary by the refinements of modern culture, which has given us a vast variety of artificially prepared articles of diet, deluding the ignorant with an appearance of strengthening qualities in which they are wholly deficient. In this category come the entire group of starches—arrowroot, tapioca, sago, the patent corn-flour, and so on. To these, though of much more value than they, must be added

* An army surgeon once wrote—"I have wandered a good deal about the world, and never followed any prescribed rule in anything; my health has been tried in all ways; and, by the aids of temperance and hard work, I have worn out two armies in two wars, and probably could wear out another before my period of old age arrives; I eat no animal food, drink no wine, or malt liquor, or spirits of any kind; I wear no flannel, and neither regard wind nor rain, heat nor cold, where business is in the way."

rice and the potato, which are admirable adjuncts of a richer diet, poor and inadequate in themselves. It is calculated that, comparing value for value in respect of nourishment, potatoes are two-and-a-half times as dear as bread ; bread, on the other hand, and preparations of wheat and similar grains, seem to be the very best and cheapest single article of food. Alone, bread is far superior to meat alone. But there is great difference in its value, according to the mode in which it is prepared. The unfermented seems to be the more nourishing ; but the whole question of the best kind of bread is yet very much in the dark. There is great reason to fear that the light white bread from which all the external portions of the grain are rejected, so universally used in England, is dangerously deficient in the nutritive qualities essential to the support of a hard worker. "A good pure brownish bread," says Dr. Brinton, "of simple wheat-meal, with even an admixture of a fourth or fifth of rye, would, for equal money value, give the labouring population a food incomparably more abundant and nutritious than that which they now make use of as pure white bread ; and in no way could the dyspeptic affluent set their poorer neighbours a better dietetic example, than by adopting, were it at some little pains, a bread which might sometimes cure their own ailments by its mechanical quality ; as well as prevent disease and deformity among the lower classes by its nutritive value."

To a certain extent the diet should vary with the seasons. The heat of the body being maintained at an almost constant level, the external temperature constitutes an important element in the demands made on the system. In winter, therefore, rather more food is called for ; in summer, somewhat less. Meat, also, may rightly constitute a larger proportion of the winter food ; a rule to which appetite for the most part inclines. But here, too rigid a conclusion should not be drawn ; for there are instances of larger consumption of animal food in tropical countries, of which no sufficient explanation can be given, and if nature prompt to a freer use of food, and of the more solid kinds, during the higher temperature, no theory is competent to forbid it.

Of the evils of adulteration and unwholesome quality, this is not the place to speak. It may be remarked, however, that meat or grain kept until anything like decomposition commences, has a disastrous influence on health. The natives of New Zealand at one time steeped their corn until it began to decay, and a high mortality was the consequence. The use of wholesome grain diminished the death-rate by a third. It should be known, also, that the consumption of any kind of meat, in the form of sausages or otherwise, without its being subjected to a thorough process of cooking, is liable to generate disease from worms and other parasites.

The use of stimulating drinks is too large a question to be summarily disposed of here. As a brief judgment, it may be said, that while the tendency of physiological research is more and more unfavourable to their employment, every theory which assigns to them any intelligible part in life being in turn disproved, experience seems to speak with more authority on the other side. The relation to the human frame of that combination of ingredients which constitutes wine or beer, is too recondite, as yet, to be demonstrated in the test-tube, or estimated by the balance. The very different degrees in which they can be borne, or profited by, under different conditions of the nervous system, seems to point to an influence on the brain and its dependencies as the chief, or at least the primary, channel of their operation. Under great anxiety or excess of toil, their advantages are most apparent; on the other hand, they have not been found beneficial under extreme cold, the opinion of the Arctic voyagers being unfavourable to their use. The amount of alcohol which they contain is by no means the main element in their operation; independently of this, they have different and even opposite effects, as is evident from the emaciation produced by spirit-drinking, and the obesity consequent on the free consumption of beer—portrayed by Hogarth in "Gin Alley," and "Beer Lane." The choice must depend, therefore, on individual peculiarities; and variety and occasional intermission in their use is always advisable. They should be taken as an aid to digestion; not habitually, to relieve sinking or depression—a practice full of danger. To those who will have recourse to the hurtful indulgence of spirit and water, or for whom it is a necessary medicine, it is recommended, on the highest authority, to mix their beverage twelve hours before use, since the perfect solution of the spirit is effected slowly.

The use of condiments with food is justified by instinct. All the vegetable-feeding animals—to which man is most akin—seek after bitter and aromatic principles. Coffee, tea, and spices, therefore, are natural in the strictest sense, and doubtless supply, besides stimulation, some elements cunningly suited to the constitution of mankind. They are apt, however, to be abused: witness our "bride-cake," which was originally an aromatic conserve, designed to promote digestion! The aid which a moderate use of vinegar affords to the solution of the fibres of meat or fish is well known.

Is sleep after dinner a good thing? On the part of some persons of weak digestion it seems to be so. The habit should not be acquired without an attempt to ward off the necessity by a reduction of the amount of food. If this have unfavourable effects, an ample compensation for the time given to a short post-prandial sleep may be obtained by earlier wakefulness in the morning. On the other hand, Dr. Beaumont found, in the case of St. Martin, that digestion was promoted by moderate exercise, such as walking, immediately following the meal. In all cases experience must decide.

There is one more element which plays a most important part in digestion, and that is the state of the nervous system. More often than men think, the seat of their digestive difficulties lies neither on their tables nor in their stomach, but in their brain. Worry, agitation, oppression with care, restlessness of aim, a monotonous or despondent life, all these express themselves in capricious appetites and undigested food. Very often, too, a remedy for these evils is vainly sought in change or restriction of a diet by no means particularly faulty. The influence of the mental state upon the disposal of the food has been demonstrated in the case of prisoners. The depression attending the prison life, has made absolutely indispensable a compensation, in the form of a more liberal diet, for those whose sentence extends over any considerable period; and thus has arisen that comparative good feeling of the criminal, as compared with other classes of the community, which has sometimes excited so much comment. In his heavy mental atmosphere, the prisoner languishes upon a diet which might suffice a hope- and home- cheered man with the same amount of work.

That food difficulties are often merely a symptom, and bid us correct other things than our diet, we have proof, too, in the almost immediate effect of a change of scene and occupation. Who cannot eat anything when he is travelling, or when otherwise his nerves are kept in good order and his mind in pleasant excitement? Those patient and laborious servants upon whom is laid the office of keeping in repair the ever-wasting fabric of our life, work well and cheerfully, or painfully and ill, just as the superior powers whose needs they serve shed on them a bright or a depressing influence. They are infinitely accommodating; they will accept the conditions of any circumstance: man can live from the equator to the pole, and may embrace any variety of position in the intermediate zones, unchecked by murmurings from them; but they demand to serve a happy master. And thus, here, as everywhere, nature speaks a moral language, and her laws shine with a veiled spiritual light. It is true that for sound digestion the physical conditions must be fulfilled; but in these, wide latitude is given, and secret monitors within prompt or check all who are willing to be led. Not for these does nature most imperatively demand our care; but for a conscience void of offence, a sympathetic and kindly heart, a thoughtfulness diverted from selfish to generous ends. These are, above all, the conditions of a good digestion. And the most fatal violation of those conditions is to ponder with excessive carefulness the question, What shall I eat, or what shall I drink? The very organs themselves repel the misdirected zeal. It has been shown that attention fixed on any part of the body alters its condition, deranges to a slight degree the circulation in its vessels, and disturbs its perfect balance of nourishment and work. Thought cannot safely rest on any of the processes of life within us. These, as they are carried on without our co-operation, must be free also from the fretful importunities of our anxiety. Man was made to give the dominion to the spiritual part within him and the moral law without ; and his organization, in the point of food at least, is true to his destiny.

CHAPTER V.

WHAT ARE THE NERVES?

OF old, nervous meant strong. The nervous man was he whose muscles were like cords beneath his skin, and whose frame was knit into the highest tension. The name of nerve was applied rather to the tendons than to those susceptible strings to which we have appropriated it. Men had scarcely, in those days, discovered that they had nerves. But these have come into more prominence in recent times, and however little we may know about them, we can no longer be ignorant of their existence. Probably, few of those who live in cities, or come in any way within the vortex of our social life, have escaped occasional attacks of nervousness, or are able at all times to set that insidious enemy at defiance.

Is nervousness, then, an inevitable condition of civilization; a tax we must be content to pay for our advantages? or can we free ourselves from its assaults without paying too great a price for the immunity? What is the malady and its cause?—that we may know what the cure must be.

And first, have the nerves really anything to do with it? or have they borne the blame, while other portions of our organization have been at fault? When we are in that excitable, tremulous condition, in which there is a morbid anxiety to labour, with diminished power of performance; when, without any definite ailment, we seem deadened in every faculty, while yet the least vexation is felt as an intolerable annoyance; are we right in saying that it is especially the nervous system that breaks down?

In order to answer this question, we must obtain, if possible, a clear idea respecting this element of our being, and know what kind of a machinery it is that we are using. And, in truth, we are, in this respect, constructed in a way eminently adapted both to excite and to reward our curiosity. Beautiful, and even mysterious, as many of the exhibitions of nervous activity appear, and wonderful as are its aggregate results, there is hardly anything in the whole range of science better ascertained, or more simple, than are many of its fundamental principles. In this respect, the study of the nervous system is like that of astronomy, in which, while the great moving force still remains unexplained, yet many laws are clearly known, and these scarcely more interesting for their practical importance than for their simplicity. "If," says Sir Charles Bell, "I could address my reader with the same freedom, and with the same examples before me, with which I speak to my pupils on this subject, I think I could interest him in it." And no one who has once experienced the fascination of the study can help having the same feeling. But it must be remembered that our knowledge extends only to a certain point. While much can be explained with certainty, many problems still remain unsolved, many questions which we naturally ask can receive only a partial answer.

It was at one time thought that the presence of a nervous system, constituted a distinction between the animal and the vegetable. But this opinion does not seem to be correct. The lowest animals have no discoverable nerves; they lead merely a sort of vegetative life, and their simple structure does not demand any special mechanism for bringing into union the actions of different parts. Yet, although this is the case, the nervous system is one of the chief characteristics of animal life, and it makes its appearance immediately there is exhibited in the animal scale any complexity of structure. By its means the various organs are blended into a whole; and thus the animal is an unit or individual, while the plant always remains a mere bundle of more or less similar parts. The proper life of the animal consists in an ability to react in a definite manner upon objects that affect it from without, not only by a motion of the part immediately affected, but by the combined movements of many, and it may be distant, organs. In this lies the primary need for a nervous system. It is in its simplest aspect merely a channel, by which the affections of one portion of the body are enabled to call out the activity of another. Keeping this idea in view, we shall find there is no difficulty in following, in their general principles, the structure or the functions of the nervous system, even in its most highly developed and complicated forms.

It was an ancient notion that man is a microcosm, a little world, combining in himself all the powers and principles that are distributed throughout the greater world around him. In physiology the same idea has found a place in the representation that man embodies, and is an union of, all the lower animal natures. These ideas may have been mere dreams; yet they were dreams that contained an element of truth. The most rigid examination with the dissecting knife confirms them in a certain sense. In his nervous system man does present a combination of the structures and activities of the various forms of life below him. We live, in respect to our nerves, distinct and separate lives, and unite in our own person opposite existences. The spinal cord has one life of its own; the lower part of the brain another; and by means of its upper part we live a third kind of life higher than the other two.

The effects, and the proof also, of this diversity of life within us, are partially seen in the variety of actions which we are capable of carrying on at the same time, without their interfering with each other. By this means it is that, without taking any thought, we breathe regularly fifteen times in the minute; that we maintain ourselves in the erect position without any consciousness of effort; that (almost equally without consciousness when our attention is otherwise engaged) we walk, or eat, or perform other habitual motions, and at the same time carry on a distinct train of thought, or perform complicated and delicate manual operations. We are able to do all these things at once because, besides distinct groups of muscles, we have distinct nervous systems operating within us, each regulating its own circle of activities.

But elaborate as is the structure thus provided as the condition of our varied life, and diverse as are the results which ensue from the action of its different parts, it is all constructed on one plan. Its operations when combined, as they are in our experience, make up a whole of which we cannot think without wonder, and the intricacy of which seems to defy comprehension; but simplicity comes with analysis. The various elements which make up the nervous activity are presented to us by nature in various classes of animals, separated, and, as it were, distinctly exposed to view, while through them all there runs an identity of character which makes them easily reducible to a single law.

What are nerves wanted for? Not, in the first place, to make the body alive, or to give it the power of acting. The various structures of which it is composed, each for itself, have their own active properties, their own power of responding to stimulus. The muscle contracts when it is touched, or when it is galvanized, though no nerve be present; the gland pours forth its secretion under the like conditions. A due supply of blood alone is necessary for all these operations. But for animal life, except in its lowest grades, this kind of activity is not enough. The sensitive plant possesses as much as this; and indeed, so far as we can judge, this "irritability" (as the tendency to perform a motion on being touched is termed) is essentially the same property in the plant and in the animal. In fact, if we suppose such a mechanism to be connected with a sensitive plant, that on any given leaf being touched, not that leaf only, but others also, and those in a distant part of the plant, should be thrown into motion—say in such a way as to guard the irritated part—we should have a pretty good imitation of the animal activity. Such a result might be brought about if there were introduced into the plant a system of tubes, or fibres, which should convey an impulse from each point to various others; or more completely still, if these fibres were connected with a central apparatus that should gather up the impulses transmitted from every leaf, and pass them on in an orderly sequence to the rest. By such an arrangement it is evident a sort of animal intelligent-looking activity might be grafted on to the mere vegetable "irritability" of the plant. No fresh power would be needed in these fibres or in the central apparatus; only a capability of receiving, and transmitting unimpaired, the impulses conveyed to it from every quarter. No fresh power would be needed, only a "susceptibility" and a definite arrangement. In truth, owing to the greater amount of the action induced in the leaves of the sensitive plant, than that of the stimulus by which they are excited—a mere breath being sufficient often to produce a long contractile motion—these actions might go on by means of such an arrangement of fibres, continually multiplying, until a slight touch might suffice to throw the whole tree into—we will venture to say—convulsions. It is evident, however, that if any complicated series of actions were desired; if a touch (or other stimulus) applied to any single leaf were meant to call forth a corresponding action in distant parts; and especially if any large number of these actions were to be combined together, and this in many or varied groups, then the arrangement of the fibres would need to be exceedingly exact and complex. There would need to be points also at which the various impulses might be transferred from one set of fibres to another, or their progress altogether arrested for a time. In brief, the arrangements would be somewhat like those of an elaborate telegraphic system.

Such a system of tubes or fibres would closely represent in some essential characters the nervous system. If we look at the human brain, we find that it consists mainly of a vast mass of fibres. Their number, tenuity, and variety of direction are so great, that no skill has hitherto availed to trace them in detail, though their general course has been pretty well made out. The annexed figure may give a general conception of their multitude, and the intricacy of the web they form. Emanating from the

Fig. 14.

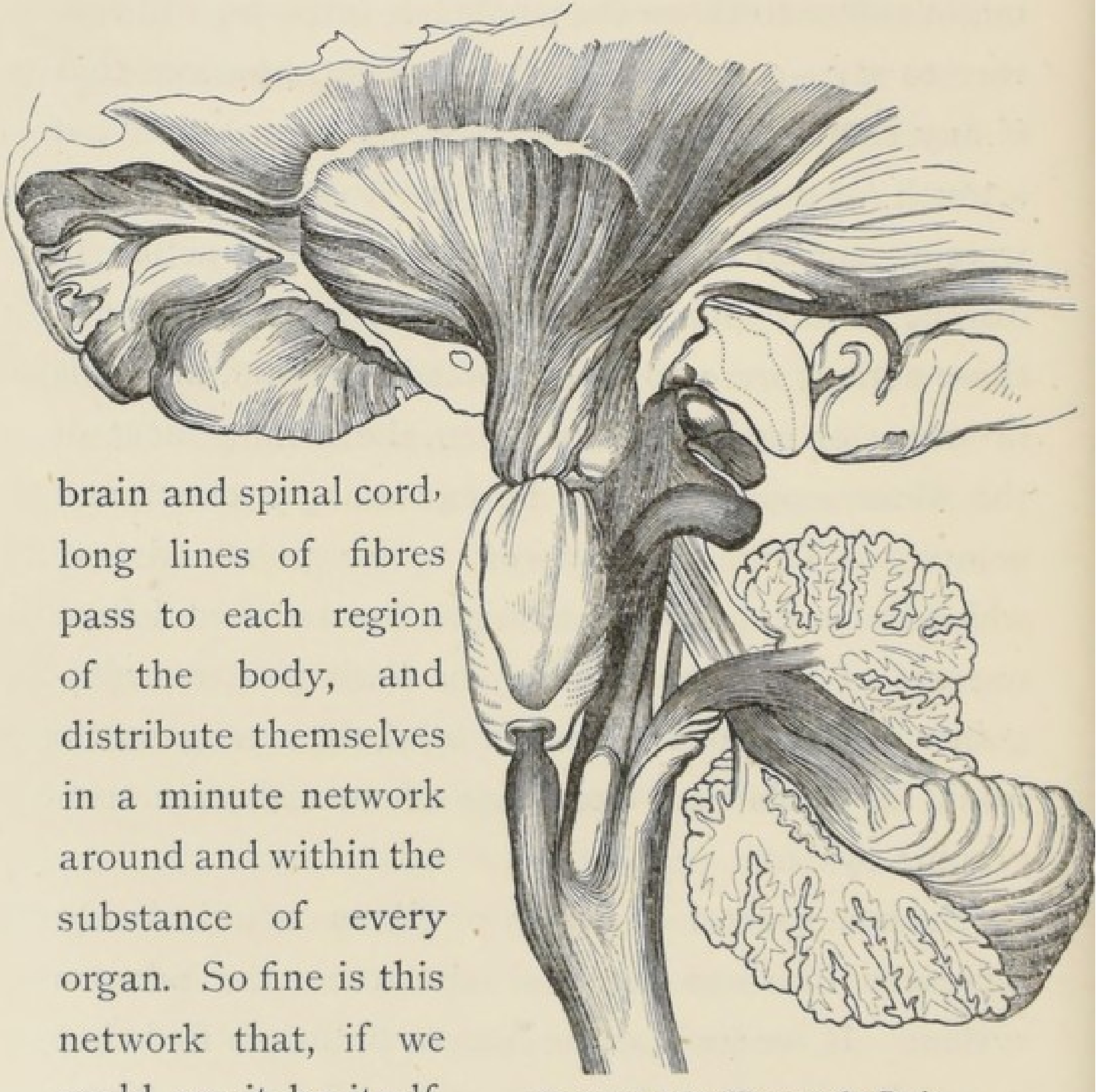


Diagram of the Fibres of the Brain.

brain and spinal cord, long lines of fibres pass to each region of the body, and distribute themselves in a minute network around and within the substance of every organ. So fine is this network that, if we could see it by itself, it would appear before us a perfect image of the body, all pure nerve.

We have thus, in our own persons, to do with a structure similar to that which has been supposed. Our body is not primarily dependent upon its nerves; it is active in itself, instinct and throbbing with force almost in every part, but waiting the touch of the master's hand before, in health, its ordered activities are set free. Take away from a man his nervous system (if it could be done with impunity), and there were left not lifeless clay, not even a mere inanimate and passive mechanism; there were left a body physically alive, endowed with active powers as containing in every part more or less of nature's force; but a body worthless *as a body*, with no unity in its action, nor possibility of ordered movement to any definite purpose; a structure, in the whole or in the parts of which more or fewer actions might go on, and go on with vigour, but in which these actions could be made subservient to no end.

The fibres which constitute the chief mass of the nervous system are simple in their structure, so far as the microscope can reveal it, and present a very curious analogy to a telegraphic wire. Like the latter, each nervous fibre consists of a small central thread (or tube, perhaps, in the case of the nerve, though the tubular structure cannot be demonstrated) surrounded by a layer of a different substance. The central thread (or axis) is of a greyish colour; the surrounding material is of a glassy appearance, soon becoming an opaque white after death, and giving their characteristic white appearance to the nerves. The fibre, consisting of these two portions, is included in a sheath (a sort of very fine skin) which separates it from the adjacent bodies. If we roll up a wax candle in paper, that will give us a rough illustration of the nerve fibre. The paper is the external "sheath;" the wax is the intermediate white matter; the wick is the central axis. It is most natural to believe that the analogy suggested by this structure is a true one, and that the white substance acts the part of the gutta-percha round the electric wire, as an insulating medium for the currents which travel along the central portion. But this is not proved. Probably, owing to the minuteness of the parts, it is beyond the possibility of experimental proof. For in man two or three thousand of these fibres would occupy but an

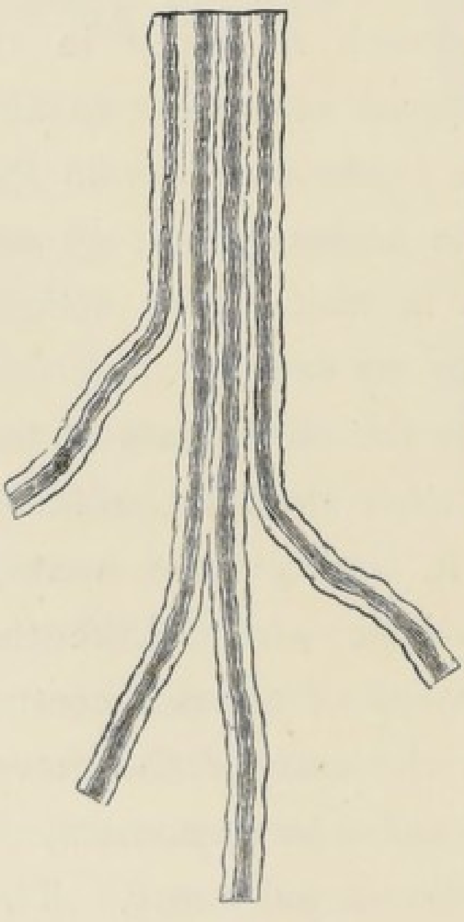


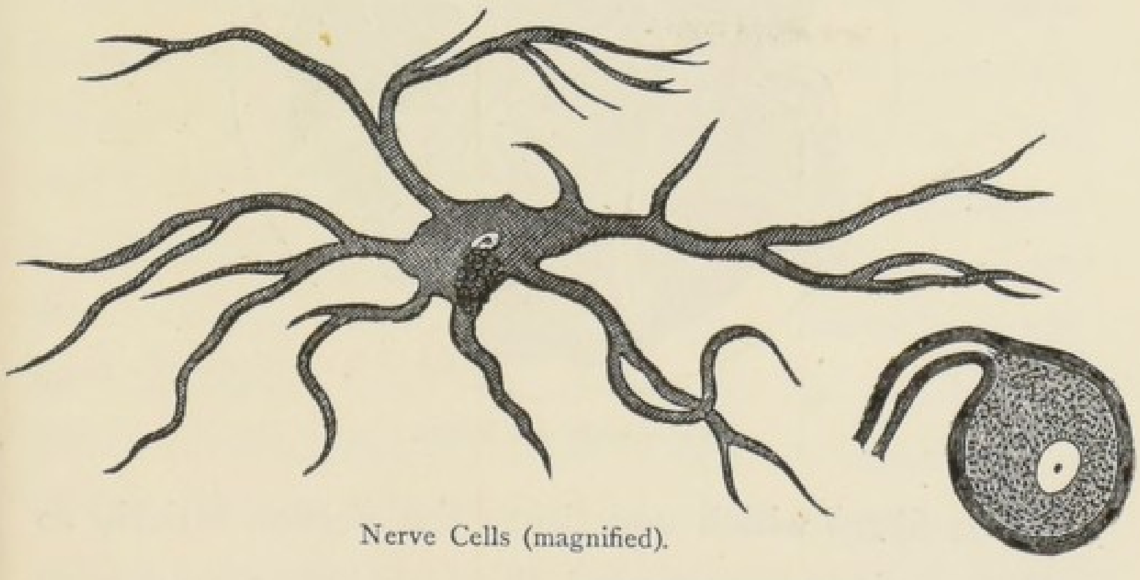
Fig. 15.

inch in their largest part, and both at their origin and their termination they are much smaller. Many of them are contained in every nerve that is visible to the naked eye. Fig. 15 represents a small nervous twig dividing.

They terminate probably in various ways. Their ends may seem to thin out and become free, or they may form a loop, and so return back in their course. Each nerve fibre runs in an unbroken line from its origin to its termination.

There is another kind of nervous matter, besides the fibres; and that consists of cells. Two of the forms which these cells assume are shown in fig. 16.

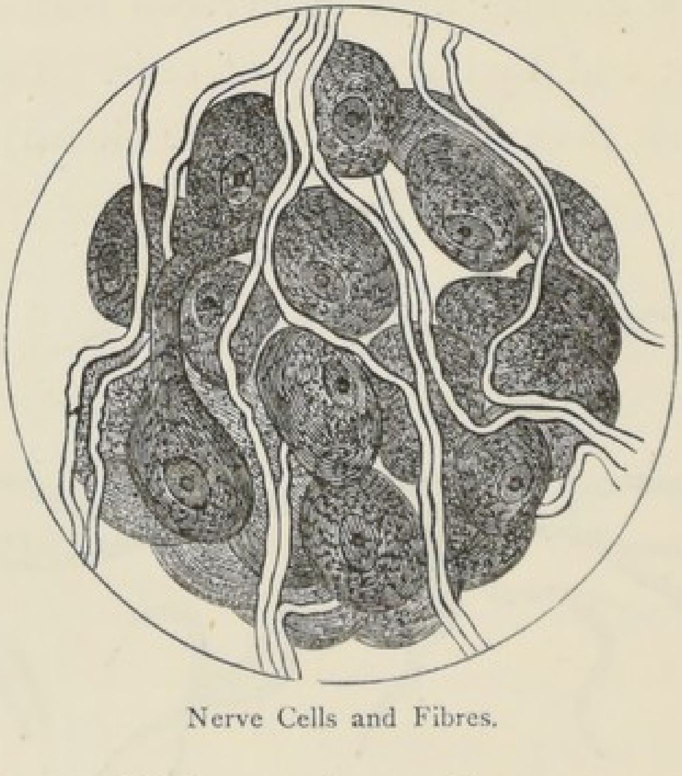
Fig. 16.



Nerve Cells (magnified).

The nerve fibres sometimes run into them; sometimes they pass among them without appearing to communicate, as represented in fig. 17. Cells of this kind form a thin layer over the surface of the brain, and its fibres for the most part have their origin from or among them. They also exist in large numbers in certain spots in the substance of the brain, and they are found within the spinal cord in its whole length. They have a pale pinkish hue, and wherever they are found they go by the name of "grey matter," the nerve fibres being called the white matter.

Fig. 17.



Nerve Cells and Fibres.

The fibres which constitute the nerves, strictly so called, are conductors, and they conduct to and from the cells. What, then, is the part played by the latter?

Before answering this question, it is worth while to pause, and note (as we may well do with something like surprise) the extreme simplicity of form exhibited by this element of the nervous system. In the grey matter of the brain we are arrived at the very highest organic structure, the great achievement of the vital force, the texture in which bodily life culminates, and for the sake of which, we might almost say, all the other organs exist. And we find a structure of the very lowest form. Mere cells and granules—Nature's first and roughest work, her very starting-point in the organic kingdom—strewn in a mere mass with no appreciable order over the ends of a multitude of fibres, and loosely folded up, as it seems, for convenient stowage! This is what meets the eye. Is this the laboratory of reason; the birthplace of thought; the home of genius and imagination; the palace of the soul? Nay, is this even the source and spring of bodily order; the seat of government and control for the disorderly rabble of the muscles? Should we not have expected when we came thus to the inmost shrine of life, and penetrated to the council-chamber of the mind, to find all that had before appeared of skilful architecture and elaborate machinery surpassed and thrown into the shade? But it is all cast away. Mechanical contrivances for mechanical effects! Skilful grouping and complex organization there may be for the hand, the eye, the tongue; for all parts and every function where the mind is not. But where the spirit comes, take all that scaffolding away.

Whether this suggestion be a true one or not, we do not know. Most probably it is not true; because it is a guess, and expresses ignorance, which *ought* to be deceived. But it remains a noteworthy fact, nevertheless, and surely puts our anticipation somewhat at fault, that at the very summit of the organic world, everything that we are accustomed to call structure, and to admire as beautiful, either to the eye or to the intellect, sinks to its lowest pitch. The grey matter of the brain, however, is very abundantly supplied with blood.

But to descend again to *terra firma*—what is the part played by the grey or cellular matter, so far as we can discover it? In order to gain clear ideas on this point, we must consider the general plan on which the nervous system is arranged, and regard it first in its simplest forms. Omitting the lowest members of the animal series in which nerves are found (and in which precisely the same principles prevail), we find in the class of insects a pattern to which all the higher forms may be referred. Fig. 18 is a diagram of the nervous system of the centipede. It consists of a series of little groups of nerve cells, arranged on

Fig. 18.

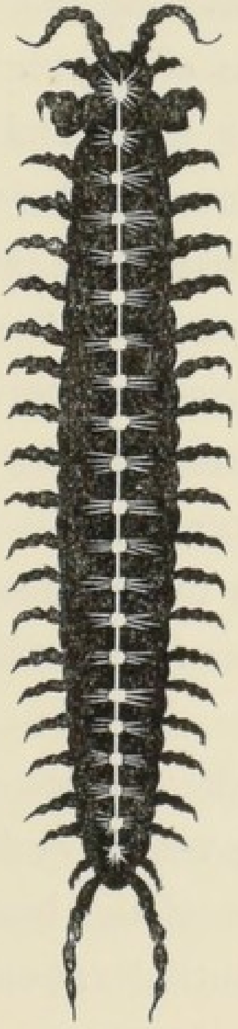
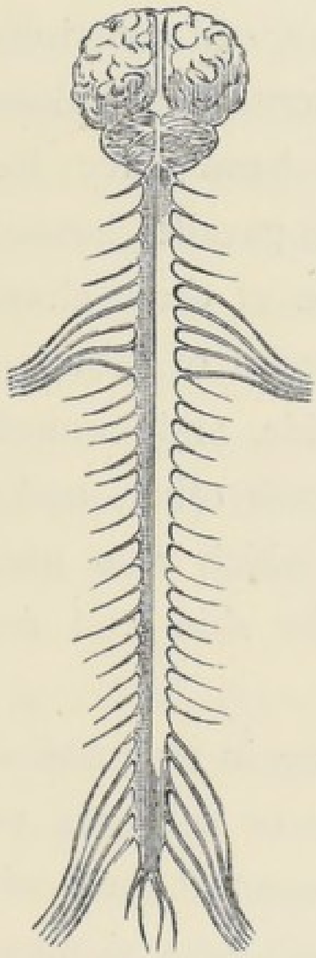


Fig. 19.



each side of the middle line, a pair in every segment of the body, and additional ones in the head, connected with the organs of sight, smell, touch, &c. These are all united to each other by bands of fibres, and each one sends out nerves to the organs contained in the segment in which it is placed. The nervous system of the highest animals is but a repetition, in an enlarged and condensed form, of this simple type. Fig. 19 represents the brain and spinal cord of man. The masses of cells, we perceive, have become joined together, and constitute not a series of double knots, but a continuous column of varying size; and those in the head have become enormously developed. But the parallel between the two structures remains, in spite of these changes. The spinal cord of man is a series of groups of cells, giving off nerves on each side, and connected by communicating fibres with each other, and with the larger groups in the brain, which also give off nerves to the nose and eye, the skin and muscles of the face, and other parts.

Thus in man and all animals alike, masses of grey matter, or cells, are placed at the centre, and nerve fibres connect them with the organs of the body. It has been proved, also, by the beautiful experiments of Sir Charles Bell, that the nerve fibres are of two kinds; some conveying an influence from the organs to the centres where the nerve cells are placed, and others carrying back an influence from them to the organs. So these groups of cells evidently answer to the *stations* of the electric telegraph. They are the points at which the messages are received from one line and passed on along another.* But besides this, the cells are the generators of the nervous power. For the living telegraph flashes along its wires not only messages, but the force also which ensures their fulfilment. A nerve bears inwards, say from the hand or foot, an impression, it may be of the slightest kind; but the cells (richly bathed as they are by air-containing blood) are thrown into active change by this slight stimulus, and are thus able to send out a force along the nerves leading to large groups of muscles, and excite them all to vigorous motion. Just so a message from one line may, by its stimulus to human wills, be transmitted from a station in twenty new directions.

In its simplest form this is called the "reflex function"—a name given to it by Dr. Marshall Hall, to whose investigations we owe much of our knowledge respecting the laws of nervous action. The idea of a reflex action is simply that to which reference has been made before; a stimulus to one part of the body being conveyed by a conductor to the cells

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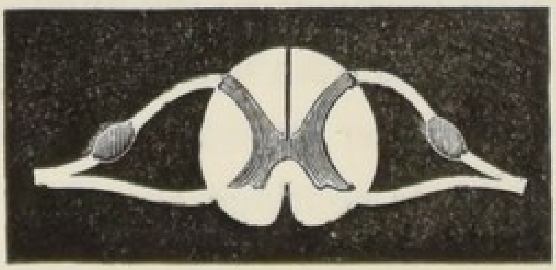
* They are called "ganglia" in scientific language; but this word has no deep meaning: it signifies a knot, and was applied to them simply with reference to the form they present at some places. Where a nerve passes through a small group of cells, the latter looks something like a knot tied in it.

at the centre, and "reflected" by them upon another, which it excites to activity. Thus, for example, a pinch or prick of the skin excites the muscles to contract. The name of "reflex" has been given to this action, because it may, and in many cases naturally does, take place without consciousness. There may be no feeling and no will, yet actions having all the appearance of design may be produced. Thus in some cases of paralysis, when owing to an injury of the spinal cord all sensibility and all voluntary power, in respect to one or more of the limbs, are abolished, a pinch or tickling of the paralysed member will cause it to be withdrawn, without any consciousness on the patient's part. This is an exhibition of the reflex function of the spinal cord. Similar results, of even more striking character, may be produced at will in the lower creatures. We know how long decapitated insects continue to move their limbs; how vigorously, for example, a headless wasp plies his sting. "If the head of a centipede be cut off while it is in motion, the body will continue to move onward by the action of the legs; and the same will take place in the separate parts, if the body be divided into several distinct portions. After these actions have come to an end, they may be excited again by irritating any part of the nervous centres or the cut extremity of the nervous cord. The body is moved forward by the regular and successive action of the legs, as in the natural state, but its movements are always forward, never backward, and are only directed to one side when the forward movement is checked by an obstacle. If, again, the nervous cord of a centipede be divided in the middle of the trunk, so that the hinder legs are cut off from connection with the head, they will continue to move, but not in harmony with those of the fore part of the body, being completely paralysed so far as the animal's controlling power is concerned, though still capable of performing reflex movements by the influence of their own nerve cells, which may thus continue to propel the body in opposition to the determinations of the animal itself. The case is still more remarkable when the nervous cord is not merely divided, but a portion of it is entirely removed from the middle of the trunk; for the anterior legs still remain obedient to the animal's control, the legs of the segments from which the cord has been removed are altogether motionless, while those of the posterior segments continue to act in a manner which shows that the animal has no power of checking or directing them.

"The stimulus to the reflex movements of the legs in the foregoing cases appears to be given by the contact of the extremities with the solid surface on which they rest. In other instances the appropriate impression can only be made by the contact of a liquid. Thus a water beetle, having had its head removed, remained motionless as long as it rested on a dry surface, but when cast into water, it executed the usual swimming motions with great energy and rapidity, striking all its comrades to one side by its violence, and persisting in these for more than half an hour." *

Facts of this kind prove that the ordinary movements of the legs and wings, in insects and similar animals, are effected not by a direct effort of will, but reflexly, through the medium of the little collections of nervous cells with which the several parts are connected by their nerves; while impulses derived from their "brain" serve only to harmonize, control, and direct their spontaneous motions. The spinal cord in ourselves has a similar office. Fig. 20 represents a section of it, about its middle portion. A nerve is seen proceeding from it on each

Fig. 20.



* Dr. Carpenter.

side. The white portions in the figure represent the external layers of the cord, which consist of white fibres; the dark part represents the central cellular or grey matter. Each nerve arises from the cord by two roots: the anterior one is the nerve of motion, or that which conveys impulses from the centre to the muscles; the posterior is the nerve of sensation, which conveys impulses from the skin and other parts to the centre. It will be seen that the posterior root alone is in immediate connection with the grey matter. This root also has a small mass of nerve cells situated upon it, a short distance from its origin; the motor root has none. While the nerve is perfect, if it be irritated (as by galvanism, pricking, &c.) at any point below the junction of its roots, the animal gives signs of pain, and some or all of the muscles to which it is distributed are at the same time thrown into contraction, But the proof that these two "roots" of the nerve (or two nerves, as they should perhaps be considered. though they are bound up in one sheath) have different offices, is this:—If the roots are separately divided, sensation is cut off by the division of the posterior, and the power of voluntary motion by that of the anterior root. At the same time, irritation of the posterior root *above* the point of division, causes pain, and irritation of the anterior *below* the point at which it is divided, still produces movement in the muscles. This was an experiment of Sir Charles Bell's, and it puts it beyond question that the nerves which convey sensation upwards and those which carry motor impulses downwards are different.

We have called the nerve which carries impressions upwards *sensitive;* and so it is, but only by virtue of the connection of the cord with the brain. If it be cut off from that, sensation ceases, but, as before shown, all the actions which sensation ordinarily prompts do not cease. The spinal cord is organized as a centre for reflex action in the highest animals, as the simple nervous cord is in insects ; and similar results to those which are produced in insects when connection with the head is severed, ensue also, under like circumstances, in quadrupeds and man, though less powerfully, and lasting for a very brief interval. A fowl flaps her wings and struggles for several seconds after the spinal cord is completely divided. And in reptiles, in which the processes of life, being less vigorous, are also less rapidly exhausted, reflex actions will continue a long time after complete removal of the brain. A frog, for example, in such a condition will put up its leg as if to push away anything that irritates its side. Cut off, therefore, from the brain, the nerve called sensitive still produces an effect, and induces more or less perfectly its appropriate action, although no sensation accompanies it. An action of this kind is called automatic.*

Thus we live an automatic life, in which various actions are carried on merely by virtue of the mechanical powers in the organs, and the arrangement of the nerves and cells within the spinal cord. We may call this our spinal life. It is the entire life, probably, of the lowest animals, whose functions are thus taken up into our being, and made a basis on which is erected the superstructure of our conscious, our human, life. By means of it we perform the actions which we can carry on without any heed, or even knowledge of their taking place. Walking, when our attention is wholly absorbed in something else, affords a good illustration of an action performed automatically. "When we are walking without attending to our steps, the foot coming down to the

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* The proof that there is no sensation when the connection with the brain is severed, is given by cases of paralysis from disease or injury, in which this severance is effected, and consciousness in respect to the parts thus cut off is wholly wanting. It has been argued that there is a consciousness—a sensation—pertaining to the cord itself; but this is not within the ordinary meaning of the term, and that question belongs at present wholly to the domain of speculation.

ground conveys the quasi-sensation of its contact to the spinal centres ; these are roused to a corresponding motion ; in other words, they command the muscles of the other leg to put it into a forward movement. No sooner is this executed, than at the end of the movement another manifest quasi-sensation (an impression which might be felt, but is not) is afforded by the fresh contact with the earth, which contact, reaching the centres, engenders a second motion, and so forth, throughout the walk. There is a simple circle, in which quasi-sensation excites motion at the centre, and motion produces quasi-sensation at the extremes. Thus, the foot on the ground represents sensation, and that in progress motion, and the two contemplated together represent the links in a chain of nervous fate."

This automatic action is the foundation of our nervous life ; but other forms of life are in immediate relation with it, modifying and controlling it, and reducing it to a diminished amount and importance. Just as the animal rises in the scale, so do its lower, or automatic functions receive more influence from those above them, and express more fully the dictates of consciousness and will. Man is the least automatic of all animals, through the greater preponderance of his conscious part, which uses the automatic organs as its ever ready instrument. But the instrument must exist, or it could not be used; and constantly supreme as is the rational part in man, it can exercise this supremacy only because the inferior and merely physical powers are ever waiting on its behests.

At the upper part of the spinal cord there is added on another set of nervous centres—masses, that is, of grey matter—which preside over other actions, those, namely, of breathing and of eating. These are still essentially automatic, yet less purely so than some of those whose seat is lower down the cord. They are situated in an expanded portion of the spinal cord, just below its junction with the brain; and here is found a special part of the nervous system, the destruction of which is at once fatal to life. Not, however, because there is any special vitality connected with it, but simply because on it depends the performance of respiration. To this part is conveyed the stimulus arising from the presence of impure blood in the lungs or in the system at large, and from it radiates the influence which calls into play the group of muscles which expand the chest. A sensation—the need of breathing—which becomes overpowering when long resisted, is normally connected with the performance of respiration; but this is not essential. In profound coma, or unconsciousness from disease, and under the action of chloroform, respiration continues, though slowly, and with diminished energy. The case is the same with the act of swallowing, which, like breathing, is automatic so far as the act itself is concerned, being produced without, and even against, our will, upon the contact of food with the upper part of the throat; and though normally connected with certain sensations, will yet take place in their absence. We swallow during sleep, and infants born with the brain wholly wanting can both breathe and suck.

Fig. 21.

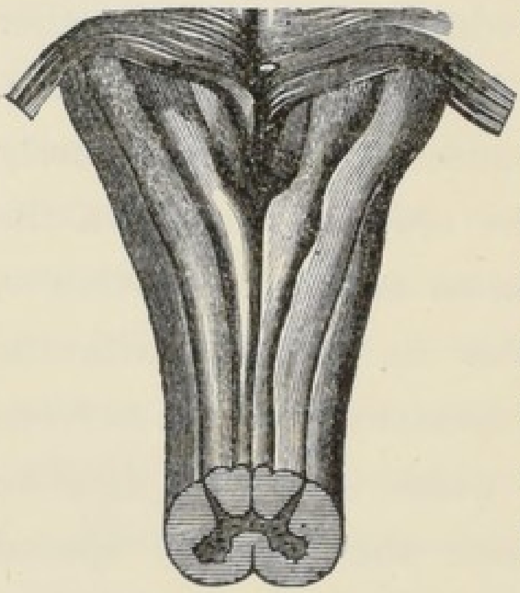


Fig. 21 represents the upper portion of the spinal cord, on which these actions depend.

Each of these partly automatic actions has a special nerve appropriated as its *excitor*, that is, a nerve which receives impressions from the organs concerned; the lung cells on the one hand, and the surface of the back part of the mouth on the other. These nerves convey a stimulus to the centre, and from thence it is diffused through other nerves (of motion) to the muscles by which the appointed action is effected. But the excitement of these muscles is not dependent on this special nerve alone; respiration especially has the widest relations, and almost all the sensitive nerves in the body may rouse or modify it. The sudden inspiration produced by the shock of cold water on the skin is a familiar instance of this kind of action.

Above all these parts comes the brain, containing the nervous centres which subserve feeling, thought, and will; but the description of these we must leave to another time, and also of the means by which all these separate parts are harmoniously blended into one, and made to co-operate in every action of the man. In the meantime, we see what the method is by which a basis is laid for our higher life of consciousness and moral choice, in the subordination to these powers of an animal machine, in which the processes requisite for maintaining life are carried on of themselves. If we had to perform by direct volition the actions that have been enumerated all our energy would be squandered upon them, and we should have no time for anything better. Breathing alone would occupy all our life, if each breath were a distinct voluntary act. By the committal of so much to a mere unconscious operation of nervous power, mind is emancipated, and placed in its fit relations; devoted to other interests and burdened with nobler cares.

This lower portion of the nervous system, however, controlling as it does the functions of chief necessity to life, is of paramount importance to health. Derangements of its action are seen in the paroxysms of asthma, and the seizures of epilepsy, in both of which affections the muscles are thrown into excessive contraction through a morbid condition induced in the spinal cord. Of a different order are that languor and feeling of utter disability for muscular exertion which creep over us at times. These feelings show that the nerve-centres which preside over muscular exertion have become oppressed and sluggish; perhaps through being badly nourished for want of proper exercise. Of a different kind, again, are tremblings of the muscles, or involuntary jerks and twitchings, and, in brief, all that condition known by the expressive name of "fidgets;" and which will sometimes affect the best-meaning people at the most unbecoming times. This affection is capable of a sufficiently simple explanation. The nervous centres which control the muscular activity (that "reflex" or involuntary activity which has been described) are then in a state of undue excitement, and yielding to stimuli too slight, or without any external stimulus at all, they call the muscles into irregular and spasmodic contraction. Cramps and a tendency to involuntary sighing are often due to a similar condition; the muscles themselves, however, sometimes sharing with the spinal cord in an increased excitability.

What is the source of this irritability which renders it impossible to keep the muscles still? We can answer, in general, that irritability means weakness—it is a tendency to too easy an overthrow of the balance in which the living textures exist; the excessive action arises from too rapid a decay. A philosophical physician compares it to the whirling movement of the hands of a watch, of which the mainspring is broken; and the eminent French experimentalist, M. Claude Bernard, has thrown a light on this condition by pointing out that an unnatural proneness to activity exists in every organ of a living animal, at a period immediately preceding the death of the part. In our physical as in our moral nature, strength is calm, patient, orderly; weakness hurries, cannot be at rest, attempts too much. The force which, in the living frame, binds up the elements into organic forms, being relaxed, too easily permits them to sink down, and ineffectual mimicries of energy ensue.

But how is living strength to be ensured in respect to the functions we have spoken of? The laws we have been tracing give us a partial answer to this question. Strength in the living body is maintained by the full but natural exercise of each organ; and as we have seen, the actions of these portions of the nervous system is made dependent upon influences conveyed to them by the sensitive nerves distributed over the various parts of the body. And among these the nerves passing to the skin are the chief. The full access of all healthful stimuli to the surface, and its freedom from all that irritates or impedes its functions, are the first external conditions of the normal vigour of this nervous circle. Among these stimuli, fresh air and pure water hold the first place. Sufficient warmth is second. The great, and even wonderful advantages of cleanliness are partly referable to the direct influence of a skin healthily active, open to all the natural stimuli, and free from morbid irritation, upon the nerve-centres of which it is the appointed excitant. This influence is altogether distinct from those cleansing functions which the healthy skin performs for the blood; and in any just estimate of its value is far too important to be overlooked.

That state of general vigour which we call "Tone" also depends upon the healthy action of these nervous centres. It consists in an habitual moderate contraction of the muscles, due to a constant stimulus exerted on them by the spinal cord, and is valuable less for itself than as a sign of a sound nervous balance. Tone is maintained partly by healthful impressions radiated upon the spinal cord, through the nerves, from all parts of the body, and partly by the stimulus poured down upon it from the brain. So it is disturbed by whatever conveys irritating or depressing influences in either direction. A single injudicious meal, a single sleepless night, a single passion or piece of bad news, will destroy it. On the other hand, a vivid hope, a cheerful resolve, an absorbing interest, will restore it as if by magic. For in man these lower officers in the nervous hierarchy draw their very breath according to the biddings of the higher powers. But the dependence of the higher on the lower is no less direct. The mutual action takes place in each line. A chief condition of keeping the brain healthy is to keep these unconscious nervous functions in full vigour, and in natural alternations of activity and repose. Thus it is that (besides its effect in increasing the breathing and the general vigour of the vital processes) muscular exercise has so manifest a beneficial influence on a depressed or irritable state of mind. The bodily movement, by affording an outlet to the activity of the spinal cord, withdraws a source of irritation from the brain ; or it may relieve excitement of that organ by carrying off its energy into a safe channel. We see evidence of the same law in the delightful effect of a cheerful walk, and in the demand for violent exertion, which is so frequent in insanity. Every part of the nervous system makes its influence felt by all the rest. A sort of constitutional monarchy exists within us ; no power in this small state is absolute, or can escape the checks and limitations which the other powers impose. Doubtless the brain is King ; but Lords and Commons have their seats below, and guard their privilege with jealous zeal. If the "constitution" of our personal realm is to be preserved intact, it must be by the efforts of each part, lawfully directed to a common end.

CHAPTER VI.

THE BRAIN AND ITS USE.

WE cannot wonder at the interest with which the brain has been regarded ever since it was discovered that consciousness had its seat within it. What a strange thing it seems that feeling and thought should be traced up to a soft piece of marrow within the head, and there fixed. How provocative of curiosity, how stimulative to hope! If we could but penetrate deeply enough into this little bit of matter, open as it is to all our senses, with microscopes and chemical analysis to aid them, would not the whole secret of life stand before us? Should we not then know why we think, and how it is we feel, what consciousness depends on, and how the senses are made the ministers not of impressions only, but of knowledge? The whole mystery seems to be in our hands. 'Tis here, if only we could stay the fleeting breath, and grasp it as it flies.

So men have reasoned; as we should reason were we in their place. And so they have been deluded by a false hope into the attainment of solid benefits. They have dug into the field of the brain at every point in search of a treasure which was never there; but a rich harvest has repaid them. The fable of the old man and his sons is a picture of our relation to nature. We are ever allured to labour by promise of a hidden treasure, and ever fruitful fields of unsuspected worth reward the wasted toil. The philosopher's stone entrapped men into chemistry; the hope of astrologic lore into the knowledge of the stars; the pursuit of the hidden secrets of the soul has richly cheated us into an acquaintance with the vital laws of consciousness; and so has revealed to us the method of fulfilling their demands.

Cells in the centre, and fibres running to and from them, as we have seen, constitute the spinal cord and its nerves; and we can understand tolerably well how these simple elements should suffice for the ends which the spinal cord and its nerves fulfil. Given the groups of muscles which move the various portions of the body, and let them be connected with central organs capable of receiving impressions, of multiplying and reflecting them in definite directions, and we can see how an exquisite mechanical arrangement of such elements should bring to pass the most delicate or complex movements. Cells to generate force, and fibres to bring and carry stimulus, are suitable enough to produce unconscious actions, however rational they may look, or fruitful in uses they may be. There is an adaptation between the means and the end. We may even explain a great part of instinct so. But what have cells and fibres to do with thought, with love, with moral choice and will? Yet beyond these, there is nothing visible in the brain. In studying the spinal cord, we have made acquaintance with all that the acutest anatomist can show us there.

Such identity of structure, such difference of use! It is very perplexing. Yet we need not fall back on the idea urged by some, that since the brain is used for feeling and for thinking, therefore the spinal cord (which is just like it, only arranged inside out) must be so too; and that, in fact, our backs contrive and will, though we know nothing of it. Disappointing as it is to find only these inexplicable cells where we might have hoped for so much more, we may, perhaps, find a better consolation than that theory affords. May we venture to suggest a larger notion? Since, in this instance of the brain, it is undeniable that material actions depend on mind, may we not accept this as the rule of all material actions? What is once, surely may be always. The brain then would not differ from other material existences in being connected with feeling and with thought, but would be distinguished merely by being connected with thought and feeling that are *ours*. It reveals to us, so, the law of all matter—to be ruled and moved by mind: but the brain alone is thus ruled and moved directly by *our* mind. Of the mind that rules and uses the rest of nature we are not conscious; it is not "we," but it is not therefore non-existent. The brain seems to us, then, so strange an exception in nature, because only at this one point do we rightly perceive it as an instrument of consciousness. The apparent exception comes, not from peculiarity in this case, but from our not perceiving what is in the rest. One point in favour of this theory would be, that it supposes nothing but what we are obliged on any theory to admit. And this at least we know, that persistent effort, long-continued study, or persevering will, modify the brain of man, and will even in time perceptibly alter its form. The brain at least is moved by mind.

Cells and fibres! Surely no one would have believed how much could be done with them. Being the simplest means of effecting the offices needed from the little nervous system of the lowest creatures, they are still used when there are added on to these the lofty functions of human life. For it is part of nature's economy ever to employ existing resources; to construct the higher from the lower, and on the pattern which that lower affords. The advance of the nervous organization, therefore, being upwards from the merely unconscious system, which is termed "reflex," the superadded parts are based on the model of that; and the reflected actions of the spinal cord thus become the key to the structure and functions of the brain. In its germ—in an image, perhaps, we should say—the consciousness, the life of man are contained in his spinal cord. The history of the whole may be read there, reduced to its simplest form.

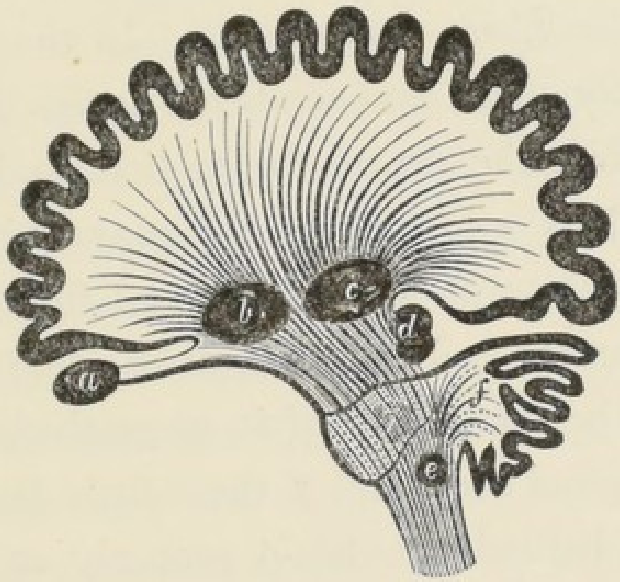
It is certain that we have not been able to find the mind in the brain; but it is hardly too much to say that we can find the brain in the mind; that is, in our mode of feeling and thinking, of consciously acting, suffering, and enjoying, we may find reflected the constitution of the brain, and the relations of its parts. Thus, it is by outward impressions that our mental activity is called forth; we think and will because we perceive and feel. And when perception and feeling have moved us to reflection and excited us to act, we carry out our determinations by a simple effort, unconscious of the varied machinery we have to put in motion to perform even the smallest act. Clearly there is a "reflex function" here; a stimulus transmitted, a reception at a centre or station—the central station of all—and a transmission again of a stimulus to the active organs, or muscles. Consciousness is in the centre, and reflects, and Will takes the place of mere physical impulse; but the plan and arrangement are the same as in the spinal cord.

Now, for this mode of operation, what order of parts should there be? We can pretty well tell it beforehand. There is wanted first, a centre (consisting of cells, of course), in which impressions from all the nerves should be received, and grouped, ready for transmission to the "reflecting" organ:* then there must be a centre—another mass of cells—for the purpose of receiving and subjecting to the process of reflection, in its double sense, these impressions; and finally another centre to receive the single impulse of the will, and transmit it with order and precision to the muscles suited to carry out its commands. And all these parts must be fully united, by conducting

* Is it not curious that the word "reflect" should possess the twofold meaning which it has—assigned to it, moreover, long before the construction of the brain was understood?

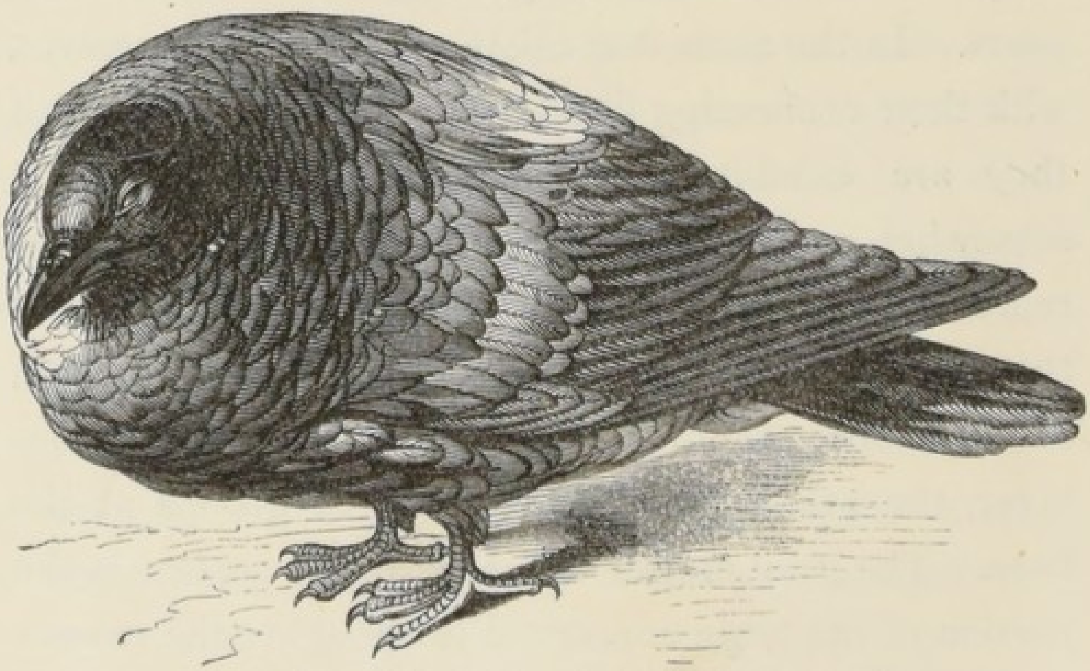
lines of fibres, with each other and with the spinal cord.

Fig. 22.



This is the structure of the brain; speaking generally, of course, and disregarding some subordinate parts. In the main it consists of these three centres, with their connecting fibres. See Figure 22, in which they are exhibited, for simplicity's sake, with a somewhat exaggerated distinctness, the dark portions representing the groups of cells. It will be seen that the gray or cellular matter is arranged in two main lines; — one covering the surface in a continuous layer, the other placed in a series of groups at the base. The gray matter which is at the surface is the portion of the brain concerned in thought; the masses at the base are the centres of sensation and motion. The higher portion of the brain is termed the hemispheres, from its shape, and it is the special organ of the mind. It consists of cells on the surface and fibres within, being opposite in this to the spinal cord, in which the fibres are outside. In the figure, *a* is the centre for smell, and sends off nerves to the nose; *b* is, probably, the centre for motion, and *c* that for feeling. These two centres are connected by fibres with those parts of the spinal cord from which the nerves of motion and of feeling arise; that is with the front and the back part of it respectively; *e* represents the spinal cord, and *f* the "little brain" which is situated behind the brain properly so called (or cerebrum), and is covered in by it.

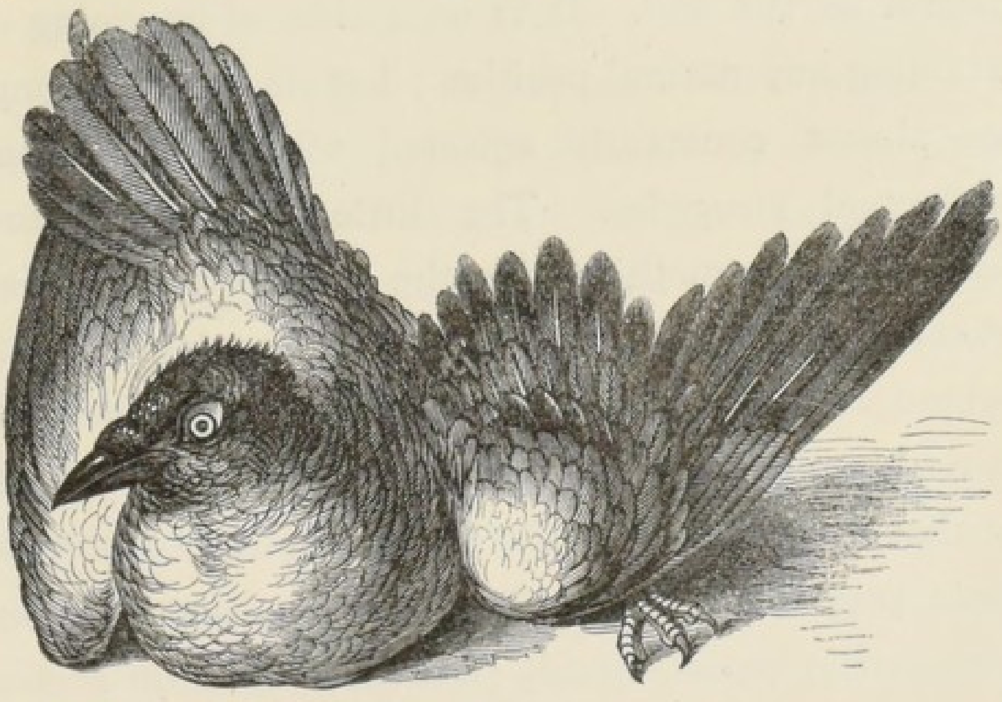
Fig. 23.



Pigeon from which the large brain has been removed.

Of this little brain or *cerebellum*, as it is called (that being the diminutive of cerebrum), what is the office? This is rather a doubtful point as yet, but the results of experiments indicate that it serves the purpose of associating the various muscles, and enabling the animal to execute the complicated movements which involve their united action. Figs. 23 and 24 show the contrast presented by a pigeon from which the hemispheres of the true brain have been removed, and one which has suffered the loss of the little brain. In the former case (see Fig. 23) the bird is deprived of anything like the power of thought; it stands plunged in a state of profound stupor, and is almost entirely

Fig. 24.



Pigeon from which the little brain has been removed.

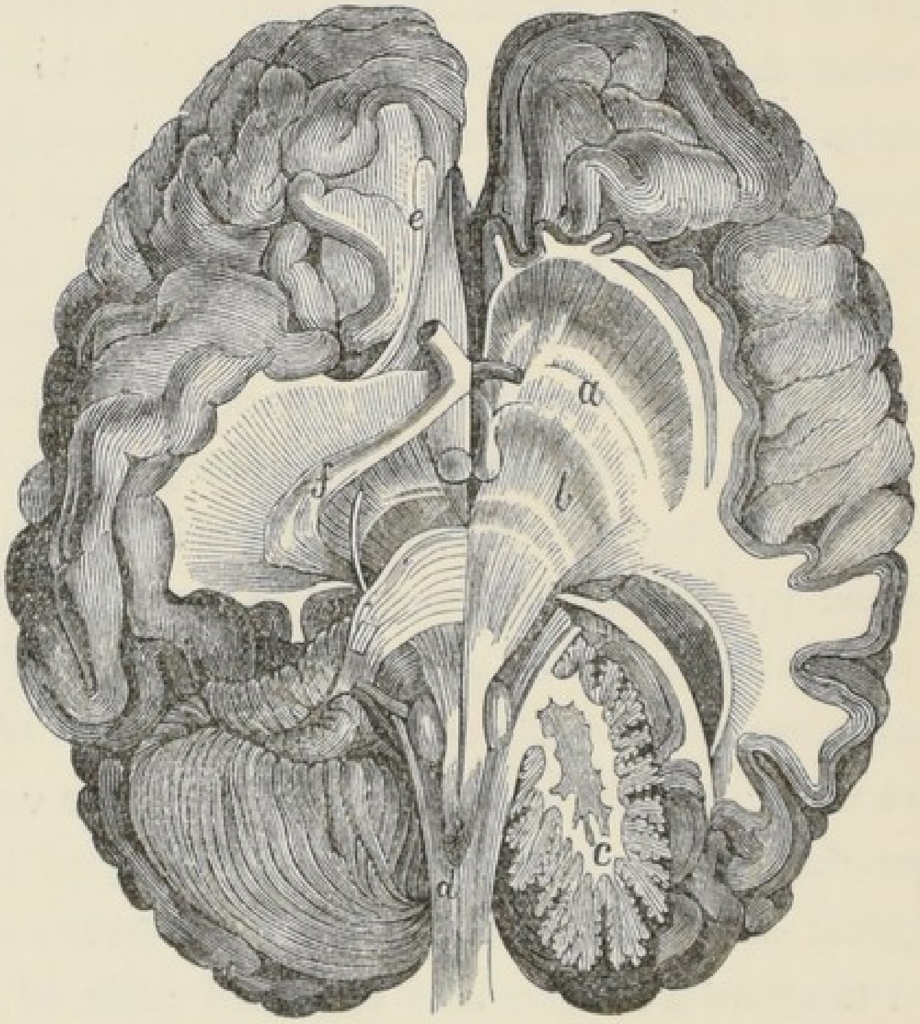
inattentive to surrounding objects. Occasionally it opens its eyes with a vacant stare, stretches its neck, perhaps shakes its bill once or twice, or smooths down the feathers upon its shoulders, and then relapses into its former apathy. At the same time it seems to perceive impressions on its senses or skin, and responds to them by slight movements. It may even follow a light with its eyes. The bird from which the little brain has been removed, on the other hand (see Fig. 24), is in a constant state of agitation. It is easily terrified, and endeavours frequently, and with violent struggles, to escape the notice of those who are watching it, but its movements are sprawling and unnatural, and are evidently no longer under the control of the will. It is incapable of assuming or retaining any natural position ; but its legs and wings are almost constantly agitated with irregular and ineffectual struggles. The little brain, therefore, seems to act something like the part of a regulating wheel to an engine, in respect to the larger brain behind which it lies concealed. But it has doubtless other functions also ; one of which is very likely to be that of maintaining the nervous activity while the brain proper is asleep. The cells on its surface are arranged in layers, closely packed, so that on section it gives an appearance somewhat like a tree. Hence it was called the "Arbor Vitæ," or Tree of Life (see

Fig. 25 *c*), in the early days of anatomy ; and the name seems to recall to us the vague sense of wonder with which these structures could not fail to impress their first discoverers.

The effect of removing the hemispheres of the brain, as described above, proves them to be the organs of thought ; but similar evidence is furnished by other facts. Intelligence is exhibited in the animal world in close correspondence with the degree of development of these organs. As the animal rises in the scale, so do the upper parts of the brain make their appearance. In fishes they are exceedingly small. The brain-case of the shark will scarcely admit the finger. As we advance among the quadrupeds they become larger, and their surface is gathered up into convolutions so as to afford room for a greater extent of gray matter. In man the hemispheres of the brain constitute nine-tenths of its entire mass ; and the convolutions attain a size vastly larger than in any other creature. Taking in both the great and the little brain, they have been calculated to afford a surface, in a full-sized adult, of 670 square inches. The convolutions follow a definite order in their development ; they are always alike in animals of the same class, and correspond strictly on the two sides of the head.

The brain may be regarded as an expansion and unfolding of the spinal cord, which, running up into the head, spreads out into bands of radiating fibres on each side. The form thus resulting may be compared, roughly, to that of the root and first pair of

Fig. 25.



Brain seen from below. *a* and *b* centres of motion and sensation ; *c* little brain ; *d* crossing of the fibres passing from the brain to the spinal chord ; *e* nerve of smell ; *f* nerve of sight.

leaves put forth by a growing seed. The fibres on each side curve round in a beautifully spiral manner externally, so as to return upon themselves, and they are thus hidden from view by the gray matter which covers their surface. In Fig. 25, the lower part of the hemispheres being represented as cut away, the bands of fibres are exhibited in their course. Upon them are situated two swellings on each side, consisting of the groups of cells which, as we have seen (Fig. 22), constitute the centres for feeling and for motion.

The fibres, thus diverging from each other, leave in the middle line a narrow interspace; and arching upwards and downwards, they leave also a central cavity upon each side. These spaces, being divided by bands of fibres here and there, have received the fanciful name of the "ventricles" (or little stomachs) of the brain; and five of them are enumerated. They answer the purpose of permitting the free passage of blood to and from the interior of the brain, and are filled with the same fluid that bathes its exterior. For the whole of the central nervous system, brain and spinal cord alike, reposes on a water bed; it is surrounded by a membrane folded on itself (like a double nightcap when placed on the head), and filled with a thin layer of fluid, closely resembling water. This fluid separates the brain from its bony case, guards it from shocks, and gives it, both externally and in the ventricles within, the most delicate and exact support in all its motions.

Beneath this double membrane a fine tissue, carrying a close mesh of blood-vessels, immediately overlies the surface of the brain, and dipping down between the convolutions, bathes them with a copious supply of blood: and around the whole there is wrapped a tough membrane which lines the bones, separates the various portions of the brain by strong partitions, sends off sheaths around the nerves, and furnishes channels for the returning blood.

The brain, then, is a double organ, consisting of two distinct halves precisely corresponding to each other. In fact, though they are contained within one cavity, we have as truly two brains as we have two eyes or two hands. On their superior aspect these two brains are separated by a deep interval. They are united, however, below, in man and the higher animals, by large and numerous bands of fibres passing from one to the other.

The doubleness of the brain has given rise to some curious speculations. Dr. Wigan argues that the mind is double also, explaining on this principle some forms of mental disease. And though we may not accept this idea, we certainly seem to find in our experience many traces of the influence of our double brain.

How often, for example, we are conscious of carrying on a train of thought, and at the same time calmly criticizing ourselves in doing it. In day-dreaming, do we not think in two ways at once; indulging unbounded fancies on the one hand (or brain) and holding on to the cold reality by the other? If the latter also were to slip its grasp, how far should we be from temporary madness? In disease, these characteristics of thought become still more marked: delirium often begins with the feeling of being two persons, or in two conditions, at once; or illusions are at the same time felt as realities and yet known to be false. Can we help referring these conditions to a disharmony between the brains? Or those strange experiences called "double consciousness," in which a person passes alternately from one condition of thought, apprehension, memory, into another entirely different, forgetting wholly in the one state what has happened during the other—do we not naturally ascribe them to an alternate activity and torpor of the two "organs of the mind?" We may not be quite right in these ideas, but we can hardly avoid entertaining them. And even in healthful, vigorous thought, is not the action of both brains to be traced? May not *attention* be the bringing both of them to bear on one subject, as *looking* is directing both eyes to a common point? Do we not almost feel, when intent upon a thought, as if we grasped it with one part of our mind and worked upon it with another, holding it steady, as it were, while we bring our force to bear upon it?

But besides any uses of this kind, the doubleness of the brain also serves the purpose of providing a surplusage or excess of power, beyond that which is habitually in demand. We possess a reservoir of nervous faculty not drawn upon in ordinary life, so that great losses may be sustained by the brain without giving rise to any apparent symptoms. Large portions of one hemisphere have been destroyed by disease or injury, and yet the mental powers have seemed entirely unimpaired; just as a person may be almost blind on one side for a long while without discovering his loss. Of this the most striking instance on record is, perhaps, the following, which, incredible as it may seem, is reported on good authority. A pointed iron bar, three and a half feet long and one inch and a quarter in diameter, was driven by the premature blasting of a rock completely through the side of the head of a man who was present. It entered below the temple, and made its exit at the top of the forehead, just about the middle line. The man was at first stunned, and lay in a delirious, semi-stupefied state for about three weeks. At the end of sixteen months, however, he was in perfect health, with the wounds healed and with the mental and bodily functions unimpaired, except that the sight was lost in the eye of the injured side.* Those curious cases, too, in which one side of the body suffers some peculiar affection exactly limited to the middle line, are attributable to a diverse action of the two hemispheres of the brain. Some persons perspire only on one side, and they are apt to be thrown into this partial perspiration by any nervous agitation. Sir Henry Holland mentions the case of a horse which had this peculiarity, and became giddy when heated. Many affections of the skin, also, which are greatly under the influence of the nervous system, are precisely limited in the same way.

The brain, however, consists of two brains united into one, only because the body also is, in strictness, two bodies united into one. Each half of the body is presided over by its own half of the brain; but not by that which is nearest to it. The fibres, descending from the brain to the limbs, cross each other, and go to the opposite side. (See fig. 25.) The execution of Solomon's judgment was physically, as well as morally, impossible. To divide, is virtually to decapitate, the living frame. Each mangled portion

* *Treatise on Human Physiology*, by JOHN C. DALTON, jun.

would contain not its own brain, but its fellow's. So it is that when paralysis ensues from disease in one hemisphere of the brain, the opposite side of the body is deprived of its powers. This, however, does not hold of the face; from the same cause the face may be rendered motionless on one side, and the limbs on the other.

But, indeed, the brain might have been made to startle us with unforeseen results. Who, for instance, would have supposed that the seat of sensibility should be itself entirely insensitive? Yet this is the fact. While all parts of the spinal cord, and all the nerves, are sensitive to any irritant, to a touch, a prick, or an electric shock, any one of these exciting intense pain or producing convulsive movements, the chief part of the brain is insensible to them all. It may be cut, contused, burnt, electrified, done anything to, with no result save that loss of its powers, which follows destruction of its substance. And this character of indifference to direct stimulation seems to extend (according to the careful experiments of Flourens) just to those parts of the brain which are concerned in the mental processes. Where consciousness is connected with the function, there sensibility to physical stimulus is lost. There is thus a sort of oppositeness between those portions of the nervous system which conduct impressions to the central organ, and those whose office it is to present these impressions to the mind. Each is susceptible of its appropriate stimulus, and of that alone. The brain responds directly to the mental forces of thought and will, but to physical stimuli only when conveyed to it through the appointed nervous channel. The spinal cord and nerves are directly amenable to physical stimuli, but obey the mental power only when conveyed to them through the brain. Each portion is thus the converse of the other. If we imagine the nervous system spread out before us, it would be sensitive to irritation in all parts except its centre, while in that centre alone would be found the power of awakening consciousness. The brain sits there like a monarch, inaccessible except through his ministers.

Perhaps there is something similar to this in our mental constitution. We know well how little we can do by direct effort in the way of remembering or of thinking. Thought, as well as sensation, has its appointed channels, and cannot be commanded. We cannot compel an idea to arise ; we can only facilitate its up-springing by opening our minds to that class of subjects which shall most readily suggest it to us. The mind has its own system of nerves, to the impulses of which alone it will respond; these ramify over the entire body of our knowledge, and find their expression in the laws of the "association of ideas."

But one of the most curious points connected with the action of the brain, is the part it seems to play in what may be termed "unconscious thinking." Sir William Hamilton pointed out that our perceptions are often made up of a number of impressions, each of which is itself unperceived. When the roaring of the sea is heard at a distance, the total sound is an aggregate of a multitude of smaller sounds, those of the separate waves, themselves too weak to reach the ear. In a somewhat similar way, intellectual results are arrived at by a course of thoughts (if we must call them so), each step in which seems too slight or too evanescent to be itself perceived. Dr. Laycock has especially pursued this subject, and has shown how constant and how important a part of our experience it is which assumes this form. Every one knows how often a new light arises on matters which have perplexed us, without any effort or even consciousness of our own about them, as if our ideas re-arranged themselves while we slept, or attended to other things; and the highest flights of genius, the inspirations alike of the poet and the man of science, are the forms of thought which seem most emphatically to partake of this character. Of these achievements, often, nothing can be said, even by their authors, but that "they come to them." Now, in such cases there seems good reason to believe that physiological laws express themselves. Changes proceeding in the brain, in harmony with nature, afford results which partake of nature's perfection; the more perfect because free from the bias or constraint imposed by deliberate effort. The fantastic dreams which ensue from the perverted action of the brain under stimulant or narcotic poisoning, present a parallel but contrasted case. Sometimes in disease very singular results are manifested from this cause.

In some of the odd freaks, again, known as absence of mind, we see another illustration of unconscious action in the brain. There are two kinds of such absence. Sometimes an intense activity of certain powers throws the other faculties into undue abeyance: Sir Isaac Newton forgot to eat; and Socrates is said to have stood motionless foı a whole day and night. But sometimes the activity of these other faculties is in excess, and the absorbed attention seems to give an unrestrained liberty to processes which should be held in check. Thus an unfortunately absent man may, quite unknowingly, take up money not his own, if it lies before him, and transfer it to his own pocket; the stimulus of sight and habit not being balanced by the reflecting powers. The possibility of this occurrence, which is quite beyond doubt as a matter of fact, might well be allowed to plead on the side of mercy in some cases of apparent theft. Like this, too, are the instances in which dying men have enacted over again the parts which they have been accustomed to play in life—the merchant counting up his books, the judge charging the jury.

But, in truth, the more closely we scrutinize our mental powers, and note the laws they follow, the more we are struck with the narrow limits within which our own action is restricted. To a vast extent we are quite passive, and rather suffer our thoughts than think them. We may even be said rather to suffer than to do a large proportion of our own actions. Much of our life passes before us like a panorama, in which we are indeed the most interested of spectators, but can hardly be accounted the actors. Nay, we find that to a very great extent our effort is habitually required, and exerted, to control actions that would otherwise take place; to command quiescence rather than movement. The body is quick to respond to innumerable stimuli, operating upon it at all times and in every variety of mode; its pent-up force is ever ready to break forth, and does break forth, save as a regulating power is exerted upon it, either through the will or the operation of the superior parts of the nervous system. We may take winking as an instance. What an effort it demands to prevent our eyes from closing, when any object threatens to come into contact with them. It seems, indeed, impossible to avoid the action beyond a certain nearness of approach, even when there is the most perfect confidence that no contact will ensue, and there is, therefore, no struggle of the will.

It is in facts of this kind that the nature of the brain, and the part it plays in our experience, are perhaps best to be seen. We may call it an instrument, but we must remember that it is itself an active one. Nay, for this very reason it is suitable to be an instrument for us. Itself a part of nature, with nature's laws expressing themselves within it in constantly recurring activities, it lays for our consciousness exactly the basis that we need. We are thus brought, by its means, into relation with the material world in its highest and intensest form, and read off, as it were, in the form of thoughts, the culminating processes of Life—itself the crown and flower of all the physical developments of force. The brain presents Nature to our conscious part, and presents it worthily.

Again, the brain, united by means of the nerves with every portion of our bodily frames, and thus transmitting to every portion in its turn the stimulus which results from the actions that take place within it, renders the whole body the representative and exponent of the soul. Expressed to consciousness, on the one hand, in the form of emotion or of thought, these same actions in the brain, upon the other, penetrate, and mould by a subtle alchemy, the most interior recesses of the body, and their effects proclaim themselves on lip or cheek, in eye or hand. Thus the subordination of the body to the mind is effected perfectly, and without care on our part; as, indeed, no care of ours could ever avail to maintain it through all the innumerable variations of the mental states. And here the significance of the various "centres," or groups of cells, which we have seen to enter into the formation of the brain again becomes apparent. Besides the actions which take place unconsciously within us, even those of which we are distinctly conscious are of different kinds. Some are immediately dependent upon sensations. The act of sneezing, for example, is one which no effort of the will can exactly reproduce; it follows directly upon a peculiar feeling, and demands for its production that the feeling should be of a certain intensity. Tears and laughter, when caused by physical sensations—by tickling or by pain—come under the same category. There is thus a whole class of actions which depend upon sensation, and these have their own demonstrable centre in the brain. At least, there is sufficient evidence to make it exceedingly probable that one of the swellings which are formed upon the fibres coming up from the spinal cord and expanding outwards to the hemispheres, is this centre (see Figs. 22 and 25). Impressions on the nerves may reach this spot, and be at once reflected —that is, may excite a change in the cells collected there, and put into activity the nerves proceeding to certain groups of muscles, or to certain glands. When this is the case, we have an action dependent on, or at least connected with, sensation, and not involving any of the higher faculties, as thought or will.

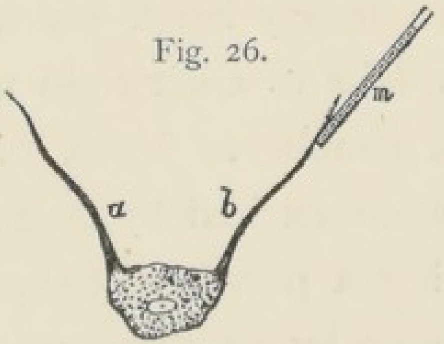
In the tendency of the brain to give rise to actions of this class, lies a chief source of the power of habit, and the fatal bondage under which the victim of habitual vice is laid, and so often struggles against in vain. The chain between sensation and its consequent acts grows stronger with practice, and acquires ever new directions. It is thus that irresistible influence of the desire for drink, which is now recognized as nothing less than a distinct form of insanity by the best pathologists, becomes established ; the taste or even the sight becomes all-powerful, and brings on the accustomed act while the will is almost asleep.

And very far short of this utter wreck and ruin of the man, the predominance of the inferior portion of the brain may still be exhibited in the undue influence of sense, in various ways. There is ever a tendency in us to suffer the immediate link of sensuous feeling with thought or action to anticipate or set aside the verdict of the nobler powers ; and this tendency is no less visible in the intellectual than in the moral life of man, and vitiates belief no less than deeds. The demand upon our manhood ever is to counteract this facile connection between sensation and its natural consequents. The struggle which constitutes our life is thus forewritten in our brains.

The last and highest "centre" in the brain is the grey matter spread upon its surface, and embracing in its many folds the substance of the hemispheres. Here we approach the very throne of thought, but we recognize essentially the same relations that we have met with before. The final secret of our will is not to be read even here. The highest portions of the nervous system consent to be governed by the same laws which regulate the operation of the inferior parts; like them receiving and reacting on impressions. The thoughts that pass through our minds give rise to actions that may be quite involuntary, and indicate merely the reflecting of a stimulus from the hemispheres of the brain; just as in other cases it is reflected from the centre of feeling at its base, or from the spinal cord. Certain exaggerated actions of this kind have furnished ground for much wonderment and some imposture, and have been set forth, under the name of "electro-biology," and so on, as the basis of new sciences; yet they present nothing of the marvellous to any one who has mastered the physiological significance of the hearty laugh which a good and timely joke never fails to elicit from a well-constituted mind. Ideas, simply as ideas, or through the influence of emotions excited by them, produce actions in the body, if not prevented either by the presence of other ideas or by an active will. No one who has uttered an involuntary exclamation of joy, or lifted his hands in surprise, or been nauseated by an idea suddenly suggested, can doubt the fact. Nor is it difficult to understand. Those nervous cells, apart from which ideas never come to us, were spread over the fibres of the brain in order that it might be so. When, therefore, a ring suspended from the fingers strikes the hour against a glass, or hats and tables are endowed with abnormal energy by the laying on of hands; or when a patient, first reduced to a passive and absorbed condition, acts out the part suggested to him;—we simply have exhibited to us, isolated, and as it were dissected out, certain elements which are essential to our nature, and without which, in their due balance and proportion, man would lose some of his most characteristic attributes.

The plan on which the nervous system is constructed is well illustrated by the subjoined diagrams, which we copy from Dr. Draper. Fig. 26 exhibits the simple nervous circle: a fibre to receive an impression, a cell at the centre, and another fibre passing off from it to convey the stimulus to a muscle. The next step is the addition to these simple elements of another centre (a cell or number of cells), connected with the former, to which a portion of the stimulus is conveyed, and in which a certain amount of force may be stored up for future use, and serve to modify the influence of future impressions. Thus we understand how variable results may be produced by the

Fig. 26.



same stimuli (Fig. 27). In Fig. 28, the fibre conveying the stimulus away from the centre is suppressed, so that the total effect of the impression received is stored up. The first of these forms (Fig. 26) represents the structure of the spinal cord ; the second and third (Figs. 27 and 28) represent the cord combined with the

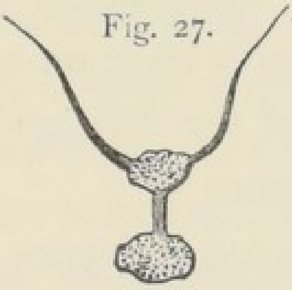


Fig. 27.


Fig. 28.

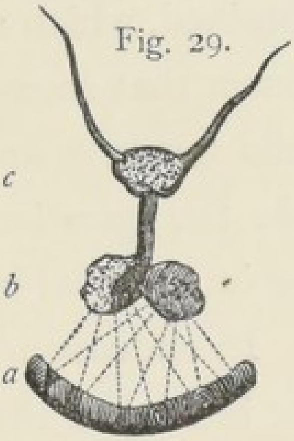


Fig. 29.

"centre of sensation," in the base of the brain. Fig. 29 shows the addition of yet a third centre—that of thought. Here the intermediate centre is shown double ; one portion being assigned for the reception of impressions (centre of sensation), the other for the transmission of stimuli to the muscles (centre of motion). Under these simple forms all the modes of action of the nervous system may be classed :—*a* represents the intellectual brain ; *b*, the sensational brain, and probable seat of instinct ; and *c*, the spinal cord (or "automatic brain"). These three conjoined, and mutually modified in their action by each other, exhibit the sum total of the nervous life. Of course, upon the "intellectual brain" the mind or spirit operates. At least in our present ignorance we must so speak. On physiological grounds, some power which operates on the nervous system from above may be reasonably postulated; but whether (if we knew how to look for it) a truer notion might not be obtained, which might enable us to avoid the hopeless chasm that seems to separate "mind and matter," we need not here anticipate. We must also leave on one side the question of phrenology or of the division of the intellectual brain into distinct organs.

In endeavouring to trace the mutual influence of the brain and the other organs of the body, our great guide is found in the principle of the constancy of force. If we remember that an action once commenced, in the material world, does not cease, but goes on indefinitely producing equivalent effects, and that this law holds good as much in the living body as in the rest of nature, the foundation of this mutual inter-action, difficult though it may be to trace in all its details, becomes perfectly simple. The nervous system, indeed, may be regarded as a structure adapted for turning this law of nature to account, and for employing on useful purposes the indestructible force that is ever circulating through the body. The nerves afford to it channels of least resistance, and conduct it where it will produce results that are needful for the animal, or at least—when no derangement is present—harmless. Thus the muscles carry off, and return into the world without, the force arising from the brain-changes which our conscious life involves. They are at once instruments of motion and safety-valves; sometimes one of these offices predominating, sometimes the other. Laughing is an evident instance of the latter use; walking may be either. Conversely, the nervous system takes up, and is thrown into action by, the force resulting from the innumerable changes which take place in the other organs.

If the influence which the brain thus exerts be prevented from travelling in one direction, it takes another. But it never fails. Thus it is that controlled emotion, or passion which finds no outward vent, is so powerful, and often so disastrous, in its effects upon the health. The will has a certain power to direct the action through one or another set of nerves, but some equivalent action it cannot avert. Manifest or hidden, every mental state will have its full proportionate effect.

The power of the brain over the vital condition of the body is exerted through a particular set of nerves, which have been called the "sympathetic system."

These are somewhat smaller and simpler than the nerves of sensation and of motion, with which, however, they are intimately connected. They are distributed to the organs on which life depends (the lungs, heart, stomach, &c.), and to the blood-vessels all over the body. Blushing is effected through their agency, and through them, too, the pallor which accompanies fear or anger. And in these instances we have revealed to us one main secret of the control exerted by the brain over all the vital processes. The condition of the blood-vessels everywhere, and especially in the most vital organs, is regulated from moment to moment by its changing moods. Even the vessels from which it draws its own supply are subject to the same influence, and it immediately controls the nutrition, not only of its servitors, but of its own substance.

Thus the condition of the brain is necessarily the key to that of the whole body; both directly, by its power over the heart and the breathing, and still more profoundly by its indirect control over the supply of blood, its influence is universally paramount. There is no mystery in the effects produced on health by excess of mental labour, or by long-continued care, nor in the bodily torpor which attends a merely inactive mind. "Nervousness" naturally results from an over-taxed brain: it is an expression of its deranged circulation and imperfect nutrition. The wonder surely is, not that it occurs so often, but that amid the rude shocks to which our life is subject it is not more frequently experienced. The self-regulating power, which preserves the balance true amid such variety of circumstance, might well excite our surprise. It is like that adapting power, possessed in its greatest degree by man alone of all the higher animals, by which all climates can be borne and all diets assimilated. And if we could see aright, doubtless we should find that man exceeds other creatures as much in his power to bear safely mental changes as those of external circumstance. We might thus explain the frequent instances narrated of the death of animals separated from their fellows or their masters. Their lower nature may be more difficult to rouse, but their brain succumbs more readily.

The intimate relations which must exist between the brain and the health of the whole body, appear still more manifest, if we take into account the relative amount of the activity that is concentrated within this single organ. In no other is the poise of the forces apparently so delicate or so easily disturbed, and in none, accordingly, is there anything like the same amount of change. Of the beautiful contrivances by which the supply of blood is regulated, and a channel furnished to guard against disturbing circumstances, we have not had time to speak ; but the mere quantity of blood sent to the brain speaks volumes. It has been variously estimated at from a fourth to a fifth of the whole blood in the body ; and the same tale of immense activity is told, not only by the phosphorus which exists in large measure in the nervous substance, and especially in the cells, but by the vast amount of waste of which evidence is given after mental labour. According to the best comparisons that have been made, the total bodily waste from this cause vastly exceeds in amount that which attends an equal period of hard muscular exertion. From this it is easy to understand the ill effects of too protracted or exhausting mental toil. But another lesson is equally taught by the same facts—a lesson of an opposite kind, indeed, yet resting on the same physiological basis, and warranted by an experience not less conclusive. If exhaustive labour of the brain overstrains the vessels, and consumes the vital energy at a greater rate than it can be replaced, the absence of its due use is no less certainly hurtful on the other side. The energies of every vital function receive a considerable and essential portion of their stimulus from the activity which the brain is adapted to carry on. The torpid, unhealthy frame and languid circulation of the idiot are but an exaggerated instance of the unnatural torpor to which he condemns himself who wastes his life in indolence, or consumes it in dissipation. To him Nature, indeed, has been kinder, but he does but abuse her bounty to become a worse enemy to himself.

If we would have our bodies healthy our brains must be used, and used in orderly and vigorous ways, that the life-giving streams of force may flow down from them into the expectant organs, which can minister but as they are ministered unto. We admire the vigorous animal life of the Greeks, and with justice we recognize, and partly seek to imitate, the various gymnastic and other means which they employed to secure it. But probably we should make a fatal error if we omitted from our calculation the hearty and generous earnestness with which the highest subjects of art, speculation, and politics were pursued by them. Surely in their case the beautiful and energetic mental life was expressed in the athletic and graceful frame. And were it a mere extravagance to ask whether some part of the lassitude and weariness of life, of which we hear so much in our day, might be due to lack of mental occupation on worthy subjects, exciting and repaying a generous enthusiasm, as well as to an over-exercise on lower ones?—whether an engrossment on matters which have not substance enough to justify or satisfy the mental grasp, be not at the root of some part of the maladies which affect us? Any one who tries it soon finds out how wearying, how disproportionately exhausting, is an overdose of "light literature," compared with an equal amount of time spent on real work. Of this we may be sure, that the due exercise of brain—of thought—is one of the essential elements of human life. The perfect health of a man is not the same as that of an ox or a horse. The preponderating capacity of his nervous part demands a corresponding life.

But the very same causes which make the normal exercise of the brain especially needful, render its excess especially baneful. The signs of this excess—or excess combined with misdirection—meet us on all hands; in weariness, despondency, disgust, or causeless anger; in racking neuralgic pains, or gradual decay of vital power, or in the insidious threatenings of serious disease. How could these results be guarded against, we ask? The answer can be but one. Health can no more be obtained without its price than anything else. Nature has for ever for-bidden it. The flame of life can neither be fed nor renewed with stolen fire. The one condition of rescue from the effects of overwork is rest and change ; fresh air and the soothing influence of natural scenery if they can be obtained ; and he is a false promiser who offers any other.

We are apt to grumble at the condition, and say it cannot be fulfilled. There are some cases in which it cannot : some heroic lives (the happiest they of all) which must be laid—either by force of internal impulse, or claims of inexorable duty—a sacrifice upon that altar which the human race feeds ever with new victims. And of these, not a few names are fresh in the memories, and should be warm in the hearts of men. But if we look with a more heedful eye, it may be that this demand for moderation in mental toil will appear as beautiful as it is inevitable ; as good and full of benefits for man, as it is demonstrably involved in the nature of his frame. True, the command to rest imposes limits, often painfully felt, on human activity. But let us suppose that these limits had been wanting, or indefinitely removed—were not human life blasted in its fairest parts ? If unbounded work could have been done by man, would not his moral nature have been utterly dwarfed and crushed ? Disease and death—good angels in disguise—step in to interpose between us and fatal ills. Our life is selfish and cruel enough; but what would it have become if a common weakness had not bound men together? Even now we hear, not without indignation, of houses in which, though one week's holiday is granted in the year, it is withheld if through sickness the stipulated seven days have been consumed; so that the men who need it most pass years in such employ, and get no holiday.

For the sake of the moral lessons it teaches man, we may welcome the demand to limit labour even when it presses most vexatiously upon us. But there is another lesson, also, which it might help us to learn. Incessant work and worry kill the man through his brain. The brain, then, is not constructed for a world that demands incessant work and worry; it rejects that view of it, and of our life, with an emphatic negative. The world for which it was designed was one on which thought might rest in peace, and exertion be restrained within reasonable bounds. It was a world about which we need not fret ourselves, and our interests in which we might hold lightly. Is there not the glimmer of a revelation here? In the very nature He has given us, does not our Maker vouch that *this* world is such an one, if we did but know it truly? Our life is a riddle, doubtless; but we may know what sort of a solution it shall have.

A few points respecting the brain and the use of it we have thus picked out; leaving the tale, perforce, much less than half told. With a few words more we must conclude. The relations which the brain bears to nature afford us the most instructive guidance as to the means which are adapted to maintain its health. The very life of it is in change. We have seen that its activity is always elicited by *excitors*—that is, by changes in the circumstances under which it is placed. It is perpetually being raised up to a certain pitch or level, and then perpetually readjusting itself to new conditions. Monotony is stagnation, and to it stagnation is decay. It is by variety that its powers are developed and maintained. Thus, for example, it is neither in an exclusively rustic life, nor in one passed wholly in a city, that the most perfect energy of brain or mind can be expected; but rather in alternations between the two. Each condition then prepares for the highest operation of the other. The organization rapidly adjusts itself to conditions which are permanent; and in the purer air the entire level of the life is carried to a different pitch rather than special energy developed. The invention of towns were a pure gain to humanity, if due admixture of the country life can be secured. And to obtain this advantage for our labouring populations is one of the great tasks of our age. Our physiology teaches us that the vice and misery of our great towns can never be combated successfully in the strongholds which they have made their own, and fortified for ages: the courts and alleys where the poisonous atmosphere combines with all hateful sights and sounds at once to deaden and to irritate the nervous sensibility. From the continued breathing of a vitiated atmosphere inevitably arises either apathy or a craving for intoxicating drinks; in all probability, each in turn. The dark blood, accumulating in the vessels, at first acts as an irritant, and then reduces the organs to a state of lowered activity; both conditions alike exciting the taste for poisonous doses of alcohol. To deliver the brains of the industrious poor from these oppressive demons of bad air and hateful sights, were a task worthy of the highest ambition. Nor is it foreign to our theme. For of all work for the idle, or change for those who have been overborne by their own pressing cares, what but a genuine interest in the pains and aspirations of those who need our aid comes nearest to the true "Use of the brain?"

CHAPTER VII.

ON NURSING AS A PROFESSION.

It appears to me that, while much good thought and labour have been bestowed on the subject of extending the sphere of occupation for women, especially of those not born to poverty, some simple circumstances have been overlooked.

We find ladies by birth, a few of them, thinking it natural and right, and losing nothing in social position thereby, to receive payment for acting as doctors. We find also ladies of a similar rank gladly volunteering their unpaid services as nurses, but refusing to be paid.

I do not see that this difference is founded on the nature of things. Is it not rather merely the result of a habit of thinking about nursing, which perhaps might have been suitable to former times (though this is doubtful), but is certainly inappropriate to our own?

That habit of thinking classes nursing, more or less, but certainly with a strong tendency to become less decided, with menial occupations. It is considered, though an excellent and most respectable vocation, not one for a lady to follow as a means of livelihood, unless she is content to sink a little in the social scale. Charity, which dignifies all things, alone exonerates her from that penalty if she pursues it.

There might be reason to suppose that a rooted feeling of this kind had some basis in fact, and was not likely to be altered, if it were not that a striking parallel existed, and not very long ago, in the practice of medicine itself. It is now well understood that the surgeon and the physician stand on the same professional level, and occupy in all respects an equal position. But, until within a very few generations, this was not the case. The surgeon was a mechanic rather than a professional man, was supposed to be a barber as well as a surgeon, and acted merely under the directions of the physician to do manual work. But, as we now perceive, this was a mistaken idea of his true relation. Some men opened their eyes to the fact of this mistake, saw that surgery, though supposed to be menial in its character, was, in truth, a profession of equal rank with that of the physician, and from that time it became so practically.

Now, is not our idea of nursing a precisely similar mistake? It would surely be unreasonable to do more than ask this question? Can any one think it is in its own nature more menial than surgery? Could any occupation whatever call more emphatically for the qualities characteristically termed professional, or better known as those of the gentleman and the lady?

The anomalous position of the surgeon was rectified, and a new *profession* opened to men, simply by the fact of its being perceived that the anomaly existed. Does it need anything more to rectify the anomaly in the case of nursing, and so to open a new *profession* to women?

Let any one, or at least let a few persons, able to maintain their ground, insist on treating as a profession any occupation that in itself truly is one, and it becomes one in their hands. This happened in respect to surgery. Is it likely it could fail in respect to nursing? It is simply acting according to facts, which always succeeds; and than which, indeed, nothing else is permanently successful.

To make any occupation a profession, one essential thing—though by no means the most important—is that *some* of those who follow it should be well, and even highly, paid. It is important to notice that this is necessary only in the case of some. Even a very few are sufficient, provided the professional education and feeling thoroughly pervade the whole body. Thus, the standing of every curate is secured, however small his salary, by the general dignity of the body of the clergy, to which the large income of its highest members contributes its share. And in the medical profession likewise, the education being common to all (up to a certain point), the good social position secured by the most successful extends its influence over the poorest; and the striving general practitioner, who, most praiseworthily, in neighbourhoods where it is needed, prescribes and furnishes medicine for the charge of one or two shillings, meets on perfect equality the heads of the profession, and feels around him at every moment the honour of the whole body. He is a gentleman, and is so regarded, if he have not forfeited the name, as truly as any physician who wears a well-earned title. His position is made the better *through* that title.

So in respect to nursing, that it should cease to be regarded as an occupation implying a social position not above a certain level, doubtless would demand that a high rate of remuneration, and an excellent social position, should be enjoyed by some of the body; but, provided there were a common bond of true knowledge and high feeling pervading the whole, these more fortunate members need be by no means numerous. Their honour would involve the honour of the whole; and the *lady* who, well-instructed in her art, and with an enthusiasm which should render her incapable of degrading it, should spend her time in the abodes of the poor for such small sums as their means could afford, would find that the honour of the whole body was to her "a robe and a diadem," and would place her, as far as it places the curate, from having her social grade tested by her purse.

Two questions, therefore, present themselves from a practical point of view; first, that of the remuneration which might be expected; and, second, that of the education demanded and to be obtained, and the kind of work to be done.

For my own part, I have no scruple in putting the question of the remuneration likely to be obtained first. The practical question hinges very greatly upon that, and besides it is, in one sense, the more important, because if there were doubt on any point this might be thought the doubtful one. Any needful or desirable education would be attainable beyond all doubt, sooner or later—is, indeed, partly attainable already—and would find plenty of well-qualified persons glad to develop it. As for the scientific work to be done by well-trained nurses, also, that needs no arguing, especially now that medical science has recourse to fresh methods of investigation so numerous, so exact and complex, and demanding for their proper application so much time.

To come, therefore, to the question of remuneration. This should, as I have said, be *large* for a few. By large I mean, at the maximum, fully three guineas a day, without at all limiting it to this sum. It should not fall below this maximum, because the whole conception is that the ladies practising the profession of nursing should be on a social par with the members of the medical profession; so that, for instance, a parent with sons and daughters might bring up a son to be a physician, and a daughter to be a nurse, and feel that he had placed them in the same position. In a word, that the nurse should occupy the same status that the lady who qualifies herself as a medical practitioner aspires to (and no doubt deserves and has).* Whether or not such a rate of payment will

* Perhaps I may be permitted to ask here whether the desire (surely not altogether unnatural) of ladies to practise medicine has not been determined in part by the mistake in respect to nursing to which I have adverted; so that if this had been rectified sooner, and nursing placed in its proper position, that important department of the healing art might have hoped to have been rendered illustrious by services which it is ill able to spare.

be attainable and grow to be customary evidently depends not on any person's will or wish or skill, or talents of any kind, but simply on the question whether the services to be rendered will be held of value in averting death or restoring health. If the sick believe that, by securing the services of such a nurse as is supposed, their chances of recovery will be materially increased, the remuneration is perfectly assured. It is needless to argue that for that which is really believed to promote the prospect of prolonging life, no expense will be spared, or that there are ample means for meeting, in a very considerable number of cases, the fees that I have named. The sums which are cheerfully contributed to institutions of nursing sisters by wealthy patients who have enjoyed their services, also sufficiently answer the question.

That the payment will be forthcoming, therefore, if the right nurse is worth it, I consider quite assured. But will she be? Will her presence by the bedside contribute importantly to recovery?

This question, too, might be briefly dismissed as one already settled. But it is worth while to go a little into detail on this point. The nurse—a lady in all respects, whose very presence, therefore, is a source of cheerfulness and comfort, and soothes instead of irritating the brain—will have been trained to regulate all the constantly operating influences of air, temperature, light, &c., in the best way that medical science knows how to direct; she will have the best skill in the final preparation and administration of food; will know every contrivance for securing sleep, and have a trained experience to enable her to adopt the best method for each case. She will have her perceptions quick, her sensibilities acute, yet well under command, and will have learnt well (and this is a branch of the nursing art, the importance of which is but beginning to be estimated, and which promises to rise into the greatest prominence) how to be truthful, open, and honest with a restless and suspicious patient, to control and support a weak one, to *recognize* (an intensely difficult problem), and calm (but one degree less difficult), the first commencement of morbid emotion or thought, and ward off, if it can be averted, threatened delirium; or to watch for and develop into sanity again the first gleam of returning reason. Above all she will not—as ignorant and coarse-minded persons not permeated with true *professional* feeling almost always will—attempt to interfere with and modify according to her own notions the strictly *medical* treatment. She will have her hands and thoughts full of her own work, and will be quite sufficiently impressed (if her opinion is like mine) with the much greater importance of her own office than the doctor's in a large number of cases, not to wish to interfere with his affairs.

But why should I enumerate the things she will do, when the chief thing of all will be that she will do her share to *create a new art of nursing* that will teach us all a little of what nursing should be like, and make my description (which I tremble to think I have written) seem above all absurd? But I have written of the rudimentary or incipient nurse of the true order, not of the nurse that is to be. And what I have described will be less than half her duties. I remarked before how great an extension the means employed in medical research have recently undergone. It is enough to refer to the use of the thermometer. Hourly observations by means of this instrument, or even more frequent ones, are found to throw a hitherto unattainable light on the nature and progress of many diseases, and that is the same thing as saying that they afford an invaluable aid to their treatment. In hospitals, such observations are made by the elder students and house physicians, but in private practice it is evident that they are necessarily omitted, except at the rare intervals of the physician's visit. Hereby not only is the skill of the physician brought into bearing with fewer than the utmost attainable advantages, but a valuable resource is lost to science. With persons ever at the bedside skilled in observing with the utmost accuracy and without disturbance to the patient all those delicate variations which disease presents, medical knowledge itself might be expected to enter upon a new development. I have mentioned the thermometer; but the use of that instrument is far from including all the region of minute and continued observation on which the perfect knowledge of disease depends. And with the observing and recording power at hand, in the form of a body of skilled ladies, new subjects and methods of observation could hardly fail to develop themselves. The true nurse's part, indeed, would be one essentially of observation, and apart from all the benefits it would confer upon the patient, would provide materials on which the future life of medicine might base itself. Here, at least, there seems to be a sphere in which Nature plainly calls for the mutual co-operation of the two sexes, to build up conjointly—the one as physician, the other as nurse, but with no unequal share—a worthy science of the healing art. If it be true, as I believe it is in some forms of disease, that the requisite minuteness and completeness of observation can be attained only by means of a more or less constant presence in the sick chamber, then surely it is evident that Nature has assigned to woman this share in the task, and that, in performing this share, her place can be in no way inferior to that of those to whom the other portion of the work is given.

There is yet another branch of the art of nursing of not less consequence than either of those I have mentioned, and that is the prevention of the spread of disease. Recent researches have done much to give definiteness to our knowledge of this point, and there is no doubt that great progress is before us. But as knowledge of any kind increases, so does the demand for skilled persons to apply it. We know now, for example, very much about the spread of cholera, fever, and scarlatina; we know that certain methods, applied at definite times and in definite ways, with sufficient perseverance and watchfulness, will go very far to ensure the limitation of these and many other diseases to the person first attacked. Do we not want persons trained to apply these methods—persons habituated to their use, and capable of carrying them out in that absolutely complete way on which their whole value depends?

So far, I have considered my subject mainly on its professional or medical side; but it has another aspect, a social one, which seems to me of hardly less importance. First, it might prevent so much illness which arises from *overfatigue in nursing*. No medical practitioner can fail to have been most painfully impressed with the frequency with which broken health in women of the middle classes dates from protracted attendance on sick friends; and this not from want of means, but for lack simply of persons with whom to share the burden. Like other things which are not understood, nursing is supposed to be a thing which every one understands, and accordingly, when illness comes, utterly untrained women apply themselves to it with a zeal stimulated by affection to a pitch alike disastrous to the patient and themselves. How can overweariness, which is fatal to efficiency in all other things, leave efficiency in nursing unimpaired? It is only ignorance—an ignorance fatal to innumerable lives in England now—that fancies the reckless energies of unskilled affection are more available in the sick room than in the other exigencies of life. Instead of diminishing disease, unwise attentions to the sick multiply it. The truly efficient nurse would never waste her strength, or (except in cases of temporary emergency) suffer it to be taxed beyond the point of greatest efficiency; and in her necessary intervals of repose would afford ample scope for the efforts of domestic affection, which under her direction would themselves be rendered doubly efficient. Nor should it be thought that nursing such as I have supposed would involve any interference with offices of family love. By relieving anxiety and diminishing fatigue it would tend to facilitate the intercourse of affection with the object of its solicitude, and set free the wife or daughter or sister or friend to render more fully that which she alone can give, and which in truth it requires no schooling to know how best to give.

To put the case on the lowest ground ; if it should be thought that such nursing as suggested would add too much to the expense of illness, the saved health of those who now vainly strive by exaggerated toil to atone for lack of knowledge, alone, would more than make amends.

Then again, here is a profession, truly a profession, equal to the highest in dignity opened to woman, in which she does not compete with men. Different minds will probably appreciate this fact differently ; to me it seems on many grounds, economic and social alike, one of very great value.

The comparative inexpensiveness of the education also—comparatively inexpensive, though needing to be wide and deep—is a very important advantage in a social point of view. Doubtless for those able to afford it, a perfect nurse-education might absorb resources as large, and as long a time, as the completest medical education does now; but the highest attainable point of culture never can become that at which the mass must be content to stop. And for a satisfactory education in the profession of nursing, if sought with love by those whose minds were previously well-stored, and accustomed to hearty work, it is probable no very expensive course would be required. Thus a door would be opened for the legitimate ambition of the young women of families not wealthy; for the daughters perhaps of struggling fathers, who might see opened before them an opportunity, in reward for faithful toil, of rising to a station of honour and respect, and of fulfilling that ambition which is often so healthful a stimulus to sons, of helping, by their efforts, to advance the well-being of those they love. A legitimate path for ambition would be opened to them.

In the last place, the interests of charity would be promoted. For no restraint would be placed on the benevolent efforts of those ladies who should prefer still to act as nurses without payment, and so to spend their lives in doing good; and why should their number or their zeal be diminished? But on the other hand, every one who looks impartially at the world hitherto must acknowledge that those things which rest for their doing on charity alone seldom are thoroughly well done. To how large an extent medical men give their labour gratuitously to the poor, long after the doing so has ceased to be of any possible advantage to themselves, is partly known to all. Must not the sick poor be benefited in like way by the presence among them of a large number of kind-hearted ladies, filled with a professional zeal for good nursing for its own sake, and as being that whereon their own renown and prosperity depend? Would they be more apt to turn a deaf ear to the call of suffering humanity than their male *confrères* have proved themselves to be?

CHAPTER VIII.

SEEING WITH THE EYES SHUT.

THE advantages of keeping the eyes open have been often, if not sung, at least insisted on in prose. It is one of the first things the child learns to do, and one of the last the man is suffered to forget. But so far as I am aware, the advantages of the opposite plan have never been duly set forth. Yet everything in this world has two sides. Certainly the art of seeing has.

I shall not dwell upon (what would be a subject in itself) the great art of overlooking, one branch of which Sydney Smith so happily described as that of "taking short views." Though what is that man's condition who cannot abstain from seeing; who cannot be blind to the insult of folly, or to the weakness of a friend; who cannot turn away his eyes from contingencies which foresight cannot avert? His perverse vision is his misery.

But besides this, as wisdom, though it is expressed by speech and action, is often best shown by silence or a "masterly inactivity," so closing the eyes, the chief instruments of knowledge, has much to do with knowing. Nature herself gives us a hint of this. Do we not close our eyes, or cover them with our hand, when we would solve some particularly knotty problem? Even the pretences of clairvoyants, however much disproved, tell in the same direction. There seems to be some persuasion in the human heart that closing the eyes is a road to more than common sight. So strong is this persuasion that even the pit of the stomach is credited with miraculous powers. And the visions which visit us in sleep gather about them the same feeling: "for dreams too are from Jove."

The ancients fabled that love is blind; because it sees and must see with closed eyes. Lord Bacon speaks much of the dry light of the intellect—the *lumen siccum*, as he terms it—free from all tinge of passion, emotion, or desire. But who could tolerate such a dry light in his home, banishing the glory from around the wife and mother's head, and stripping the wonder from the prattle of the child? Who could bear to look with such clear cold vision into the most sacred spot of life? The eyes that see thus must be shut, before the true home can reveal itself.

And not only in the realm of the affections, but in all that gives its charm, and fascination, and grace to life, the first condition of true insight is to see with closed eyes. "My eyes see pictures when they are shut," says Coleridge, and he expresses a fact common to the whole race of poets, artists, romancers, novelists—all close their eyes to see. Of blind poets it were long to tell the oft-told tale; but all can be blind in their own way, and see not only without, but against their eyes. The painter's art has been called the art of dreaming. All that we know, in short, of best and loftiest is seen for us thus. It is when the sun is set, the great eye of day is closed, the stars are visible.

So great a part, beyond all question, in our life, bears our faculty of seeing with closed eyes—of looking through that which is visible to them, to reach something which is not visible: all poetry, affection, joy of heart rest on it. Nay, that which is more than all these—all heroism too; all inspired and noble deeds. The patriot and the martyr see not by common vision but by a clairvoyance of their own.

All this may easily be granted. Poets and enthusiasts do see what is not visible to ordinary sight: and women—it is well for us men—have a happy knack of keeping one eye shut when they look at us. But there are other things besides art, and poetry, and love, if less attractive not less important. There is science, for example, the true and exact knowledge of things around us by which the progress of the world is carried on. Does not that depend on keeping the eyes open?

It seems so: yet it is very remarkable, when we come to think, how emphatically science presents itself as an illustration of the contrary. Nowhere, not among the most extravagant romancers or spasmodic poets, is the effect of looking with the eyes closed so evident as in the scientific interpretation of nature. Through custom we fail to be much impressed with this fact, but we feel it at once when we reflect. The general view of nature which is presented by science is as unlike the impression we receive by our senses as can well be conceived: and this not in one or two instances alone, but almost without exception, and especially in those cases in which the exactness of our knowledge is most unquestionable. It is needless to do more than refer to the general results of astronomy, in which the most overpowering dictates of our senses are resolved, and this without violence, into their exact opposites. But let us look at the forces which are recognized as operative in the planetary and stellar motions. Newton saw the moon falling to the earth:—but he saw it, surely, with closed eyes. To ordinary vision it does not fall. If it approaches the earth slightly in one part of its course, it rises from it equally in another. The explanation of the elliptic orbit by gravity is possible only by looking away from, refusing to be influenced by, the obvious appearance—setting free the mind, as it were, by closing the outward sense. Nor is the case different with any other science that truly deserves the name. The chemist repudiates the transmutation of the substances with which he deals; but that idea could not fail to have been suggested to the first students of the science. It is the plain fact to sense: only the intellectual eye can keep its gaze fixed upon the element, and recognize it in all changes still unchanged. Or, if we take physiology again, in no science is the unlikeness, the utter divergence, of the appearance from the truth more striking. We cannot wonder at the long delays which have marked, and marred, its progress. The impression which the sense receives from living objects, the intellect refers to causes not only hidden but almost incredible. The eye that would clearly discern them must be resolutely shut against the seeming. How else can we apprehend this apparently distinctive agent in nature—Life—as a revelation of universal force, or refer the seemingly spontaneous growth, development, and activity of an organic body to the silent action of that very chemical affinity which destroys it? The evidence of sense here, too, has to be, not indeed rejected, but taken up and inverted by the mind.

But we need not refer at length to special sciences, because the general ideas in which they all converge present the same character in an emphatic form. The great generalization that motion never ceases—how is this to be seen but with the eyes closed? closed against all that we experience or can directly find. We are surrounded by motions which do cease, by forces which produce a single effect, and then, so far as our feeling is concerned, are gone and lost, dissipated, and no more to be found. That which we know as the highest truth in science is only to be known by a resolute turning our backs upon all that our experience seems to teach, or our natural conviction assures us of—as is proved, indeed, by the long-continued vain attempts to obtain perpetual motion. Those men simply had not seen with their eyes closed. For, to such vision, motion *is* perpetual.

Let us think for a moment what a wonderful world it is that we see when we look at it thus, as science bids us, not according to, but *through* the senses; tracing in imagination the development of human thought. We see the flat earth round itself into a sphere, and our fellows beneath our feet look up to a heaven where we had fancied the abyss. We see this sphere loosed from its moorings, and sent rolling through the depths of space, and as it rolls, the crystalline vault of heaven relaxes its bands, and expands, and grows, until it stretches out into the boundless universe which taxes our imagination still in vain. We see the mountain tops beneath the sea, receiving there the freight of relics which, on their mighty altars, they shall uplift to heaven. We see earth's surface fashioned by water on a ball of fire. We see it no more haunted by spirits, dwelling innumerable in every wood, or vale, or fount, but itself animated with a secret and all-embracing life, instinct with gleaming force, and daily drinking in new draughts from heaven, until it overflows in every strong or graceful living form. We see it permeated through and through with streams of power, circulating as if through vital arteries; each linked with the other in an endless chain, and at our bidding rising up into our own frames, lending their vigour to our arm or brain.

In not one point does the vision answer to what our senses feel; infinitely and in all points it surpasses them. And this opposition to the natural dictates of sense, which permeates all science, is especially characteristic of its proudest names. It distinguishes alike the discoverer and the inventor, and is often especially manifest in the latter. It is not that the inventor must behold in mental vision what never has been realized to sense. This may not, indeed, always be true. Many inventions have been apparently stumbled on, and as little foreseen by their discoverers as by any other man. But he who does what has never been done before, or arranges old means successfully to new ends, must recognize alike obstacles that never have appeared, and elements of success which the field of vision does not include. This is in part the reason of the opposition which new schemes, even those which are the most successful in the end, so constantly encounter frcm the best authorities of their time. The calculations and inferences of the objectors are sound enough according to all that eyes can see: the distinction of the inventor is that he can see also with the eyes closed. In like manner, it is not the novelty which promises complete success according to established ways and notions, that truly does succeed. New truth is ever the improbable. It is evident the innovator is one who affirms or acts against appearances; and truth, with us, has been but a series of innovations.

But when we look beyond the mere facts into their reason, something very beautiful presents itself, and beautiful under many aspects. Advancing knowledge ever involves an opposition to the natural dictates of sense. It must do so; for in what does such advance consist but in recognizing ever more and more of that which has been unperceived? If our tendency to put trust in appearances were not so strong, the necessity of such an opposition might well be called a truism. Knowledge—to us who have to acquire it—is ever a supplying of the deficiencies of sense. By gradual advance, and by greater or smaller steps at intervals, we exclude the results of its insufficiency, and arrive at the opinions which we should have naturally and without effort if we had perfect, instead of our very limited, perceptive powers. We learn to think, in science, that which truly-perceiving senses would show us. Our propensity to error consists in this: that while our senses only show us part, we tend to trust them as if they showed us all. Thus, force is constant, unceasing, ever equally operative; but our senses only perceive it here and there, just where it comes within the sphere of their sensibility: all the rest is blank to them. Hence the idea they suggest to us is not that of one ever operative power, but of many severed and isolated powers. Here and in all parallel cases we cannot help having the false notion, but we can escape from it.

And how? By the co-operation of two faculties in our investigations. In science, sense and intellect are united, and by the intellect the sense is partly supplemented, partly made to supply its own defects. This latter element it is that constitutes the distinctive character of modern science: the use of sense subordinately to intellect. It is this *use* of sense which it took men so long to learn. For though it is true, as has been said, that our scientific knowledge is opposed in the very highest degree to the natural impressions of our senses, and that each great step of its advance could have been taken only by a man resolutely blind to those impressions; yet is that knowledge strictly conformed to, and based upon, the evidence of sense. The difference is between sense used, and sense abused; and the abuse comes first—the misplaced uncritical assurance.

Thus it is the subjecting of sense which leads to its perfecting; it gains its full development in being opposed. Its life is in its sacrifice. Good observing comes through good thinking; the eye sees that which it brings the power to see. Through our complex nature our senses are made the means of a knowledge above themselves; larger and truer than their own apprehension. And truth is gathered from error, as from the nettle, danger, is plucked the flower, safety.

Bearing on this point is an expression used by Professor Faraday in a lecture delivered a few years ago: that in experimenting, we must first fix in our minds "clear ideas of the physically possible and impossible." These words have been severely criticised by an eminent mathematician, as if they meant that we should determine beforehand what events can happen; as if, for example, Professor Faraday had implied that we might have made up our minds against the possible existence of the Australian boomerang, which returns when it is thrown. But, in fact, the expression merely marks the subordination, in the mind of this great observer, of sense to intellect. By him, every sensible experience is referred to, and tested by, an intellectual authority, and no seeming connection of events is accepted which will not stand the test. He is prepared to see against his eyesight.

There are other reasons, besides its narrow limits, for the impressions given to us by sense misleading us. For example, the sense can seldom distinguish the operation of negatives. How, when they saw light bodies rising, could men avoid supposing a special power of lightness? And again, that mutual dependence of opposites, which so greatly simplifies the chain of natural events when it is understood, could not but mislead an unsubordinated sense. The seeming contradiction involved in mutually opposing things depending on each other (as vital force on chemical attractions, for example) takes long to overcome. Add to which, the fact that our perceptions have, for the most part, an inverse order; the effect being perceived before the cause.

To see with the eyes shut, then, merely means duly to subordinate the senses to the intellect. So essential a part is it of the process of our knowing, so deeply is it based in our own nature and in the nature of things, that it might almost be made a test of truth, in a question of any considerable magnitude or depth—has there been vision here with the eyes closed as well as open? It means only—have the natural deficiencies of the senses been supplied?

But the union of sense and intellect in science is beautiful under other aspects, of which I will refer to only one. Our pleasures are doubled: opposite desires and tendencies are gratified together. Between these two faculties there must be a certain opposition. Sense, for its enjoyment, demands variety; the intellect finds its satisfaction only in unity. Both are filled. In science there is presented, at the same time, an unbounded variety to sense, and to the intellect the perception of an unity through all, which is, to intellectual men, a pleasure with which no sensible gratification can compete. We are doubly blessed. To see nature one, as the intellect (subordinating and using sense) can see it, leaves all its sensible variety untouched, adds indeed boundlessly to its amount ; but adds also another charm surpassing all.

We see, too, why in this unavoidable conflict between the two faculties which co-operate in science, the sense is that which must be subordinate. It is adapted to this place, and flourishes eminently therein, because it gives us impressions, and not facts. It tells us, I am thus affected ; the cause of the affection it leaves to be explored.

Seeing these things, we have a vantage-ground for understanding some parts of human life. It is not a matter for surprise that our knowledge has advanced so slowly, and amid strifes and controversies so prolonged. The tendency to trust our impressions, instead of seeking to explain them by the conjoint use of the higher faculty of thought, has been an ever-recurring obstacle. It takes us long to see that our senses were meant to give us partial and defective apprehensions—means for the acquisition of knowledge, but not knowledge in themselves. Nor can we fail to see that the ancient speculation, which set itself to think out the constitution of the world and repudiated sense, idle as it was in some respects, yet does not lack a certain justification. As an attempt to give to the intellectual faculty scope and dominion it was no error ; it erred in not making sense its instrument. And this arose emphatically from inability to see with the eyes shut ; shut resolutely on the apparent fact. With certain exceptions, the men of old could not—as in these days men can and do—deliberately face sense, and contradict its strongest evidence. It took long centuries of discipline and failure to nerve men to this task ; to take up their own most strong assurance, look *through* it, and compel it to reveal its meaning.

What harmony, again, these thoughts exhibit in different spheres of human life. The path of moral goodness, what is it but "repression of ourself?" Sometimes we wonder that it should be so ; often we wish it were not. But this is no strange fact ; it introduces no new element into our experience. Self-repression is as much a law of knowing truth, as it is of doing right. The secret of the warfare lies deep in our nature's hidden springs, below the parting of the streams of thought and action ; it implicates them both alike. The discord is the fruit and proof of the greatness of our nature ; the prophecy of a harmony sublime enough to make all discords tributary.

And yet once more : this complex nature of ours which involves the union of opposing elements in knowledge, as it gives the key to the intellectual life of man, does it not also cast a light upon his moral history?—that deep dark problem which we seem alike unable to solve or to forget. Does the material world deceive our sense, and falsehood to our bodily eyes take the place of truth, demanding a deeper insight to interpret their own message to themselves, and is it not so with the higher world of man? We must have knowledge deeper than our own feelings to apprehend aright the face of nature; must we not have it also to understand the human soul and grasp its destiny? Morally to see this dark and evil scene of earth aright must we not see it with eyes resolutely closed? How much there is in it we know that we do not see: how much more, unseen, that we do not know. We see the evil deed, but not the hard-fought struggle, or the bitter tears; the falling under sin, but not the radical transformation of the man. We see the wasted efforts, but not the accomplished work; the mysterious progress, not the end. How should that be a great and godlike world which did not baffle, which did not even deceive, our heart, untaught to mistrust and rise above itself?

CHAPTER IX.

*FORCE.**

ANY one who glances over a modern scientific work will probably be struck with the frequent recurrence in it of the term Force. And if unfamiliar with the modes of thought which its use expresses, he can hardly fail to have contemplated it with somewhat of a doubtful curiosity. Whether he rightly understands it or not, he would hardly venture to say without a good deal of consideration. The word is not exactly a technical or purely scientific term, yet it seems to be used in a special sense. The ordinary idea conveyed by it is familiar enough to our experience, and the use of the word in science seems to vouch for an identity between ordinary and scientific ideas, and give fair promise of simplicity. Yet the promise is kept only to the ear. The name of force

* To a small extent, this paper touches on subjects also treated by the writer in *Life in Nature*, Chapter X.

receives a width of application which takes it quite beyond the region of experience; and the community of language seems but to make the diversity of thought more perplexing. For there is a diversity deep and broad between the natural mode of thinking and that which science suggests. There is a barrier, none the less real because invisible, which separates the practical and "common-sense" view of things, and that which arises from the thoughtful tracing of their real connections. And this diversity of thought finds an emphatic expression in the different meanings of the word force to the initiated and the uninitiated mind. Probably it is only by means of a thorough understanding on this point, that any vivid apprehension of the world to which science introduces the student can be attained. And, happily, this understanding is not difficult to acquire. The scientific use of the term Force is a perfectly natural development of the idea which its common use conveys. The difference arises almost entirely from the stopping short of the ordinary apprehension: in other words, from the smaller sphere which our senses, as compared with our intellects, embrace.

What this difference is, and how it arises, we shall endeavour to show:—how easy it is to engraft on our habitual thoughts the further ideas given by science will sufficiently appear ; and not less, we may hope, will be evident how clear and fresh a light these ideas cast on the phenomena of nature.

The language of science speaks not only of Force in general (which seems abstract enough), but, as if to add to the perplexity, of Forces. Besides mechanical force, such as that which we exert by our arms, light, heat, and electricity are forces ; there are also the forces of chemical affinity, of gravity, of cohesion, and of magnetism ; and, lastly, the vital force. These complete the list. Here are "the forces" marshalled : the army that fights under the banner of science, or rather, perhaps, the army over which science has to gain her victory. Why all these should be called by the common name of forces we may easily see. They are all characterized by the common power of producing changes. They do that which we know it would demand an exercise of force on our part to effect. Gravity moves heavy masses ; so, under certain conditions, does heat or electricity ; so will chemical affinity or magnetism ; while the vital force is the agent in our own exertions. Light seems not to be included in this list ; yet its claim to be regarded as a force rests upon a basis as evident as that of any of the rest. It alters the chemical constitution of bodies, causing the union or decomposition of various salts ; it will determine the oxidation of metallic mirrors, literally engraving pictures upon steel ; and there is every reason to believe that it is powerfully active in inducing a crystalline state in metals long exposed to it. Now, the idea of force is evidently implied in these changes. And some of the effects of light are producible by force in the ordinary sense. Repeated blows of a hammer, or the friction of a wheel, will also cause crystallization in metallic bars—as we have reason to know from an unhappily increasing class of railway accidents.

Minute changes in bodies, then, are signs of force, in the same sense as motions of large masses. And the variety of forces have been inferred, simply enough, from the variety of the minute changes which we thus perceive. Chemical changes are ascribed to a chemical force ; electrical, to electricity ; changes of temperature, or expansion, to heat ; and so on. For each class of changes is inferred a special force, producing them.

This is the first impression that is given by an exact study of nature. The world appears before us as a passive substance (consisting of "atoms," is the most plausible idea) ; this substance being acted upon by certain powers, each having its special character, and determining particular classes of results. The forces appear, in a word, as so many separate existences; *agents* in respect to the effects attributed to them. But this is only a first step. It is impossible for the mind to rest here; and this idea of the forces as distinct agents, when farther pressed, gives place to a conception at once more intelligible and more practical.

It is evident, for example, that motion is not a separate power, which produces effects on matter, but is itself only a condition of matter. It is not a thing, but a state. The name of motion is a term applied to the condition of any body that may be moving: it does not denote an agent; it exists only in this very state of movement, and is rather an idea than a power. It is evident, therefore, in so far as the ordinary motion of visible masses is concerned (in which the relation of the facts is obvious), that when we speak of a "force," we do not mean something which has a separate existence, but merely use a name which designates a particular condition. And although this is less immediately evident with respect to the other forces, such as heat or electricity, which we cannot trace into detail by our senses—though they more easily picture themselves as substantial existences to our fancy—yet it is no less true of them, that they are but conditions of the substances in which they are found.

Two distinct kinds of proof concur in establishing this view. There is first experimental evidence; derived from the fact that the various forces can be produced by means which simply affect the condition of matter, and that they are more or less derivable from each other, or mutually convertible. This evidence is continually presented to us in very simple forms. Heat and light are common results of friction, and electricity hardly less common. When two sticks are rubbed powerfully together, and gradually growing hot at last burst into a flame, we see motion producing heat and light, and this virtually in unlimited amount. It is plain that the motion adds no substance to these bodies, it alters their condition only. It produces a luminous, a heated *state;* or, if the substances employed be glass and silk, the state known as electricity. And if we note more carefully what takes place in such cases, we find that it is not so much to the motion simply, as to the friction, that the resulting "forces" are due. The harder the pressure (the motion being of the same speed), the greater the amount of electricity or heat developed. Why should this be? We know that pressure or friction stops motion — transfers it to the resisting body. And so it is in this case. The friction is the measure of the amount of motion stopped; it is the measure also of the amount of heat (or other such force) developed. So much motion stopped (by friction), so much heat generated. Nothing can be more simple. Is not the heat this very motion presented to us under another form? We know that motion does not stop except through the resistance of other bodies, and then that it is only transferred to them, and continued by them if they are free to move. If they are not free to move, the minute particles of which they consist take up the motion; they expand, and are felt by us as hot. Heat presents itself thus to us as a state of motion, with no more obscurity than if a large body, moving rapidly, should strike upon a number of smaller ones: the single motion in such case might cease, wholly or in part, and a number of small motions would take its place. The same arguments apply equally to light and electricity. The modes in which they may be produced exhibit them as states of motion.

We have often held in our hands a body that is giving out sound—a tuning-fork, for instance. There is nothing in, or given off by, such a body except motion. It is simply vibrating. The same conception applies just as easily to bodies that are hot, electric, luminous. They are internally moving—we might say, with almost positive assurance, vibrating.

Thus, by the relations which the various forces bear to motion, demonstration is given that they must be regarded as conditions, and not as things. But in truth, such demonstration was hardly needed. Long as the opposite conception held sway over the human mind, it was only possible through a kind of intellectual paralysis. The very nature of thought rejects it. Such an agent as the supposed "force"—an existence that can neither be grasped by sense, nor intelligibly conceived, nor reverentially accepted by a moral faith—stands condemned by its own evidence as a pure chimera. The only elements with which our thoughts can deal, in respect to material nature, are substances in varying states; if, for convenience, we analyse them, in idea, into a passive matter, and various forces to work upon it, we must remember that this division can exist only in idea. Why the contrary thought prevailed so long we shall see hereafter.

Thus the idea of motion is applicable in the most obvious way to several of the forces. It is not so directly applicable to everything to which this name is given; to chemical affinity, for example, or to gravity, which are less states of action than tendencies thereto. But even to these, ideas derived from motion may be applied, if we remember that motion presents itself to us under two forms, that of active movement, and that of tendency to move. When we push our hand against a wall, the bricks do not move before it as they would if they were loose, yet the motion is virtually in them. A pressure is produced; the motion exists in equilibrium.

The forces being thus regarded no more as agents (or entities), but as conditions, they are naturally generalized under one common idea. We speak of *force*, including under this term all the active conditions of matter, of whatever kind they may be. The total amount of these active conditions is the total amount of force. The differences are differences merely of form or mode; essentially all are the same.

Languages furnish us with a parallel case. The several varieties of speech are but different forms of one radical fact—the oral communication of ideas. There are many languages; *language* is one. The various modes of speech are but equivalent expressions of the same thing, and they are mutually convertible into each other. Just so are all the many forces expressions of the one fact of physical activity, equivalent, and *translatable* among themselves. The fundamental idea may be exhibited in any variety of dialect or mode, as a man assumes first one garment and then another, himself remaining entirely unchanged. The conception of "force" grows up amid the forces, as that of "language" emerges from the multitude of tongues.

Even if the natural tendency of the mind to generalize did not lead us thus to unite all the forces under one conception, we should be compelled to do so by the fact of these "active conditions" (as we have already observed) passing continually into one another. We are obliged to think of the forces as one, because, in fact, they will not remain distinct. We cannot practically isolate any one of them, except for some special and temporary purpose: it is constantly escaping from us and passing off into other forms. Motion resolves itself in sound and heat; heat flies off in motion, in chemical or electric change; electricity is lost in sparks of light, in magnetism, in mechanical disruptions, in the production of chemical power; chemical power no sooner acts than it is no more chemical, and must be recognized in explosions, in electric currents, in heat. No force can be permanently retained; if we need to preserve any one, we must perpetually generate it afresh. Nor can we isolate any of the forces from the rest in our thought of nature, any more than in our operations upon her. To do so would be for the intellect to choose unreason ; to create disorder where order reigns. We should be perpetually losing our force without reason, and finding it reappear without necessity. We can only follow one, by recognizing the essential sameness of them all. We can only keep our intellectual hold of motion, for example, by tracing it as still the same thing, when heat takes its place, or light, or the less apparent forces of magnetism, or chemical attraction. Through all these, tracing it patiently, we may find that it at length resumes its former state, and is restored again as motion.

According to the classic poets, Proteus was Neptune's herdsman—an old man, and a most extraordinary prophet, who understood things past and present, as well as future ; so that besides the business of divination he was the revealer and interpreter of all antiquity, and secrets of every kind. He lived in a vast cave, where his custom was to tell over his herds of sea-calves at noon, and then to sleep. Whoever consulted him had no other way of obtaining an answer, but by binding him with manacles and fetters ; when he, endeavouring to free himself, would change into all kinds of shapes and miraculous forms, as of fire, water, wild beasts, &c., till at length he resumed his own shape again.

Lord Bacon, in his *Wisdom of the Ancients*, thus translates this fable. Proteus represents *matter;* servant of Neptune, as working chiefly in a fluid state; and sleeping after telling over his flocks, as having once fixed the various species of things, and then ceasing their production. Now, "if any skilful minister of nature shall apply force to matter, and by design to torture and vex it, in order to its annihilation; it, being brought under this necessity, changes and transforms itself into a strange variety of shapes and appearances; for nothing but the power of the Creator can annihilate or truly destroy it; so that at length running through the whole circle of transformations, and completing its period, it in some degree restores itself, if the force be continued."

The fable is not more true of matter than of force. This, also, has a circle of transmutations, from one to another of which it passes when it is fettered; that is, when it is resisted, or a hindrance arises to its continuance in its existing form.

This, then, is the idea of force which science presents to us. It exhibits matter as in a state of incessant action; that is, of change, or tendency to change. This action is of many kinds, and it is continually shifting from one kind to another, but it is essentially one.* We can study it as one, and undeceived by apparent loss or gain, can trace it through its boundless course. Thus we grasp nature in our thought.

And at once there suggests itself to the mind a question of the very chief importance. Is the amount of the action that is in nature always the same, or does it vary—being sometimes more and sometimes less? In a word, having obtained the general idea of force as a unity, new ideas suggest themselves respecting it: we begin to ask questions about it as a thing of which we can discuss—how much? how little? more, or less? That is, we treat force *quantitatively.*

This is simple enough. It is as natural to make this inquiry with respect to the one fact of *action,* which we have learnt to recognize under all its forms, as with respect to any one of those forms themselves. Yet it is the corner stone of modern science.

Is the quantity of force in nature (that is, of change or tendency to change) always the same?

* The reader may, if he prefers, consider the organic kingdom to be omitted from this statement, which will then be taken as applying to the inorganic world alone. Whether this is truly the case will be for special consideration.

Science answers this question in the affirmative. The amount of force does not vary.*

There are two kinds of evidence on which this position rests. First, the experimental proof; that when any one form of force ceases, there is, so far as the facts can be traced, always another taking its place, and this to an extent, when measurable, found to be exactly equivalent. The nature of this evidence is well exhibited in the law that motion stops only as it meets resistance, and then is transferred, in the same proportion, to the resisting body. But it is furnished also by all the forms of force to which the test can be applied; and though it is seldom that so exact a measure can be made as to demonstrate precise equivalence of quantity through every change, yet proofs of a more or less perfect correspondence are never wanting. The proposition has all the evidence of which its nature is susceptible. Thus, in respect to galvanism, Faraday has shown that the chemical action which produces the current, is precisely equal to the chemical effect the current will produce. And in the simple experiment of exposing cloths of different colours to sunlight on the snow,

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* For an excellent statement of the argument on this point, and the earliest in England, see Mr. GROVE'S *Correlation of the Physical Forces*. 3rd edition.

the darkest colour—that which absorbs most light—is that of which the temperature rises most, and which accordingly sinks the deepest. The mechanical effects of heat, again, have been shown by Mr. Joule to be strikingly correspondent with the amount of mechanical force expended in producing it. If a certain pressure applied, or a fall from a certain height, produces a given amount of heat, there is experimental reason to be sure, that the same amount of heat would exert an equal pressure, or raise the falling body to an equal height. Nor when any force passes through a prolonged series of changes, can there be found at any point of the chain evidence that it either loses or gains in value. Though it is so hard to collect and hold, that it can seldom be exactly reproduced, still all the evidence points unequivocally to an absolute uniformity of its amount.

But although this experimental evidence is needful in its place, it is really of subordinate value ; nor could its absence cast any doubt upon the proposition. For that rests upon a demonstration in the nature of things. To suppose the amount of action in nature to vary, would be to suppose material things capriciously to alter their own condition, and thus to overthrow the fundamental maxim on which science reposes. In truth, the constancy of force in nature is already established by implication, before it is raised as a special question. It has been established, first, in the constancy of nature's laws, and in the rational connection of all her processes. For this constancy of law, and of connection traceable by reason, is but the expression of the fact that whatever activity was operative at any time continues ever operative, even though hidden. Without this there could be no harmony to reason ; if forces absolutely ceased to operate, there must arise a discontinuity in nature, a want of conformity between that which was and that which is, which would be felt a fatal bar to science. The perpetual reproduction of the same conditions that existed previous to any given series of changes — the type of which the chemist finds in the unalterable "elements" perpetually reappearing beneath all disguises—is demonstration of the constancy of force.

But this is truly demonstrated, also, by the proofs which establish the constancy of matter. The chemist, with his balance, has made it good that in all changes *weight* never varies ; matter, he says, is never lost, is never added to, because the total weight remains invariably the same. But when the chemist argues from weight, he is arguing from force. The "imperishableness of matter" rests upon evidence furnished by the unalterableness of one of its forces.

This great doctrine of the unchanging amount of activity in nature is that which has received the name of the "conservation of force." Simply expressed, the conservation of force means, that when any kind of action—be it motion or any other—in the physical world, ceases, some other and equal action arises. There is never an absolute ceasing ; never an absolute beginning. If any action come to an end, some other continues or follows elsewhere ; if any action begin, some other, in that beginning, comes to an end. Science busies herself with tracing these ; revealing them when hidden, and referring to previous activities which have seemed to cease, any actions which appear isolated and spontaneous.

For owing to the limited capacity of our senses, which only perceive a few of the multitudinous processes which are really taking place in nature, we continually lose the chain of her operations. Its links are ever passing out of the sphere of our perception ; and, reappearing at a distant spot or point of time, they produce on us the impression of original and disconnected actions. From this cause—from this imperfection of our senses—arose the false conception of the various forces as distinct existences or causes; from this cause it was that that false conception so long maintained its sway. If our sense had been penetrating enough to follow the entire course of nature's action, and to recognize it in every shape, that thought never could have arisen. And thus it is that reason sets it aside, by supplementing sense, and teaching us to recognize the existence of that which we cannot see. By tracing the strict chain of causation throughout nature, it substitutes unvarying activity for imaginary agents.

One chief cause of our being so misled by our senses, on this point, is the existence of force under two forms: one of active operation, like the motion of an arrow shot from a bow; the other *latent* (as it has been called in the case of heat), or stored up in a hidden way, as in the tense string of the bow itself. The former of these forces (the motion) is obvious to every beholder, the latter (the tension) might escape, nay, certainly would escape, the observation of any one who had not been taught to recognize it by experience. Yet it is evident that they are the same thing. The motion of the arrow is not only due to, it is identical with, the tension of the bow. The latter becomes, passes into, the former. In doing so, it passes from a hidden into a palpable form. The case is but an instance of innumerable others; and the converse process takes place with equal frequency. Palpable and operative forces pass into the hidden form. Not only motion embodies itself (so to speak) and disappears in *pressure;* the other forces equally recede from observation, and demand the eye of reason to trace their existence. Heat, when it dissolves ice or vaporizes water, disappears, and seems to be lost; so does light, when it is "absorbed" by gases, and imparts to them fresh chemical powers, or intensifies existing ones.

Thus natural bodies present themselves to us (as regards force) in two great and well-marked divisions. Of these a tense and a relaxed bow, respectively, may serve as the types. The one group contain force within them, ready and prone to operate: such are bent springs, which contain mechanical force; vapour, which contains heat; explosive compounds, which contain chemical force; a charged electric battery, and so on.* The other group are in a passive state in respect to force; they are ready to receive it rather than prone to give it forth; springs that are unbent, crystals that have no tendency to

* Such also are, evidently, plants and animals. These are eminent instances of the force-containing groups of bodies, as little exceptional, or out of the common order of nature in this respect, as anything can possibly be.

change their composition, an electric battery that has been discharged, belong to this class. In studying nature it is necessary ever to bear in mind this distinction, and to recognize to which class any given body belongs. For there is hardly one (probably there is not one) of all the forces, which does not exist in this twofold state, and by its presence give their distinguishing characteristics to some forms of matter.

It follows, also, that all the changes occurring in nature, when considered in respect to force, are of two kinds; or rather, one single action presents itself to us under two forms. We may illustrate them by the bending and the unbending of a bow, or by the elevation and the fall of a weight. In one of these actions force is put into the substances in question, in the other it passes out of them; by the one class of actions it is absorbed, by the other it is given forth. We lift up a weight from the ground; force is exerted—it is *absorbed* in producing the raised condition of the weight; we suffer it to fall, and the force that raised it is restored to the active form. The motion the falling body acquires would suffice to raise the same weight again to an equal height.

The elevation of the weight requires an exercise of force to effect it; the fall takes place *spontaneously*, as we say. The distinction between these two kinds of actions is universal throughout nature. And we see that it must be so. The law of the conservation of force demands it. For the one of these actions is the ceasing of force to operate in a certain way, the other is its coming into new operation : that is, the two together represent its change of place, or change of form—the only change which, if its amount is constant, is possible in respect to it. Just as it is with matter, it is with force ; if it is to be present where it was not it must cease to be where it was before. But force ceasing to be where it was, or ceasing to operate as it did, is itself an action ; not a mere passive condition, but an active change. We see it in the relaxing of the tense bow, the fall of the heavy body, the union of elements which have affinities for each other—in short, in all processes which take place (as it is said) spontaneously, and give forth force as their result. That all these are the ceasing of force to act as it has previously done, is proved by the fresh exhibition of force which results from them—from the motion, or the heat, &c., to which they give rise. These could not be without a loss of force of an amount precisely equal.

The conservation of force, therefore, has two aspects under which it may be regarded. On the one hand, force may be considered simply as a "quantity" changing in distribution or in form (as we think of matter); on the other, this varying distribution may be regarded as a series of related or complementary actions. Each of these views is necessary to the student of nature, and each helps towards the full apprehension of the other. Each also has its special truth. The one recognizes the perfect calm, the absolute repose, in which all the strife and turmoil of nature are enfolded, and laid as it were to rest; the other represents the unceasing energy, the whirl of operations, by which not only that repose is undisturbed, but by means of which it is maintained. Ceaseless changes pervade all things —because there is essentially no change: these changes are ever twofold in their character—because there is no change.

Every action in nature involves, or rather is, two equal and opposite actions. There cannot be one without the other: whenever we perceive one we are justified in looking for the other. Nay, for the true understanding of the world, we are bound to look for it. If one heated body, for example, warms another of the same kind, as the temperature rises in the one it is lowered to exactly the same degree in the other. The growing hot and growing cool proceed with precisely equal steps. The pair of changes is inseparable. Or again, in an ingenious form of battery invented by Mr. Grove, the union of oxygen and hydrogen into water is caused, by means of the galvanic current which it sets up, to resolve a similar amount of water back into oxygen and hydrogen. The opposite actions in these cases are evident, because they are of the same kind; the form of the action continues identical, though its direction alters. But it is clear that the same opposite relation of the two actions might exist, although the form of them should be altogether different. The heat produced by the fall of a body to the earth is as much an instance of it, as the heat imparted to one body by the cooling of another: the electric spark produced by the union of two gases as truly displays these opposites as the disunion of the same gases again. There is equally in the one action the giving forth, and in the other the taking up of force. This is a principle to be held fast universally. In relation alike to simple and to complex processes, to plain or obscure, to large or small, in this confidence we must never relax:—Every change has its equal and opposite, which, if we see it not, is yet inevitably present, and will reward the search. All actions in nature are two equal and opposite actions. It is a law with no exception, nor possibility of exception. Nor is any change—any seeming origination or ending of an action—rightly apprehended till it is seen thus in absolute interlinking with its fellow. We are familiar with this principle in some simple instances, but the demand is that we should be sure of it in all. The very spirit of science consists in the confidence with which it is grasped, and applied to all cases, however vast beyond the reach of our observation, or complex beyond our power to unravel, however long the completion of the process may be deferred.

In some departments of nature this twofold action has long been recognized and a name assigned to it. It is called *vibration*. A body that vibrates performs two equal actions, one giving force as its result, the other requiring force to effect it. The pendulum falling from its raised position gains velocity, and this velocity restores it to the raised position again. The fall generates the force, the rise consumes it ; the two motions are opposite in respect to force.

Now, evidently this relation of two opposite actions, which is called vibration in mechanics, may be equally conceived as a vibration, whatever may be the kind of force concerned. Since every change in nature (involving force, as all such changes do) must consist of two equal and opposite actions—the ceasing of force in one relation, and its operation in another—all natural changes may, without violence, be termed *vibratile.* The whole course of nature is a series—a complex and intermingled play—of vibrations ; some of them immense, some almost infinitely small. The great pendulum of time swings to and fro, in oscillations which do not and cannot cease, because they can incur no loss. Perpetual shiftings there are among the various parts ; losings and gainings among themselves : loss to the whole, or gain, there is and can be none.

Evidently this fact of absolute vibration flows from, and is an exhibition of, the constant equivalence of force. Nor can we better picture the activity of nature to our minds, than by conceiving it as a vast, even a limitless, multitude of vibrations :—a rush and whirl, a maze, of actions to and fro ; shifting their place, changing their mode, yielding to each other, modified and altered in endless ways ; ceasing and recommencing in every quarter ; with nothing constant but that the exactness of the balance be maintained. This being, amidst the seeming mere confusion, a perfect law of order ; the activity that cannot diminish or increase works like a Life within ; a necessity organizing accident into beauty, as in the heart of man principle elevates licence into freedom.

This is the one true *constancy* in nature; essential unchangingness of being and of action. Whatever other seeming constancies there are, and there are not a few, arise from the constant recurrence of the conditions which determine them. They are not deep and fundamental, like the other. The most steadfast forms might vary, as we know they have varied, yet nature would remain the same. That which seems most fixed to sense may wax old as a garment, and be put off. The real fixity lies in that constant balance of impalpable force, which, if it failed, would loosen every bond, and nature herself were grown unnatural.

Not only is this constancy of force the key to the union, in the physical world, of law and liberty, of unity stamped everywhere, and variety almost without bounds; it is also the secret of its perpetual youth. The heavens and the earth, sing the angels in *Faust*,

> Are glorious as on creation's day.

The freshness of a new birth is on every work of creative power; the grace of its earliest days renews itself on earth with every spring. No decrepitude invades nature's heart; corruption passes over her as a shadow, leaving every member sound and strong.

It must be so. She cannot grow old ; the springs of her power cannot be exhausted. For they ever renew themselves, and every loss is equal gain. We cannot say of any one of her activities, "It was ;" we can only say, "It is."

It has long been recognized, as an impressive consequence involved in the doctrine of the absolute constancy of force, that no action of ours ever ceases in its effects ; that every word we utter alters, and alters permanently, the condition of the universe, and transmits itself undiminished through endless time and illimitable space. There is another thought hardly less suggestive, which also flows from this doctrine. If all natural action is vibration, involving opposite and equal actions, then the sum of it all exactly equals—none. These opposites are like *plus* and *minus*, so that "the sum total of all the forces in the universe is equal to—nothing ; and has been so at every moment." Look at the problem in a simple instance—in a balance, in a see-saw. Conceive the opposite motions on the two sides—the descent and the ascent—put together : are they not precisely equivalent to mere immobility of both ? Do they not (to the eye of reason) just neutralize each other, and no more ? Behold in this instance the type of all. Physical action, much as it is to us, is nothing in itself. Nothing? Not so. It is a picture, an image of that which is incomparably more. This "nothingness" rebukes our feeble and too sensuous thought, and bids us raise it to a worthier height. Doubtless there is *no action* there, where we ascribe it. It refuses to be found, because it ought not to be sought. There is no action in *things;* there is no power. But not, therefore, is no power revealed by them. Though it lies deeper, it is no less manifest; nor does it need other interpreter than that which it finds within us. The discovery of the unity of force carries with it a conviction that brings harmony to our mental life. The manifold energies of nature, uniting into one, point to one act as their source and secret. One act, perceived in many forms, in seeming infinite succession because, in truth, a present infinite; this thought, which nature teaches directly to the heart, she reveals also to the intellect, when it has learnt to penetrate her mask.

CHAPTER X.

THE FAIRY LAND OF SCIENCE.

WE have often been reminded how curiously the achievements of modern industry embody, while they often even surpass, the imaginations of the youthful world. Who has not been invited to compare Chaucer's horse of brass, the shoes of swiftness of the *Niebelungen Lied*, or the seven-leagued boots of the renowned Giant-killer, with the railway train, to the manifest advantage of the latter ; Aladdin's ring by rubbing which he could instantaneously communicate with the genii at the ends of the earth, with the electric telegraph; or the magic mirror in which were portrayed the actions of distant friends with the reflecting telescope ? Science has realized, and more than realized, some of these early dreams, and seems to cast on them almost a prophetic lustre. We can easily persuade ourselves that those weird tales were told half in earnest, and hid beneath their grotesque exterior the sincere anticipations of gifted souls, whose far-sighted gaze caught the dim outline of the future time. Nor is there any good reason against our indulging in this pleasing thought. What undeveloped power is there, in man or beast, that does not, by sportive freak or mad extravagance, foretell the achievements that are to come? Who can explain the promptings of nature in his own bosom even, until experience casts its light (and gloom) upon them?

Its light and gloom—for seldom indeed is the brightness of the hope undimmed by the fruition. The golden splendour of the dawn fails not of the promised noon, but the noon veils itself in clouds. The history of man is written in the gleesome fairy tales of old, and the heavy burden of the modern life: picture of hope, and hope fulfilled.

A pretty fairy-land our science has brought us to. It is like the "behind scenes" of a theatre. There are all the fine things we admired so innocently at a distant view; we can't deny that we have got them; "but oh, how different!" The dazzle, the sparkle, the romantic glory, where are they? Are these realities of life, also, only meant to delude an imagination that makes itself a party to the charm? *Is* all the world a stage?

Not that we are among the grumblers at our life. Stern realities, it is true, have upreared their solid framework in regions which the very wantonness of fancy claimed, crushing fancy with their weight; and sterner duties, multiplying evermore, have put chains upon the hands which once were filled with flowers, or clapped in happy play. But the sternness is better than the play; the chains are the instruments of a higher liberty. The laughing imagination gives place to dull and sober fact, only because man's heart is large, and his destiny sublime; because his nature grows with the growing centuries, and his soul learns to fill out more worthily the compass of his powers. The realization of one dream is no end: it is but another dream. The prophetic cycle of humanity contains wheel within wheel, and each fulfilment carries on the burden in a higher strain, and with a wider sweep.

Our realization of the dream of fairy tales is but another dream; it is a revelation, an onlooking, and no end or substance. A divine fatalism is upon the world, and upon man in his dominion over it: a beneficent necessity, which forbids the lower to be grasped save through the recognition of a higher. The achievements of which Science boasts, and justly boasts, as its peculiar glory, are permitted to it only by the adoption of principles which compel it to bear witness to a truth beyond itself. By science man may control nature, and work marvels that outrival magic, but in the very act he concedes that the world is not what it seems. We can easily see the proofs of this.

In the previous paper we took into consideration the scientific view of nature, and found how greatly it turned upon the idea of force. And as we pursued this idea, we found it to be, on the one hand, a very simple one, flowing directly from our own experience; while on the other, it furnished exactly the key we needed to help us to understand the world around us; enabling us to regard all material changes, of whatever kind, as exhibitions of a common fact. Thus we recognize in all the "Forces," as they are called (motion, heat, light, electricity, &c.), forms of one activity, different in mode, but always essentially the same. And this activity we saw reason to believe never alters in amount; never begins really afresh, nor comes to a true end; but only passes from one form to another, maintaining a constant equivalence through all seeming changes. So we see all things under a new aspect. This simple idea places us without difficulty in a position from which the most varied phenomena present themselves as one. All processes in the material world arrange themselves under it at once: all are instances of the shifting forms, and permanent balance of force. A unity is grasped here which no variety can obscure, nor seeming unlikeness contradict. And this is no matter of arbitrary arrangement. It is the very unity of nature that we have seized. For no grouping of events can be more natural, or seem to bring us nearer to their source, than that which regards them as embodiments of power, and fixes our thoughts on the force by which they are produced.

Nor is there wanting another charm, besides that of simplicity, in this view: it is fraught with mystery; it is rich with life. Can any thought be more pleasing to the mind, than that which thus presents nature as a perennial fountain of activity, ever flowing forth, ever returning, inexhaustibly; which recognizes in the endless series of her creations continually fresh forms of the old powers; and finds in the simplest objects storehouses and reservoirs of the most subtle energies?

For this the doctrine of force, and its unalterable constancy, involves. It carries our thoughts beyond the objects which present themselves to our senses, and makes us recognize in everything the operation of a power impalpable to sense: a power which reveals itself to us in one and in another form, but which itself eludes our grasp, and then most flies from us when we seem most nearly to approach it.

Thus, for example, in the telegraph, a magnet attracts a needle: it seems to us that there is here a power of magnetism displayed; but when we look farther, we find that this magnetism is but the representative of a galvanic current. Do we say, then, that it is galvanism that attracts? Again we look back, and we find that the galvanic current represents some chemical action—it is chemical affinity that is operative in the galvanic wire. But this affinity refers us to something still farther back, and that again to something else. Which of these forces is it that produces the effect? Clearly it is neither of them, but something which is each of them in succession; which appears to us, that is, first as one and then as another, being truly none of them, because it embraces all. To think rightly of it, we must alter our point of view, and instead of regarding the series of operations from the side, look along the axis of them, as it were, from which position the longest line appears as a point. Or again: our own bodies will one day no more be bodies such as now. They will be dust, they will be other forms of life; we can neither trace nor put limits to their changes. And equally, they have been other things before—grass, air, we know not what. The substance here, then, is not the body ; it is something which can be all these, and yet remain itself.

Dwelling on this idea of one unalterable power, we begin to feel ourselves in a new world of fascinating interest and mysterious awe. The solid globe seems almost to melt and become fluent before our eyes. All things put forth universal relations, and assume a weird and mystical character. The world becomes doubled to us : it is one world of things perceived ; one unperceivable. The objects which surround us lose their substantiality when we think of them as forms under which something which is not they, nor essentially connected with them, is presented to us ; something which has met us under forms the most unlike before, and may meet us under other forms again. In short, all nature grows like an enchanted garden ; a fairy world in which unknown existences lurk under familiar shapes, and every object seems ready, at the shaking of a wand, to take on the strangest transformations.

We cannot escape this result of regarding nature from the scientific point of view. The most solid substances become mere appearances, and we feel ourselves separated from the very reality of things by an impenetrable barrier. Struggle against the conviction as we may, we have to accept it at last. It is, indeed, accepted by the cultivators of science as an established fact, that the very reality of things is not within their sphere; and this idea is embodied in a word that has grown into familiar use, but the real significance of which, being so much opposed to our ordinary thoughts, has not become equally familiar—the word "phenomena." This term is merely a learned word for "appearances;" and when it is said—as it is said whenever the principles of science are discussed—that we only know *phenomena*, the meaning simply is that our observation and our thought penetrate only to appearances. Science deals, therefore, with an apparent world. The facts which it affirms are true of appearances, and its command is over them. The true reality of nature remains beyond its grasp, and respecting that it is silent, save as it affirms that all the changing things with which our experience is concerned are appearances of an existence which does not share their change.

Have we not well said, therefore, that science wins its triumphs in a fairy land, and in fulfilling one vision teaches us to recognize another?

From this point of view we can appreciate the full meaning of the confessions of ignorance, and references to some unfathomable reality, which fall so continually from the lips of those who, in these days, reveal to us the wonders of the material world. Scarcely ever do great discoverers or leaders in science speak, without bidding us mark to how small a depth our knowledge reaches, and how profound a mystery hides itself behind all that they can teach us! Thus Professor Faraday says: "We are not permitted, as yet, to see the source of physical power." And Professor Owen: "Perhaps the best argument from reason for a future state and the continued existence of our thinking part, is afforded by the fact of our being able to conceive, and consequently yearning to possess, some higher knowledge. The ablest endeavours to penetrate to the beginning of things do but carry us, when most successful, a few steps nearer that beginning, and then leave us on the verge of a boundless ocean of unknown truth." And Sir J. Herschel: "How far we may ever be enabled to attain a knowledge of the ultimate and inward process of nature in the production of phenomena, we have no means of knowing." And another writer has well put the case: "We talk proudly of man's dominion over nature, of scanning the heavens, of taming the lightning; but we can see little beyond the shows of things. The shadow is there, but the substance eludes our grasp. Like the physiognomist, we may indeed decipher something of Nature from the aspect of her countenance, but we cannot see the workings of her heart."

They cannot speak otherwise, for their instructed sight has caught a glimpse in nature of a mightier presence than the uninitiated eye perceives. They have felt the awe which the consciousness of something above sense and above thought inspires, and their language takes from thence a tone of higher meaning.

But is it merely to an unfathomable mystery that we are led, when there dawns on us the conviction that there is a deeper existence in nature than that which we perceive:—a profound Unity unreached by that natural apprehension to which the varying forms are all? Truly the problem appears dark enough; we seem to peer into a gulf, black from mere fathomless vacuity. But it is not so. Gazing into nature beyond the region to which our sense can carry us, we do not gaze upon vacuity, but on an existence, real, however dimly illuminated. The mystery which science encounters arises not from the cutting off of light, but from the pouring in of more; from the looming into view of that which was unperceived before. May we not compare our experience in this respect with the effect produced by the dim light of the commencing dawn? The darkness of the night derives a certain clearness from its own excess. Where everything is hidden, mystery is not. But as the gradual light comes feebly on, a feeling of vague mystery creeps over us; indistinct outlines elude the baffled sight, and objects half-perceived assuming distorted forms, fantastic visions throng upon the eye. Yet let the day advance, and the mystery its dawn created, its completeness soon dispels. May it not be thus with that unknown reality in nature which science bids us recognize? Our advancing insight makes us conscious of a mystery at first, and even yet it is but struggling with the mists of night. But why should it not bear unlooked-for revelations in its train?

For even now it tells us something and suggests much more. If "all things end in mystery," as we gladly own, the very darkness to the intellect, if it be not "from excess of light," yet may be fairly said to be made visible by light. And to other faculties of man, and nobler faculties, this darkness is no darkness at all, but a bright gleam of encouragement and hope. Is not our manhood lowered when the necessities or luxuries of life absorb us wholly; when higher aims and other objects do not permeate and leaven even our enjoyment or pursuit of these?

What feeling, therefore, but one of gladness should it call forth within us to be told that there is something more than gold in money, something more than food in bread, even though we know not what it is? "Every inquiry," says Sir John Herschel, "has a bearing on the progress of science, which teaches us that terms which we use in a narrow sphere of experience, as if we fully understood them, may, as our knowledge of nature increases, come to have superadded to them a new set of meanings and a wider range of interpretation." And has not every inquiry that brings forth such fruit a bearing on the advancement of our manhood too.

It were a pity, therefore, to avert our eyes from this revelation, dim though it be, which science makes to us of a deeper meaning in all the objects with which it deals. Even in the utterest obscurity to thought, it elevates and inspires the heart; and the resolute eye, patiently gazing, may even now discern some lineaments on which thought may fix. There are pictures, by great masters in their art, which, on the first view, present an almost shapeless mass of colour, in which no meaning can be found, but which reward the studious eye with rich shades and outlines full of meaning—if too deep to be distinctly uttered, capable of being felt the more.

For it is this recognition of a hidden essence in all things (appealing as it does to the highest portion of our nature, and giving the freest scope to the imagination) which surrounds science in our day, in spite of the stringent severity of its attitude towards facts, with an unquenchable halo of poetry. No justification of those poetic instincts which insist on finding a spiritual significance in all material things, could be more complete than that which is thus given by science. For be this "hidden essence" what it may, of this at least we may be sure, that it has a beauty and a worth which our perceptions do not exaggerate. It is something adapted to produce in us the impressions which nature produces, and to rouse in us the emotions which nature rouses. Granted that in these mere forms, which we deal with in the shape of material things, no such adaptation can be recognized—that it is an utter mystery how vibrations of the air should convey to us the infinite meanings with which music is fraught, or how any of the things we see or touch should generate thought and emotion within us—yet the mystery clears off when we remember that it is not truly they, but some deep and unknown existence, of which they are but appearances, which affects us so. Some deep and unknown existence, of which, with all the sanction of modern demonstration, we may affirm that there is that in it to which pleasure, pain, love, desire, and hatred are akin. Pursuing material laws, we do, as Sir J. Herschel says again, find that they "open out vista after vista, which seem to lead onward to the point where the material blends with and is lost in the spiritual and intellectual."

For it is to be observed that while on this point our positive knowledge is so limited, there is still much that we can affirm. We can correct some false ideas we are prone to entertain. Thus, whatever be that secret activity in nature of which all the "forces" are exhibitions to our sense, we know one thing respecting it; namely, that it is not *force*. Receiving so directly from our own action the impression of force, and seeing similar actions taking place on all hands around us, nothing could be more natural than that we should have supposed force to exist in nature. Yet when we test this idea, we find that it must rank with the child's notion of the world, which ascribes pleasure and pain to inanimate objects. Force is a sensation of our own; and is no more to be attributed to the objects in connection with which we feel it, than are the brightness of a colour or the sweetness of a taste. "When *we* take upon ourselves to alter the arrangements of the universe, we feel *pressure*, *push*, or *pull*. Accordingly we attribute to insentient matter our sensations, and we speak of an arch pressing upon its abutments, of particles of matter attracting and drawing one another, and so on. But if, instead of what we call pressure, it had been an arrangement of the creation that contact with external matter should produce a mental emotion of kindness, we should certainly have said that the particles of matter made love to each other with an affection varying conversely as the square of the distance. What a moving story the problem of the three bodies would have been then!"

We may understand this the better if we reflect that the feeling from which we derive the idea of force rests upon a consciousness of difficulty, of opposition, of imperfect ability. It arises from resisted effort. In fact, it is our own imperfection we ascribe to nature when we imagine that our feeling of force truly represents its working. In it there is neither exertion nor resistance; but a perfect Order. An Order, to explain which, if we look into ourselves at all, we must look deeper than to our sensuous experience. Nor do we look entirely in vain. There are other necessities we wot of than those of mechanical connection; another order than that of passive sequence. We cannot be rising too high in our thoughts when we bring the highest within us to interpret that which we perceive without ; and recall (as we are justified in doing by all that science teaches us) the long banished powers of the heart and soul, to aid us in our thought of nature. Goethe says, in Dr. Whewell's translation :—

All the forms resemble, yet none is the same as another ;
Thus the whole of the throng points at a deep-hidden law—
Points at a sacred riddle. Oh, could I to thee, my beloved friend,
Whisper the fortunate word by which the riddle is read !

But here we do not feel ourselves compelled to end. Our thoughts pursue the path that has been opened to them ; and it hardly seems extravagant to us (ascribing a strict truth and universal application to the words of another poet) to say of all our intercourse with Nature, in her loftiest and lowest forms alike :—

A spirit—
The undulating woods, and silent well,
And rippling rivulet, and evening gloom
When deepening the dark shades, for speech assuming—
Holds commune with us.

CHAPTER XI.

A MEDITATION; ON SKELETONS—AND SOME OTHER THINGS.

I WAS looking, the other day, at some skeletons of sparrows and mice, which an ingenious friend of mine, who is a lover of zoology, had very cleverly dissected and set up in all the glory of brilliant glass-cases, as ornaments to his bachelor apartments. And really very pretty ornaments they were. Did you ever study the skeleton of a mouse? If so, you must have been struck with the carnivorous aspect of the creature thus denuded of its outer flesh. It might pass for a tiger in miniature. And as for the sparrows, their stuck-up, self-satisfied appearance, the knowing look they put on, when thus reduced to their rudiments, surpasses imagination. The essence of the moral qualities of the bird seems almost to be concentrated in its bones. One can see that with such a foundation they could not be anything but what they are.

After admiring them for a time, I fell into a meditation on skeletons in general; and I found the subject, as I thought of it, become full of interest and suggestiveness. How come we and the animals that resemble us to have skeletons at all?

The natural impression given us by looking at a skeleton is evidently not the truth. As we gaze on the solid framework, presenting in so distinct an outline the contour of the living form, it seems to us as if it had been laid down as a basis on which the creature's structure was built up; that the bones were first marshalled in their place, and then clothed with flesh, like the dry bones in Ezekiel's vision. But it is clear that nothing can be more false than this impression. So far from the bones being laid down first, they are altogether a secondary formation: they are rather a deposit from the growing tissues than a framework on which they are built. Of bone properly so called, there is none whatever until a comparatively advanced period of growth, and its formation is preceded by a peculiar structure (termed cartilage), which is itself one of the last formed substances within the body.

But not only can we thus recognize the skeleton as a derived and secondary structure, built up within themselves by the living parts around, but we can trace in thought (though our senses cannot follow it) the mode of its origin. Here again our natural ideas would mislead us. Speaking according to our impressions, we should assign its production to the action of the vital force, and regard it as a direct exhibition of the formative power of life. But the truth is the very opposite again of this. Bone is formed in living structures by a precipitation of solid matter, which is virtually a process like that of excretion, or the casting off of waste materials. And we know by the phenomena of disease, and of natural decay, that the production of bony matter is a result of the loss and failure of vitality. Excessive *ossification* is one of the most frequent signs of the decay of vital power in old age; and a formation of bone (through weakness of life) in the arteries, the heart, and elsewhere, is a not uncommon cause of death.

This excess of bone is called degeneration; it is a descent and fall from the true vital level, and brings the parts and organs which are subjected to it so much nearer the condition of dead and unorganized matter. The elasticity and pliancy of life are lost, and the power of fulfilling its functions by just so much impaired. And the characters of bone itself indicate the same relations. It approaches the mineral not only in its hardness and its composition, but in its structure. It is an approximation to that crystalline arrangement, in the opposition to which consists one of the chief marks of the living tissue. Bone, therefore, is a step downwards from the living towards the inorganic state.

Surely in this aspect the formation of the skeleton presents itself in a most interesting light, opening a new vista to thought. Let us consider the facts for a moment. The whole bony structure of an animal consists of a substance due to a decadence or withdrawal of vitality; and thus, as it is laid down within the growing body, it marks and demonstrates such decadence. The skeleton, in fact, marks certain lines of ebbing of the vital force. And so we find another proof of the opposite processes going on in the body. Here is a tangible demonstration of the fact, unrecognized, however, till its significance had been anticipated; showing how much sharper thought is than sense. We exhume, as it were, from the body the evidence of former life, as travellers exhume the ruins of buried cities.

Is it not a curious result we thus arrive at? We are accustomed to think of the body as the product of an active power, as a revelation and embodiment of life. And we are right; it is so. But here, essential to it, constituting its fundamental portion, without which all the rest were utterly waste and useless, we find that which is the result of the very opposite: of the absence and ceasing of life. Built up in the living framework we find the product of decay. Life reposes on it, not only in the sense, often noted, of springing from and being nourished by decaying matter, but in a mechanical sense also. The basis of the structure that it builds is laid by its own failure. The fact is surely full of an interest and significance which extend beyond the region of physical into that of moral thought; and it would be so even if it stood alone. It would be evidence sufficient of a law, of a resource, as beautiful as it is curious; of an economy and an elegance, if we may venture the expression, in nature, on which the mind cannot rest without delight.

Of an economy, I say. For it is an instance not only of the use of an *absence*—of the withdrawal of a power—to produce a desired effect; but besides this, of that which we see so often in nature—so much oftener than in any of our own works, and the discovery of which ever fills us with an especial feeling of satisfaction—the use of some element or process which is otherwise necessarily present, to perform essential, or at least useful offices.

The skeleton results from comparative failure and absence of vital action; it is formed by processes which are, so far as they are special or distinctive, processes of decay, so that no force is expended in producing it. It comes as the decay of the body comes when life has fled. We might parallel it to the building of a pier by dropping stones into the water. No more *power* is needed to deposit them when once they are brought to the right place. The skeleton, we may say, is formed in the body by "dropping stones."

But more than this: this decay is a necessary part of life itself; it is already present as an essential element in the chain of the vital processes. Without decadence no active vitality is possible: the downward movement ever co-exists with the upward, by a necessity which penetrates to the very essence of material things. But this decadence, which is never absent, is thus turned to account. The very loss and failure of vitality are bidden to subserve its purposes and fulfil its needs. Decay shall render its meed to the stability of that body of which it seems to be the enemy. Out of the destroyer comes forth strength.

The law is a glorious one. The law, I say; for it *is* a law, and all the thoughts which it suggests are re-echoed from every region of the frame, and by every pulse of life. It is a law that failure and absence of the vital force, and processes of decay, should have a large and varied part in the formation, shaping, and strengthening of the living body. It is one of those natural laws, self-evident when they are known, and of a most fascinating simplicity, but which become recondite and hard to see almost from their very simpleness; which make the play of Nature's forces baffle us by its very ease.

Nay, do we speak of play in Nature, of easy, sportive, unconstrained performance? It is the very soul of genius, too; the perfectness of art, the fulness of that law which is the highest liberty. This "play-impulse," which, as Schiller truly says, is the soul of art, is the soul also of Nature's vigorous life. Nor in associating the two are we wandering absolutely from our subject. For has not every work of art its skeleton? Every poem, every essay, nay, every article? Dissect it, and you shall find—if it have any force or substance in it, if it can stand upon its feet, if it have head or body, or if its hands lay hold either of the subject or the reader—dissect it, and you shall find its skeleton. But there are two ways in art, though but one in nature, in which the skeleton may be formed. Talent does as nature seems to do, but does not; constructs it first and clothes it. Genius does as nature does. From its living creation as it grows, the skeleton crystallizes out, itself living and the result of life, as the superstructure is. So it is one with nature, truly; and the world, recognizing the kinship, gives it thence its name.

And is it not the same with Constitutions too? In the body of the State do not the framework of its laws and usages, the rules which determine the distribution of power between the governing bodies, and the privileges which are claimed by each, constitute that which answers to the skeleton? And as in life physical, so in life political, must not this framework grow, and not be laid down beforehand? As the out-birth of the natural flowings and ebbings of human passion, determined by mutual efforts and concessions, by exertions and withdrawals of power, they are built vitally into the very substance of the State, and knit it together in living strength. These broad lines mark the spots over which flowed the most stormy tides of a previous age; the areas in which were waged the hottest strifes. They are marks of a vigorous and super-abounding life, which has learnt to abstain as well as to act; to yield and to forego, as well as to assert itself. Where they exist most perfectly, no brain has thoughtfully contrived them, nor any hand cunningly elaborated their mechanism. Such a Constitution is organic; a fruit of life and not of ingenuity. And so it is that it subserves with vital ease the functions which the community performs.

But to return to the organic body: instances of the law we have noted, that failure of the vital force has a constant office in the processes of life, are everywhere. A few of them it will be interesting to recall. Every now and then we hear of a child whose fingers are *webbed*, like the feet of an aquatic bird; that is, they are united together by folds of skin that forbid their separate use. The noble human hand is thus debarred from its office, and stripped of its prerogative. But by what means? Strictly by want of a due failure of vitality, by absence of decay. For the liberation of the fingers, and the shaping of the hand into the comely and commodious instrument it forms, is committed to this agency. At their first development the fingers are always thus tied together, and they are set free only by a breaking down and removal of the material that forms the intervening membrane.

Another instance of the same process is furnished by the function of sight. At an early period of its formation the eye is an opaquely closed cavity, which would be useless for vision because incapable of admitting light. A membrane passes across its anterior portion, and obliterates the pupil. This condition lasts longer in some other animals than it does in man, and so it is that puppies and kittens are born blind, and gain their sight only when they are a few days old. The usefulness of all the exquisite and complicated mechanism of the eye is dependent at last upon a little process of decay, which gives the finishing touch to its perfection. By this decay, that membrane is broken down, and, as it is said, absorbed; that is, it is taken up atom by atom and re-conveyed into the blood.

These, however, are but instances of a widely operative law. The body is carved and modelled by decay. The failure and negation of the vital force, in the appointed places, are like the artist's chisel by which it is sculptured into grace.

In regard to the skeleton, many other interesting questions suggest themselves; and many to which I know no answer yet. We cannot help asking, for example, why its form is such as it is; why these "lines of ebbing of the vital force" have left *these* ripples and no others? For my own part I can hardly help likening them to the *nodal lines* by which vibrating plates divide themselves, and on which sand spread on their surface gathers and lies still. Why does the body of all the higher tribes of animals thus subdivide and partition itself off? Do we not feel that an answer to this question is possible, though we cannot give it? And a few vague suggestions are not beyond our power. Thus it is a well-known fact that bones are larger and stronger in proportion to the size and vigour of the muscles that are attached to them; and that they are increased in size by increased activity and growth of the corresponding muscles. Again we know that *tendon* sometimes takes the place of bone; what is bone in some animals being replaced by tendon in others. Thus in the crocodiles there are ribs attached to the spinal cord below the chest, and closing in the lower part of the body. In man the positions of these ribs are marked by bands of tendon.

And considering the skeleton as a whole, it is curious to note that its position in respect to the other portions of the body is, in the lower animals, the very opposite of that which it appears to occupy in the higher. In all the higher groups—that is, in all animals possessing a back-bone—the skeleton, with the exception of the skull, is placed *within* the body; but in all the groups below these, when it exists at all, it is external, surrounding and including all the soft parts; and the muscles are attached to it from within, as is well seen in the oyster or the crab. In fact, in its earliest condition (if we may consider the lower animals to exhibit this) the skeleton is a capsule or protecting enclosure for the body; and this relation is still visible in many of the higher orders, as in the shell, or "carapace," of the tortoise, and the bony plates which guard the head of the sturgeon. Now in the form of an external investiture it is clearly exhibited as an excretion from the animal that wears it, it is an evident casting-off of materials of a lowered vitality. Its formation may be compared to the shedding of the skin of the caterpillar or the snake, or to the hardening of the capsule of the chrysalis. Altogether different from this appears to be the position of the skeleton in the mammalia. Yet it is not truly so different if we regard its chief portions in their essential relations. Dividing the body into head, trunk, and limbs, we find the bony portion in the two former segments discharging an office, if not occupying a position, essentially the same as that which it discharges in the lower tribes. The skull surrounds and protects the brain, the spinal column surrounds and protects the spinal cord. The nervous centres in the higher animals bear the same relation to their skeleton as the whole body of the lower animals bears to theirs. It is only in the limbs that this relation is not preserved. The skeleton, therefore, is still a capsule, still formed around included parts which its office is to support and to protect, even in the highest realms of life. And it may be that the position which it thus holds is connected, in the latter cases also, with the process of decay by which its earthy composition is determined. May not, in short, the lower animal, external skeleton and all, be represented to the imagination as absorbed and embedded in the higher?

There is one suggestion more that may, perhaps without too great a licence of the fancy, be made upon this point. The articulated—that is, the ringed or jointed—form of the skeleton in all the higher group of animals is very marked. The spine, with which we may include the head, consists of a series of bony rings, which cannot but be compared to the "segments" of the insect tribe. The ribs attached to these rings present a series of parallel and consecutive divisions; the bones of the extremities are divided by their joints. Now may we venture to connect with this "segmentation," in our thoughts, a parallel on which the fancy cannot but dwell with pleasure, however doubtfully the intellect may regard it? How like a vast dragon, or icy serpent, the glacier lies in its lair in the mountain gully, or, as if endowed with a slow, cold-blooded life, glides downward towards the plain. Do we recognize the horrid likeness? There is another point of resemblance. The monster is ribbed like a living creature too: segmented like, though unlike, the spine. Now what are these markings athwart its bosom? Mr. Tyndal has brought evidence to show that they represent lines of greatest pressure, and result from a thawing of the ice due to that pressure, and followed by a renewed freezing. May we connect these two cases in our thoughts, and imagine that the lines of segmentation in the skeleton denote lines of greatest pressure, and mark a changed vital process due thereto?

But perhaps the most interesting thought which these ideas suggest relates to the connection of disease with life. Disease, we may say, in such facts as these, justifies itself, gives an account of its presence, makes good its claim to be. Of the maladies to which life succumbs scarcely any are more frequent, or more insidiously fatal, than two processes of decay which we have found playing so essential a part in the very formation of the living frame. Bone intrudes where soft and plastic structures are required, and by its dull resistance checks and benumbs the bounding stream of life. Or the living structure softens, and the firmly tenacious, though elastic, tissue of the artery or the muscle becomes relaxed, and fat usurps its place: fat, as the first stage towards utter wasting away and loss. The function accordingly fails, or the weakened organ gives way before some unusual strain. Then death ensues, and we say, and justly say, "Behold disease!" True, it is disease; yet it is a kind of disease that has been minister to health, and has alone made possible the activities of life.

Nor is this relation confined to these two instances alone. True, all disease is a defect of life; a partial dying, a failure of force where it is needed to sustain the frame which it has raised. But never does this failure come to mar and to destroy, but it recalls unnumbered instances in which the like failure has been rich in benefits. All study of the ills that flesh is heir to teaches no surer lesson than that every process of disease has its counterpart in healthful life.

Nor, perhaps, is it impossible to trace a deeper reason here. By the mysterious necessity of things which ever binds opposites together, and will let us have no light without its shadow, we know it is determined—pre-determined ere ever the first living creature drew its breath—that life must depend on death, and growth spring from decay. Disease, decay—we think of them as enemies, but they are in truth our earliest nurses. They cherished our infant life, therefore they come to gather our last breath.

Our last breath, do we call it? Is it not our first true breathing rather? The heralds of life throng around the death-bed, and the same hands that nurtured our earliest days minister to our last. It is even so: so it should be, and must. Death and decay, heralds of life they were—and are; where the new life dawns and the trembling spirit thrills on the brink of a new world, there the appointed forerunners and ministers of life must be. Without death we could not enter upon life; without processes which are essentially those we know as processes of disease, we never could have drawn our vital breath; it is by loss we gain, by failure we succeed.

Dying is a birth we witness from the outer side; we see but the departing, not the coming life: even as in this life, so called, it is but the one side we see, and that—is it not the wrong? Is it not in the failing heart, the sinking pulse, the strife abandoned, that life is revealed?—a life of higher energies, and wider sphere, of which the yielded breath and fading strength of man may well give promise.

The ministers of life are these that wait around the dying couch : of fearful seeming, but true friends ; waiting on us indeed, unseen, at every step, but then achieving all their work when the highest triumph is to be won, the final victory gained.

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